

# The strategy of performing maintenance work and its impact on maintaining the efficiency of schools' operation

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## Abstract

This The research aims to develop a strategy for various maintenance works inside buildings, whether planned, emergency, or remedial maintenance, with the aim of preserving the building and increasing its operational efficiency. The applied study also examines the impact of the proposed strategy on the efficiency of operating schools, with the aim of preserving them and increasing the life span of the building. The applied study dealt with choosing one of the schools as a study sample, which is a secondary education school that was chosen to undergo a comprehensive planned program of maintenance under the supervision of the Educational Buildings Authority and the Directorate of Education, where the goal was to rehabilitate the structure for work instead of complete replacement with total demolition. Therefore, it was chosen as a study sample and a form was applied. And monitoring and evaluation schedules designed for that school to demonstrate the suitability of the proposed maintenance strategy for application in cases of similar schools, with the aim of making recommendations to decision makers when carrying out comprehensive maintenance of a similar school with the aim of raising its efficiency and rehabilitating it. The goal is to develop a methodology for managing maintenance work to increase the efficiency of operating the school building as one of the important types of buildings, with the aim of providing spaces and spaces qualified for basic pre-university education.

## Keywords

Maintenance strategy – school maintenance – building operation efficiency - emergency maintenance.

## 1. Introduction

Educational buildings, with the services they perform, represent a national wealth and an urban front for Egypt, as they constitute an breeding and educational edifice as

an institution capable of contributing to the formation and rehabilitation of future youth and preparing them to take responsibility for building and raising their country.

Hence, preserving these buildings and extending their life

to serve many generations to come must take a great deal of importance, which requires dealing with buildings through a scientific and organized method of the maintenance process to ensure the continuation of the functional and construction efficiency of the building, which ensures security and safety and pushes the educational process forward.

The research problem is the importance of developing programs to maintain schools as one of the types of educational buildings that the state needs to preserve and rehabilitate due to the shortcomings in the number of classrooms for pre-university basic education. Therefore, the research deals with a study of different types of maintenance with the development of a strategy for a planned maintenance program that was applied to one of the school samples, which is Bahtim Secondary School, as one of the models of secondary schools subject to a rehabilitation program, where a set of monitoring and follow-up schedules and forms were designed for all the various work items within the school with the aim of following up on maintenance work. Periodically, developing a strategy for planned maintenance and applying it to the school to demonstrate the feasibility of this methodology to rehabilitate and preserve the school and increase its life span, and thus place the methodology among the results of the research to benefit from it and apply it to other schools in the future.

### 1.1. Research objective

Develop a strategy for the maintenance of educational buildings as well as methods and programs for implementation. Taking an overview of the state of educational buildings that have been constructed during the past years, it is clear that there are many defects, some of which affect the structural safety of the buildings, and some that distort their appearance and indicate defects that, if left unrepaired, would sooner or later affect the safety of the facility.

### 1.2. Research problem

Failure to implement a strategy for the maintenance of

educational buildings in a correct manner and resorting to maintenance after the building has reached a poor condition that requires major maintenance.

### 1.3. Research methodology

Data has been collected in site and through an open interview for the reasons for defects that appear in educational buildings.

- These data were analyzed for defects in educational buildings.
- Refer to studies, research and technical reports to determine the causes of those defects.
- The method of qualifying workers in the field of maintenance, whether at the school level or at the level of engineers and technicians.
- A review of the different ways to repair and strengthen the various structural elements.
- Design tables for planned maintenance elements to monitor various work items, indicating the repair method for each item.
- An applied study of one of the schools (Bahtim Secondary School for Girls), examining the current situation and applying the maintenance strategy by applying the designed maintenance tables and developing an evaluation for each element to show the extent to which the maintenance strategy has been achieved and its role in rehabilitating the building and developing the designed tables as a measuring ruler that can be applied to any school in the future. To achieve a maintenance strategy used to raise the efficiency and rehabilitation of any school.

## 2. Types and causes of defects in educational buildings.

During the past few years, the phenomenon of cracking facilities of various types and areas of use, whether as residential buildings, hospitals, administrative buildings, schools or factories, has increased. . And others. There are many types and forms of defects in these structures, ranging from minor cracks in some structural elements to the partial or complete collapse of the structure. There are

many reasons behind these defects, which can generally be traced back to the builders, users, or unexpected disasters.

The cracking of facilities and the collapse of some of them is a global phenomenon whose causes differ from one country to another, and this is evident in the large number of international and local conferences and research published in specialized scientific journals during the past few years that deal with this problem. Codes of practice for design, implementation and standard specifications for acceptance and rejection limits for building materials are constantly being developed to overcome the phenomenon of structures cracking and to obtain strong, safe and durable structures that can withstand the conditions they are exposed to over time.

