

Problems Affecting Work Flow in Building Maintenance Operation: A Case Study

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ABSTRACT. This paper attempts to identify and analyze the problems encountered in a building maintenance operation of a large urban development project in Saudi Arabia, and to suggest the appropriate solutions. It has been found that work access, approval, cancellation, interval and supplies are among the most important factors contributing to the decline in the rate of work completion. It highlights the fact that these factors became more problematic when most standards and specifications adopted, and applied materials were all imported. This paper offers some suggestions that may help in reducing these problems to a minimum, and, helps the parties involved, to apply an economical and efficient building maintenance execution system.

KEYWORDS: Maintenance operation, work obstacles, procedures, performance, access, Saudi Arabia.

1. Introduction

Pushed by the sharp increase in the demand for housing, the supply of housing in Saudi Arabia has increased rapidly during the last two decades. During the Second and Third Development Plans, the housing construction was the fastest growing sector in the Kingdom's industry^[1]. Many public institutions and government agencies have contributed to housing supply; the Ministry of Public Works and Housing, for example, has constructed about 25,202 units in major Saudi cities during the last two decades^[1]. In addition, The Ministry of Defence and Aviation, the Ministry of Interior, the National Guard, the Royal Commission of Jubail and Yanbu and most universities have constructed housing complexes for their employees.

The large foreign companies which designed and constructed the majority of these projects have applied design standards, specifications, construction systems, codes, know-how, and materials which do not, in most cases, suit the environment of Saudi Arabia^[2]. One study indicated that there was a shortage in the number of local suppliers of imported construction materials to satisfy the growing demand during construction boom times^[3]. As a result, in maintaining these projects, dependency on foreign know-how and materials often reduces the integrity and efficiency of the maintenance operations. The reflection of faulty construction materials was found to have a negative impact on building maintenance^[4]. There are indications that such problems are on the rise; a growing number of maintenance departments which have taken over maintenance operations has reported that they cannot secure adequate working drawings and specifications. Besides, it is indicated that building maintenance is largely affected by the lack of detailed drawings^[4]. This makes one suspect that, most foreign design firms and contractors have either overlooked or paid little consideration to what maintenance operations of such projects would require.

As most evidences indicate that maintenance problems are likely on increase, this paper focuses on examining the maintenance operation of an urban development project which was completed in 1986. The size of development is equivalent to a small town with all necessary services. It consists of a private component which includes single family houses with a total accommodation area of 1,343,000 square meters, and a public component which includes schools, clinics, mosques, office buildings, sports center, and clubs with a total floor area of 300,000 square meters. This project closely represents most developments which were built in Saudi Arabia in the eighties, with respect to building materials, construction methods, and socioeconomic composition of the users.

To secure the lowest price for performing maintenance operations, the project is publicly tendered. The project is normally awarded to the lowest bidder provided they fulfil all the other requirements. The diversity of contractual methods and work types involved makes the maintenance contracting system a very complex one. It also causes the amounts stated in tenders received, to vary considerably^[5]. The contract, in most cases, includes all three maintenance systems: work orders, emergency maintenance and preventive maintenance. Normally, the maintenance department of the owner supervises the work flow in the maintenance operation, and requires the contractor to submit a monthly report on work progress.

A maintenance operation often encounters various problems, which, in some cases, may cause delays or cancellation of some work orders. This paper focuses on the analysis of such problems and their impact on work flow in a mainte-

nance operation. A review of the monthly reports suggests that there are five main problems, that take place during the different stages of maintenance operations and which have various effects on the work flow and completion rate of work orders. These problems involve: access to the site, work approvals, work cancellations, work intervals, and material supplies.

2. Involved Parties

Building maintenance is a complex task. Maintenance projects are increasing in size, quantity and importance on one hand, and are being faced with limited capital budgets on the other hand^[6]. Performing maintenance jobs requires some work arrangement and approvals, which may differ according to project characteristics, management style, work environment, and the cooperation of all parties involved. Hence, some of the work orders submitted may not be completed. In a typical maintenance operation, the principal parties involved in work execution are: the owner, the contractor and the user. The attitudes of each involved party have a lot of major role on the efficiency of work flow as well as on the execution procedures of the maintenance operation.

A building owner is the principal coordinator of the maintenance operation and is the one who determines work standards, specifications and workers' qualifications. He has been considered the most responsible party in determining maintenance standards, sets priorities for work programmers and monitors the overall performance^[5]. The owner also represents the fundamental influence in the establishment of maintenance management practices^[7]. A poor management may substantially reduce the effectiveness and the quality of any work operation^[8], the owner, in most cases, assumes the role of leading management team and secures adequate and professional training to his team^[9]. It was recommended that "owners should take the initiative on improvements in contracting methods, project execution, and relationship between the parties"^[10]. In order to make contractor's actions more effective, the owner must define and establish a work and management policy that is clear and simple. To reduce the chances for disputes, conflict, and corruption, it is suggested that maintenance policy must be based on knowledge, both to define the nature and scale of the maintenance problems and create an awareness among decision-makers^[11].