And educational buildings - like the rest of the facilities - faced many problems, whether as a result of the use of old buildings that were not originally built for this purpose, or as a result of shortcomings in the various stages of construction, or the absence of appropriate maintenance work. As a result of the urgent need now to provide an appropriate number of classrooms to accommodate the increasing numbers of students in the pre-university basic education stage, the maintenance of school buildings as one of the types of educational buildings was of great importance to maintain the integrity of the structure, increase its virtual lifespan, and avoid future defects in the structure and the resulting damage. Cracks and fissures must start from the design stage and the construction implementation stage, taking into account the use of building materials that conform to the specifications, as well as following the requirements and building codes regulated during the implementation work, as the efficiency of the construction's implementation is one of the determinants to protect it from future defects.

### 2.1. Forms of defects in facilities

The defects that exist in the facilities may be defects at the level of the facilities as an integrated unit, or defects in certain structural elements, and these defects may affect the efficiency of its use or relate to its integrity and

threaten its collapse.

#### Defects specific to the building as an integrated unit. These defects are divided into two main types:

##### 1- Defects related to efficiency of use such as [1]:

Significant vertical drop, extreme slope, torsion, unacceptable cracking, uncomfortable vibrations, insufficient insulation (moisture - heat - sound).

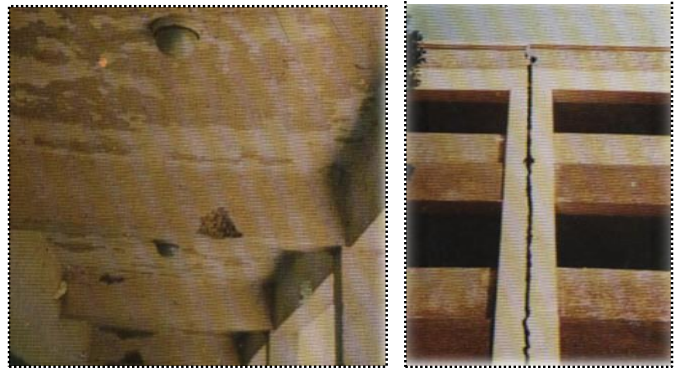


Figure (1): Cracks in the ceiling as a result of water leakage and a large percentage of chloride salts Figure (2): the width of the expansion joint as a result of the building falling (Source: Author).

##### 2- Defects related to the building safety such as:

Unbalance, partial collapse, total collapse. These defects can be summarized as follows:

Excessive deflection of elements subject to bending , excessive torsion of elements subject to stress, staining and salting, Corrosion, especially for stairs, rusting of steel reinforcement, cracks, and falling concrete fig. (3)& (4) [2].



Figure (3): A clear slope in one of the buildings Figure (4) : Buildings on the edge of a mountain are susceptible to sliding (Source: Author).

## 2-2 Reasons of defects in buildings

Buildings on the edge of a mountain are susceptible to sliding

Studies and research have confirmed the existence of thousands of reasons that may lead to defects in facilities, and through previous research and from the outcome of discussions, conferences and advisory reports, the defects can include the following reasons [2]:

- **The builders:** failures in the soil, shortcomings in design and protection, shortcomings in materials, shortcomings in implementation.
- **Users:** deficiencies in maintenance, modifications and unplanned changes.
- **Unexpected disasters:** earthquakes, fires, floods, explosions.

The defects in the facilities may be caused by one or several reasons combined from the above, which can be explained by more reasons, and they must be deeply understood to take them into consideration, whether by avoiding when constructing a modern building or when evaluating an existing building.



Figure (5): bad storage of gravel      Figure (6): bad cement storage  
 Figure (7): Steel reinforcement with a high percentage of rust (Source: ref. [3]).

### 2.2.1 Builders:

#### A. deficiencies in the soil:

One of the painful facts is that many of the buildings that showed defects, whether in the capital or in the different governorates, were not tested for the properties of their soil before construction. Thus, the design of the foundations has been built on assumptions that days have proven

to be wrong in general, which led to the occurrence of large subsidence in buildings, uneven subsidence, inclinations, torsion, or skidding, and the cracks that follow in the walls of the building and its load-bearing elements, and lead to collapse, whether partial or total. With time. The areas of deficiencies that can be traced back to the soil can be mentioned as follows [3]:

- The lack of geological information for the region as a whole, as well as the extent of its distance from the epicenters of earthquakes.
- The nature of weak soils and variable properties and behavior related to the moisture content of exfoliating or collapsing soils.
- The collapse of the soil under the foundation to exceed the loading stresses the bearing capacity of the soil under the foundation.
- Significantly varying proportional subsidence under different parts of the building.
- The ground water level fluctuates up and down the foundations, which may lead to loosening of the soil underneath and the occurrence of subsidence not taken into account.
- The presence of salts and chemicals at a high percentage in the soil without adequate protection of the foundations.
- The processes of replacing the soil with inappropriate materials and the method of soil compaction are not appropriate.
- Removal of ground water without taking into account soil disturbance.
- Drilling works adjacent to the building without proper support works for the sides of the drilling to prevent loosening of the soil under the existing part.
- The facility was exposed to large vibrations such as the movement of heavy vehicles or the hammering of piles or machines without taking adequate precautions to not transfer those vibrations from the soil to the building in a way that affects its safety. As for the problematic soils, the most common types of them, the potential problems about them and how to identify them have been summarized in **Table (1)**.

soil type	Possible problems	How to identify it
backfilling	Usually heterogeneous and its history is unknown, it subsides under load and the movement of groundwater, it may not be inert and gases may be generated from it.	1-appears in soil tests. 2-The presence of backfill can be known from the land records. 3-It may become necessary to perform special physical and chemical experiments.
bulk sand	1- compressible 2- It lands under the influence of vibrations and may have a state of fluidity in special circumstances.	1- The number of beats in the standard penetration experiment is less than ten, but beware of misclassifying the results of this experiment. 2-It may be necessary to do a static cone experiment.
delicate clay	1-Ease of reconfiguration during implementation - such as: when piling piles or moving equipment. 2-It can have a severe decrease in pressure resistance	Measure sensitivity in the field or in the lab.
shale clay	It softens when exposed to water currents, or wet and dry cycles, meaning that the soil will move with the seasons	High modulus of plasticity. Due to the concentration of mineral substances in the clay.
collapsed soil	Lack of resistance When water seeps into it or gets immersed in water, water currents cause erosion and movement of particles.	Usually a material with poor cohesion, open structure and low specific weight.
Clay containing sand and clay layers	It allows internal water pressure to transfer through large cracks, which causes rapid compression of the layers of mud adjacent to the cracks. Cracks may occur at the water or injection if the pressure is high.	Regular sampling is necessary. The use of Piezocone may be required.
residual soils	The mixing of the rock is not precisely defined and curvy, which leads to problems in determining the depth of the piles. They may contain gaps in the ground, especially in limestone rocks.	Detailed knowledge of the geological history of the area and accurate determination of the soil sector from a sufficient number of soil tests.
soluble soil	The ingress of water may lead to the removal of salts, causing a crash landing.	Local Dome' regions of the world - Adequate knowledge of the geology of the region.

Table (1): Soil conditions that could cause foundation problems (Source: Author). [3].

**B. Deficiencies in design and protection:**

The modern design and implementation codes stipulate the imperative to take the conditions surrounding the building as well as the nature of its use and the extent to which it is exposed to from a harsh climate or chemicals loaded with the atmosphere or in contact with its elements into consideration within the protection work of the building. Therefore, the codes set restrictions on the limits of acceptance and rejection of the materials used, as well as the safety factors, the quality of cement, the thickness of the cover, external paints and others, according to the conditions that the building will be exposed to. New codes have appeared that include modern theories in design and are linked in their application to materials

with distinct qualities and to serious quality and control work. However, it turns out that there may be shortcomings in the design due to many factors, including [4]:

- 1- Errors in choosing the structural system and the basic assumptions.
- 2- Errors in calculating loads.
- 3- Not taking the surrounding conditions into consideration when designing.
- 4- High stresses for the resistance of the materials used.
- 5- Concentration of stresses when transferred from one sector to another.
- 6- Problems with the struts and the movement of the elements.
- 7- Lack of structural details, which may not appear in a clear manner on the paintings, which leads to confusion, including:

- Distribution of steel skewers.
- The shape and dimensions of the skewers.
- Connections, their lengths and locations.
- The ends of the skewers and their extension from one element to another.
- Concrete cover according to exposure conditions.
- Determine the movement joints and landing joints.
- Not specifying the exact specifications of the materials used.
- Inconsistency of mixing ratios of concrete with the specifications required in the fresh and hardened state.
- Arranging casting and consolidating elements during implementation if necessary.

The most important reasons behind the appearance of defects in facilities resulting from shortcomings in design, protection, details, and areas of errors and how to identify them are summarized in **Table (2)**.