Speeding work execution in building maintenance is a function of contractor performance in terms of time and quality, and work approval of the building owner^[12]. After the owner selects a contractor and transfers all execution duties to him, the contractor's role becomes very critical. His main responsibility is to provide the materials and human resources to undertake the work orders^[5,13]. The contractor's success in carrying out his duties depends on his qualifications and expertise. To a building owner, maintenance of premises means incurring

annual expenditures^[7]. In most projects, while the role of both, the owner and the contractor is the most dominant, their objectives are conflictual; while the owner always seeks to minimize costs, the contractor seeks to maximize profits^[12,14]. In some cases, the conflict arising from such relationship may lead to undesirable outcomes. Focusing mainly on minimizing costs may lead the owner to select an unqualified contractor or subcontractor, simply because he accepted the lowest bid. In doing that, there may be an implication of accepting lower standards than it should be, and consequently might leave a negative impact on future maintenance costs. It was stated that "because of the industry's practice of accepting the lowest tender for work, it is quite common for initial savings to be made up by high maintenance costs in the future."^[7]

On the other hand, a contractor may decide that the best option to maximize profits is to manipulate procedures or compromise with requirements. He may do that through hiring unqualified subcontractors, employing low paid semi-skilled or unskilled labor, using lower quality materials or under-staffing the operation. It was indicated that, in order to win contracts in the low market prices, contractors should recruit cheap laborers with moderate skills^[12]. In this case, quality and timely completion of work by the contractor will be affected by the overall performance^[3] of the subcontractor or laborers involved^[3]. Also a contractor may choose to save money through substituting materials or spare parts with others of lesser qualities or neglecting to perform some preventive maintenance jobs. There is no doubt that the above circumstances will affect the work execution negatively in both the short and long terms.

Finally, the user's cooperation is an important factor which affects the level of performance in all stages of any maintenance operation. It has been indicated that the user is the real keystone in the maintenance process^[15]. The user's level of cooperation is reflected in his behavior in using the building and equipment, facilitating access to maintenance workers on schedule, and in reporting maintenance problems promptly. It has been found that user's cooperation has a great bearing on scheduling of maintenance jobs^[16]. Increasing user's cooperation may be achieved through encouraging user's participation, which is overlooked and rarely considered, in most maintenance operations.

3. Execution Procedure

Maintenance work has been described as fragmented and scattered and often very difficult to supervise, organize, control, and execute economically^[7,17]. Therefore, before starting work execution, one has to establish certain procedures and priorities. In a typical maintenance operation, execution procedures may be classified into five stages: requisition, access, arrangement, supplies provision, and actual execution (Figure 1). Delays or complications in one or

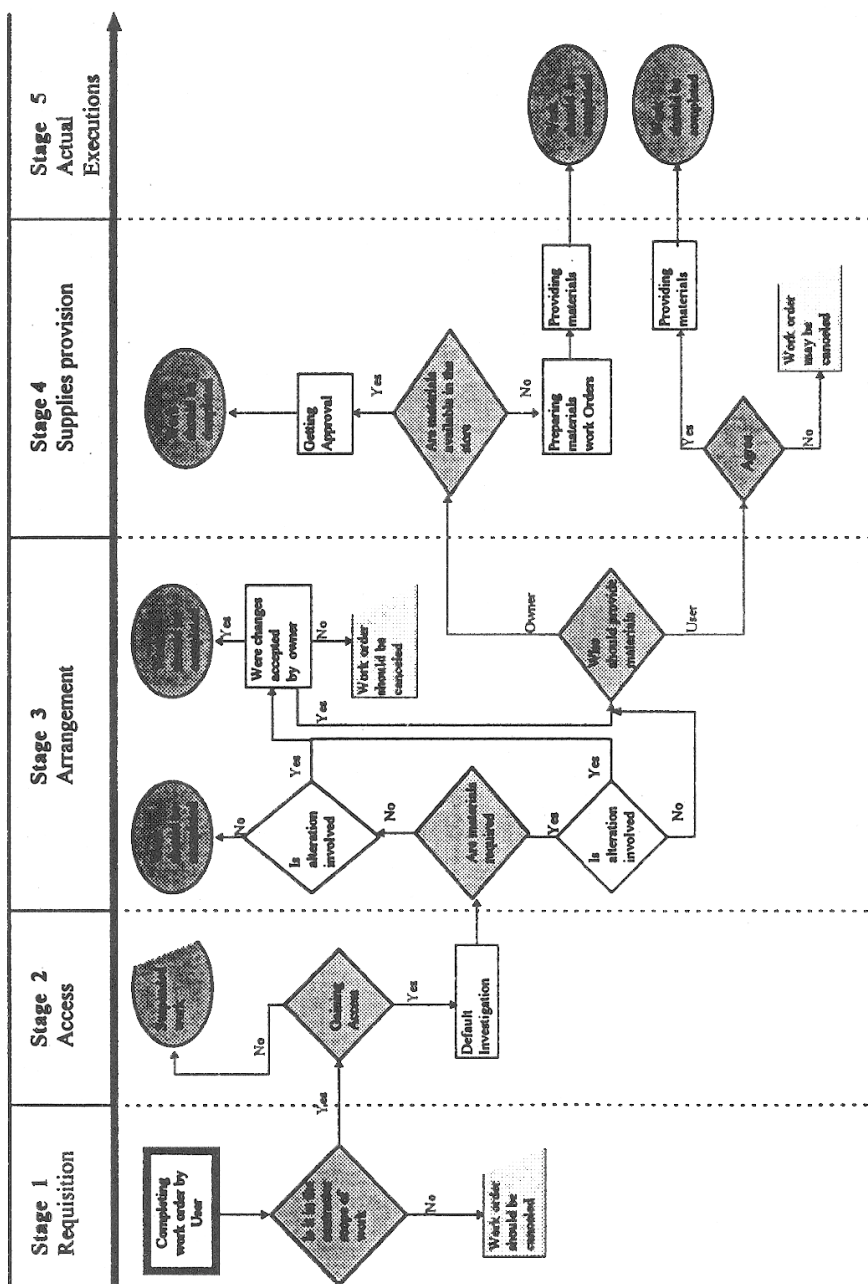


FIG. 1. Work order execution procedures.

more of these stages may result from actions or behaviors of owner, contractor or user. This may delay work flow, and in some cases such delays and complications may reach a point where a work order may be canceled or rendered incomplete.

In a corrective maintenance system, work action starts after a user reports a problem to the maintenance department. In order to submit a work order to the contractor, first, a user has to complete a Maintenance Work Order Form. If the initial inspection establishes that the work necessary is within the contractor's scope of work, the work order is processed to the next stage. Otherwise, it is canceled at stage 1. Admitting workers into the premises is the next step in processing a work order. This depends on the user's availability, which may constitute a problem, especially in buildings in private use. When access to the premises is permitted, a technician investigates the problem and proceeds to correct it and may complete the work early in stage 2. If access is denied, work is categorized as suspended at stage 2.

Executing a work order generally requires the owner's approval, which may be more problematic in cases which involve alterations and supplies. If the owner approves alterations which do not require new materials, work is usually completed at stage 3. If alterations require some new materials, the possibility of doing the work and the responsibilities of supplying the needed materials are determined at stage 3, before the work order is processed for execution at the next stage. But, if the owner disapproves such alterations, the work order is canceled at stage 3.

The decision of who should supply the materials is determined at stage 3. Normally, The section of "Work Conditions and Requirements" in the contract specifies the responsibility of supplying materials and spare parts. In most cases, either the owner or the contractor (on behalf of the owner) is the party responsible for supplying materials. In some cases, however, all or part of the responsibility of supplying materials is passed to the user. If the owner is responsible for supplying materials or spare parts, an inquiry is conducted to determine whether or not all the needed items are available in stock. In most cases, this should not constitute a problem because the owner normally requires the contractor to maintain a minimum quantity of materials and spare parts in stock, and most work orders are completed at stage 4. If the items needed are not available in stock, arranging to purchase them from local or main suppliers could be time-consuming, especially, if such items are not readily available. This may become more problematic if the user is the one who is responsible for supplying such items. First, the maintenance department has to notify the user to supply the items needed. Second, the user may decide either to agree or disagree. If the user agrees, work execution proceeds and the work order is completed at stage

4. However, if the user supplies the items needed past a certain time specified, completing the work order may extend into stage 5, the latest stage in the execution procedure. Otherwise, the work order is canceled at stage 4. In each stage the time needed to perform individual duties depends on the specific nature of each job and the level of cooperation and performance by the parties involved. Normally, stages 3 and 4 are the most time-consuming.

During work execution, the contractor has to submit to the owner, represented by his maintenance department, a monthly progress report, which specifies the count of the work. In this report, the contractor presents an overall work status in terms of orders received, orders completed, and those which remain incomplete, and presents some of the problems encountered and their implications. Figure 2 summarizes the inputs and outputs of a monthly execution system. The two main sources which feed the monthly work system are the facility user or occupant and the system feedback. For one reason or another such as the unavailability of certain materials or spare parts, some of the scheduled work orders may not be completed on the current month, and therefore, are re-entered back into the system as work orders for the following month.

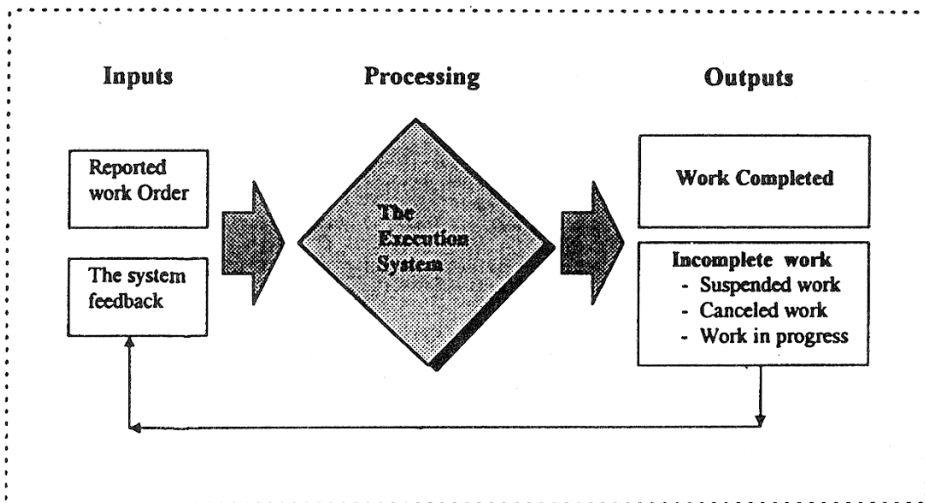


FIG. 2. The monthly work execution system.

According to work procedures the system's monthly output is classified under two main headings according to work status as work completed, or incomplete. Work completed refers to the work where work order was approved, access was permitted, materials or spare parts were supplied, and work was accomplished. Incomplete work orders result when one or more of the parties involved in a

particular job do not perform according to expectation during the execution procedure and hence causing delays in the work execution. The incomplete work includes work orders that are suspended, canceled, or in progress. At the end of the month if one or more of the parties do not accept to perform certain work that is ordered or refuse to supply certain items needed, or to provide access, work may be suspended for some time or may be canceled. Work in progress refers to all work orders that are under execution.

4. Obstacles and Performance

Classification of work orders as incomplete in various uses will be done in term of: access, approvals, cancellation, work interval and supplying materials and spare parts needed. The effect of each factor varies according to circumstances, for example, access to a building is much easier to secure in public use than in private use. Failing to gain access at the time scheduled increases the number of work orders that are classified as incomplete at an early stage of the work procedure (Figure 1). Access to the site might be difficult, space may be restricted, and interference may exist between workers and occupants^[18].

The owner is normally the party responsible for issuing approvals to purchase materials and spare parts and to execute work. Some cases which involve alteration require obtaining the owner's approval. This sometimes takes time to obtain, and as a result may cause some delays.

Cancellation of some work orders is another problem. Cancellation may result if work execution involves some alterations the owner does not accept. Cancellation also may result; 1) if the work issued is for an item that is outside either the owner's or contractor's responsibilities; 2) if no damage is found or the complaint is unjustified; 3) if an item is irreparable and the user refuses to supply the necessary materials or spare parts; 4) if there are budget limitations.

Some repair jobs may be more time consuming than others. In some cases, not all the time is only spent on repairs, but also on waiting for material or spare parts, reassessing work problems, examining the relationships between the various activities, and on waiting for approvals. Therefore, at the time of submitting the monthly report, some work orders that are presumed to be finished, have not been accomplished. As a result, such work orders will be reported as work in progress. This means that although those work orders were approved and all items needed were supplied, time extension was needed to complete the job.

The availability of the items needed in the local market and the lead time needed to obtain them are another factor which may be a source of delay. Delay of materials delivery may also extend the time of work execution in maintenance operation. Shortage of materials was found to be the most important rea-

son, 60% of the maintenance delays were attributed to lack of materials^[19]. This problem becomes more serious if the materials needed are foreign-made or should be purchased only through foreign suppliers. Materials costs also increases, particularly for most imported items^[11]. Waiting for materials approval or manufacturing increases the lead time for obtaining them. Hence, there is a strong relationship between work approvals and time to secure all the items needed, since waiting to determine who should provide such items may prolong the time necessary to obtain the required items.

Figures 3 and 4 show the contribution of individual work obstacles to the number of incomplete work orders per year for private and public uses. In comparing the two figures, it is evident that the contribution of work obstacles differs according to use type. Access and approvals stand as the most contributing factors to incomplete work in private use. The significance of access seems to decline over time, whereas approval gains significance with time. The contributions of cancellation, work interval and supplies seem to be insignificant compared to access and approval, however, cancellation is more important than work interval and supplies. In public use, the contribution of individual work obstacles are more fluctuated and relatively smaller than the significant obstacles in private use. Cancellation, supplies and intervals are the most contributing factors which have contributed to incomplete work orders. Figure 4 shows that the percentages of incomplete work orders related to each factor is high, and some of them gain significance over time. However, the total contribution of access and approval is smaller and declines over time.

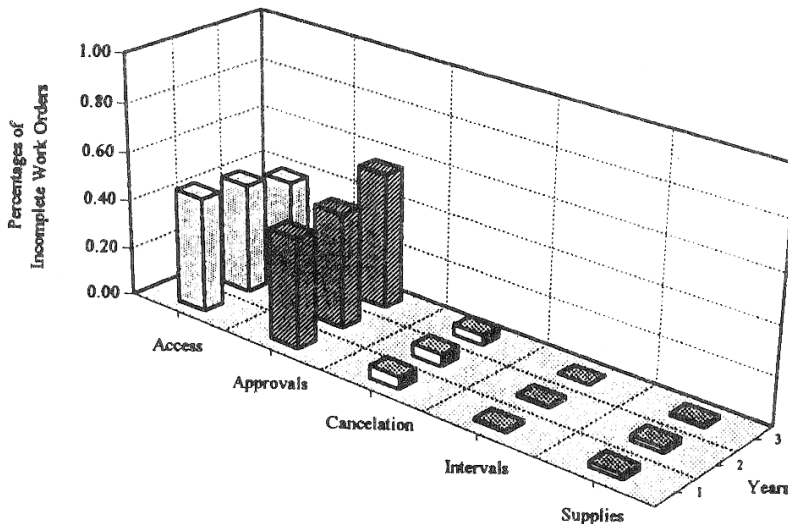


FIG. 3. The contribution of individual obstacles to the number of incomplete work orders in private use.

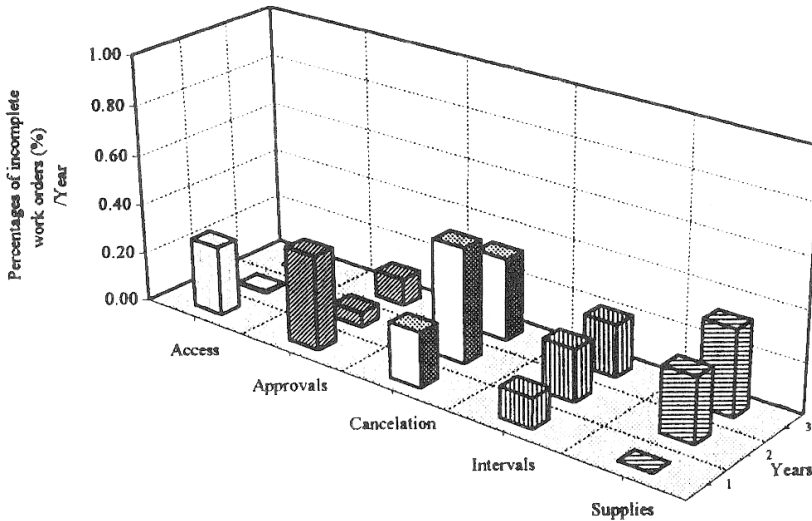


FIG. 4. The contribution of individual obstacles to the number of incomplete work orders in public use.

The data suggests that the higher the number of the work orders received, the less the percentage of the work orders completed, and the higher the percentage of incomplete work orders, except in the case of a good management system. To examine this hypothesis, Figure 5 shows the number of incomplete work orders per month per square meter for the forty-one months of maintenance operation for private and public uses. In both private and public uses the number of incomplete work orders increases over time. The number of incomplete work orders in private use increases rapidly over time (with slope of incomplete work orders equal to 3.9), whereas in public use the number of incomplete work orders increases gradually over time (with slope of incomplete work orders equal to 1.6).

This suggests that the total contribution of the work obstacles increases over time. Normally, the objective of the involved parties is to have all work orders completed. For example, the contractor normally works hard to have all the reported work orders completed in a month, in order to keep his work performance level acceptable to the maintenance department and to get his full payment monthly. Monthly rate of completion (the number of work orders completed / work orders received for each month) is a measure of the level of monthly work performance. Figures 6 and 7 show the level of work performance over 41 months, the line of average completion rate (the mean) and the standard deviations. The level of work performance is high in both private and public uses, though higher in public use (at an average completion rate of 96%) than in private use (which equals to 84%). In both private and public uses, the

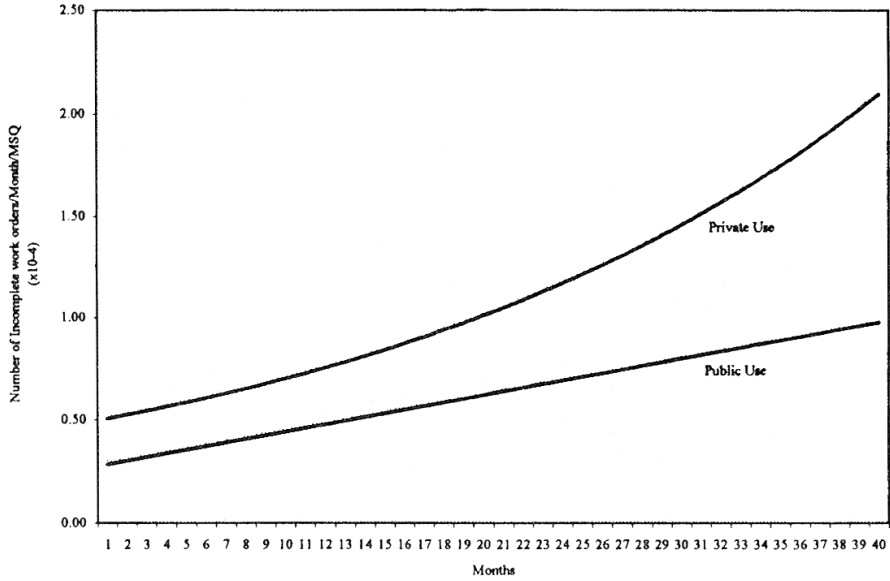


FIG. 5. Increasing number of incomplete work orders over time for different uses.

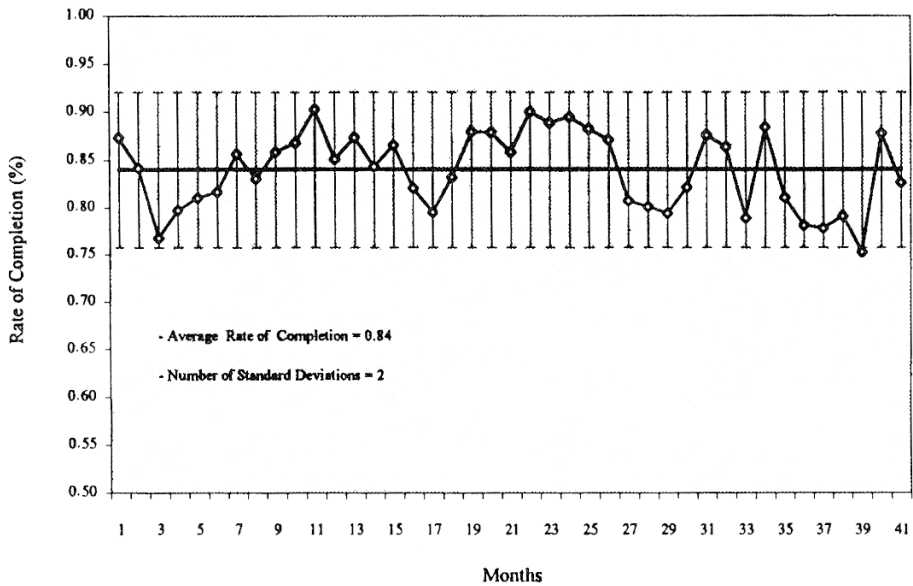


FIG. 6. Level of work performance in private use.

level of work performance is fluctuated over the 41 months. This fluctuation is a function of the significance of the contribution of work obstacles in the individual month. However, the deviation of the level of monthly work performance from the mean is twice higher in private use (with standard deviation equal to 0.20) than in public use (which equals to 0.10).

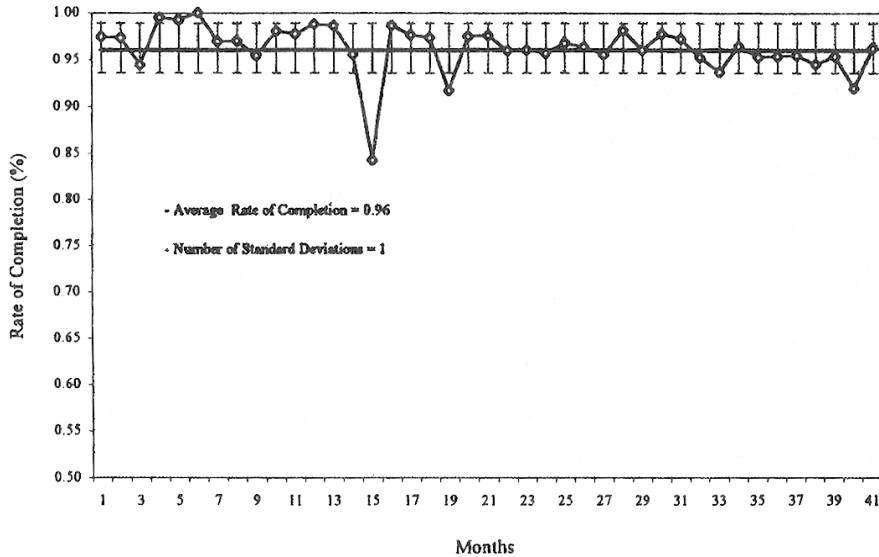


Fig. 7. Level of work performance in public use.

5. Difficulties Control

It is important to understand the underlying reasons behind some of the factors which cause work delays, in order to be able to avoid them, and to minimize their negative effects. Table 1 suggests that the reasons underlying such factors differ significantly between the public and private uses. While work access does not constitute a problem in the public use, it stands as a major problem in private use because of the frequent unavailability of an occupant to admit a worker to investigate or solve the problems. Maintenance departments should be particularly aware of work access in private use. This is because executing number of work orders in private building depends on gaining access which represents the first step as shown in Figure 1, through which defaults can be investigated or executed. If a user is not available or denies a worker access to property, a work order will be suspended until access is allowed.

The effect of such a factor can be minimized by increasing user participation in the maintenance operation. User participation is a process rather than a single function and in describing user involvement the terms 'consultation' and 'partici-

TABLE 1. Problems facing maintenance operation and reasons causing them.

Building types	Access	%	Approvals	%	Cancellation	%	Intervals	%	Supplies	%	
Public	N/A	-	No approval.	73	Close by owner.	73	Work in progress.	85	Searching for material in the local market	70	
			Inform the building authorities.	14	Not repairable.	5	Work under study.	2.5	No approval from yet from owner.	2	
			Material not approved	13	Not in the contractor scope of work.	7	Work was scheduled on....	2.5	Order placed for fabrication.	19	
					Wrong complaint	1	Waiting for other work to be completed.	5	Waiting for quotation from abroad.	9	
					Work orders closed temporarily	5	Proposal with owner for approval.	5			
					No damage was found.	4					
			Spare parts not available in the market.	5							
Private	Resident not available	100	Inform tenant to provide materials	100	Wrong location.	55	Work in progress	100	Searching for materials in the local market.	66	
					Spare parts not available in the market	2.5			Waiting for materials order from supplier.	17	
					Canceled by tenant	25				Order placed for fabrication.	17
					Different spare part	2.5					
					Different trade	1.3					
					Canceled by owner.	5.2					
			Does not belong to owner.	2.5							
			No description of complaints.	6							

pation' can be seen as representing different stages on the participation continuity^[20]. In large maintenance projects senior managers may have no time to spend on concerns of individual tenants^[21]. In this case, maintenance management should seek other solutions such as, holding annual meetings to allow all parties involved (such as owner, contractor, user and possibly suppliers) to exchange ideas and discuss certain issues, which may include the general maintenance system's policy, as well as the users' obligations. One way to involve users in maintenance work, is to establish an educational and informational system such as training manuals, to organize training programs, and to use mass-media and publicity^[15,22].

The contractor should inquire about the occupant's most appropriate time to have a worker in. For ordering repairs and monitoring performance, a building user ought to know when the work will be carried out^[15]. This is to improve the accessibility for maintenance workers to execute the work on schedule. The Chartered Institute of Building found that, for residential buildings in the United Kingdom, the normal work hours are the accessible time for internal maintenance work^[22]. However, this may not be the case in Saudi Arabia; special cultural traits influence people's daily time schedule, and, hence, affect the scheduling of maintenance work^[16]. Therefore, it is recommended that the maintenance contract should indicate that the owner must ensure adequate access to the work place in order to minimize the unavoidable^[7]. Also, the user should be informed when the work will be carried out^[5].

The procedure of the approval system in public use is quite different from that in private use. In the latter, the time spent on instructing the user to supply materials and receive them constitutes the main causes, whereas, in the former, rejecting work orders, not approving work material, and informing or arranging with other building authorities account for the main causes. However, 73% of the work orders listed under this factor in public use were not completed because work was not approved, while all work orders listed under that factor in private use were not completed because of the handling of materials and the long time involved in such procedures. To eliminate such a problem, work approval procedure should be simplified and the user participation in running maintenance work should be improved. Delegating some work approval to middle managers and supervisors should reduce time consumed in work approval by the project manager. Consequently, it has been recommended that before a maintenance project is awarded to a contractor, adequate steps should be taken to ensure that proceedings compile with the approval work program and to ensure that satisfactory control is determined^[18].

Regarding the work cancellation factor, 73% of the total work orders listed under this factor in public use were not completed because they were closed by

the owner, while 55% of the work orders listed under this factor in private use were not completed because of giving the wrong location. The number of canceled work orders appears to increase in both private and public uses. As suggested from Table 1, there are various causes of cancellation, and therefore, different strategies should be adopted in order to control their distinct effects. More attention could be given to the more important causes such as closing work orders by owner, and work order that are not in the scope of the contract in the case of public use, and such as giving the wrong address and canceling work orders by the user in the case of private use.

Regarding work interval, 85% of incomplete work orders in public use and all incomplete work orders in private use are listed as work in progress, and this may be attributed to the long work interval which exceeds one month. Neglecting some of the critical jobs that should have been done by the work order system or preventive maintenance should increase the normal work interval. Delays can result in further damage which requires essential corrective action that often costs more to undertake^[17]. To eliminate job enlargement and cost overruns, it is desirable to recover defaults in their early stages. Except for time interval since the volume of work in public use is massive, and it often takes more than a month to be completed, there is a general consensus that controlling work obstacles in public use is much easier than in private use. In order to monitor work performance in this case, maintenance requests have to be turned into job authorizations, with an agreed charge and performance deadline for the contractor^[5]. The owner is also entitled to assess the workload requirements and organizing men and materials to undertake the work in the most efficient manner and to determine the acceptable periods of time to execute the ordered work^[5].

Regarding work requirements or supplies, searching for materials in the local market was the dominant reason causing the delays in completing work orders; it accounted for 70% of the incomplete work orders listed under work requirement in public use and 66% of those in the private use. Placing items for fabrication and waiting for materials ordered from suppliers are also important reasons contributing to incomplete work orders. While the cost of maintenance materials exceeds the cost of maintenance labor, little attention is paid to the inventory operation^[22]. The difficulties of supplying materials and spare parts on time can be improved by providing user with enough information about the availability of materials in the local market and the names and addresses of main suppliers. This reduces the time spent on searching for work materials and spare parts.

Announcing main suppliers by project main characteristics such as buildings type, materials type and specifications should improve their knowledge about future demands and improve the availability of work requirements in the local

market. It is important that parties concerned with maintenance such owner, contractor, user and supplier have a wide knowledge and understanding of the buildings for which they are responsible. This information can be produced as a loose-leaf maintenance manual to be available for all those parties^[7]. In terms of user involvement in maintenance operation, a user ought to be familiar with the best way to use the building, and with how to respond to the external and internal maintenance requirements and procedures^[15].

6. Conclusion

The analysis above shows that work access, approval, cancellation, interval and supplies are the most important factors which control the efficient execution of maintenance operations, and which require the most attention of managers of maintenance operations. In this case study, the importance of these factors differs according to building use; access and approval are the most important factors affecting work completion in private use, whereas cancellation, interval and supplies are the most important factors affecting work completion in public use.

Thus, increasing the rate of work completion requires appropriate manipulation of these factors. In attacking related problems, the roles of awareness of the owner, contractor and user in carrying out maintenance duties is essential. Mismanagement of work approval, weak participation of building users, shortage of materials and spare parts in local markets, and work cancellation at work stages account for the main causes of delay of work execution in maintenance operations.

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المشكلات التي تؤثر في سير الأعمال لمشاريع صيانة المباني : دراسة حالة

أحمد بن حسن العرجاني

أستاذ مساعد ، كلية العمارة والتخطيط ، جامعة الملك سعود
الرياض - المملكة العربية السعودية

المستخلص . من خلال دراسة أحد مشاريع الصيانة القائمة في المملكة العربية السعودية تم تعريف وتحليل أهم المشكلات التي تؤثر على سير الأعمال في مشروعات صيانة المباني التي تتسبب بدورها في تدني مستوى الإنجاز في هذه المشاريع .

تبين من خلال هذه الدراسة أن من أهم مسببات هذه المشكلة :
(١) طريقة الوصول إلى مكان العطل ، (٢) نظام الموافقة علي تنفيذ الأعمال ، (٣) إلغاء الأعمال ، (٤) فترات تنفيذ الأعمال ، (٥) الإمدادات بالمواد وقطع الغيار . كما تشير الدراسة إلى أن حجم هذه المؤثرات قد يزيد عندما تكون معظم المعايير والمواصفات والمواد المستخدمة في عملية التشييد مستوردة من الخارج كما هو الحال في معظم المشاريع القائمة . وتقدم الدراسة بعض الاقتراحات للأطراف العاملة في مجال تشغيل وصيانة المباني التي قد تخفف من حجم تأثير تلك المشكلات لتكون الأنظمة المتبعة في الصيانة أقل كلفة وأفضل أداءً .