**C. Deficiencies in materials:**

Undoubtedly, the use of defective materials has a destructive effect and represents one of the main reasons behind the appearance of defects in the last product, which is the building. The limits of acceptance and rejection of materials are due to the extent to which their properties conform

identify	Mistakes that can happen	scope	Status
Revision of the calculation sheet. Revision the drawing with the calculation sheet.	Errors in structural analysis. Not writing section	the calculation	Design Defects
Revision of load conditions.	Not taking all loading conditions into consideration (winds - earthquakes - frequent loads)	loads	
Border Cases Revision	Not taking all the circumstances into consideration	The surrounding circumstances	
Revision the weights and loads according to the nature of the building	Errors in assuming loads or movement of weights	Assumptions	
Revision drawing notes.	Errors in estimating the resistance of materials and structure to various stresses.	materials and structure	
Struts details	Not taking the effect of movement as a result of friction at the moving pillars.	struts	
Revision joints drawing	Not enough joints	expansion/contraction	
detail drawings	Failure to determine the appropriate concrete cover for the conditions to which the building is exposed	concrete cover	Shortcomings in the details
slaps and beams drawing	Not specifying the appropriate cohesion lengths for the skewers, especially at the ends of the beams.	Cohesion lengths	
Do joints allow movement?	Not specifying the locations of the casting and expansion joints or defects in their details.	Joints	
Columns, beams and walls sections	Steel accumulation causing nesting or the use of large diameters with small diameters	Sections	
Specification revision	Inadequate specifications or not applicable to the situation in nature	Specifications	

Table (2):Scopes of design deficiencies, details and errors that occur from the Egyptian standard specifications that are issued. From the General Authority for Standardization of the Ministry of Industry and related to building materials is the main reference for acceptance and rejection of these materials. These specifications generally include how to take the test sample and its quantity representing the quantity supplied or the subject of inspection, as well as the standard tests and how they are conducted, the limits of acceptance and rejection, and the permissible tolerances. In the absence of Egyptian specifications for a specific building material, an agreement is made between the parties through a contract by reference to specific international specifications that are appropriate to the conditions of the building to resort to when judging the validity of these materials [6].

It is worth noting that the testing of materials used in construction before use on a correct laboratory basis and

(Source: Au- proper inspection periodicity does not receive sufficient care in most of the implementation sites, which has the greatest impact behind the phenomenon of defects and collapses in facilities and significantly reduce the life of use Figure (8), Figure (9).



Figure (8): Wrong gravel calibration method using the loader Figure (9): Wrong water calibration method using a bucket (Source: ref. [7]).

The field and laboratory tests on concrete mixtures, whether in the fresh or hardened condition, are absolutely important and must be performed with precision to control the quality of the structural elements, which represent the basic structure of buildings, and the weakness of any part of its parts may lead to serious defects that start with cracks and may end with the complete collapse of the building.



Figure (10): Wrong gravel calibration method

Figure (11): Wrong way to implement concrete manually leads to damage to the steel mesh (Source: ref. [8]).

#### D. Deficiencies in implementation:

A set of Egyptian codes for construction and building works were issued, and the word code is a word that means "law". The codes of practice include the principles of design and implementation conditions that govern the construction process, which if followed, the product would be of a balanced, strong and durable building. Codes of practice always begin with the assurance that the materials used are usable by meeting the requirements of the standards.

As for the reinforced concrete structures, which represent the vast majority of the facilities in the current era, poor implementation is intended to not comply with the provisions of the code, starting with the storage of materials separated from each other and protected in a good manner from the surrounding conditions, as well as the correct calibration of materials, proper mixing and transportation without separating or bleeding, and proper com-

paction. The treatment, the surface finish and the necessary repairs after removing the tension and the limits of the tolerances in each of these items [9].

Also, the shortcomings in implementation may occur as a result of defects in the forms and Wrenches in terms of their balance, strength, dimensions, and the extent of their tightness to prevent leakage of cement paste from them.

Increasing the water of the concrete mix, which is what the majority do for ease of operation or for not adding additives, and consequently the material savings leads to the weakness of concrete and increase its porosity and the occurrence of water leakage from its elements and the subsequent rust of the reinforcement steel.

There are implementation errors that the code states to avoid, such as not using different types of cement or steel with the same structural element, what will result in differences in the emotions generated as a result of stresses and defects will occur in those elements [9].

Non-compliance with what was stated in the drawing , both in terms of foundation levels, the quality of foundations and reinforcement in terms of types, diameters, distribution, formation, lengths, appropriate extension, and good fixing of the skewers, whether longitudinal, sweeping, or cantilevers leads to the appearance of defects in the facilities.

Non-compliance with what was stated in the boards, both in terms of foundation levels, the quality of foundations and reinforcement in terms of types, diameters, distribution, formation, lengths, appropriate extension, and good fixing of the skewers, whether longitudinal, sweeping, or cantilevers leads to the appearance of defects in the building .

#### 2.2.2 Users of the building

It is unfortunate that the majority of government buildings - even those built less than ten years ago - it is very difficult to find any engineering data about them, whether from soil studies (if they were originally conducted) or structural drawings , etc. The works of modifications necessitate carrying out studying the soil, making an architectural and structural elevation of the building, deciding

its condition, the defects in it, the condition of its concrete in terms of its resistance, the content of salts in it, the condition of the steel reinforcement, and a structural review from reality. In the absence of these studies, researches, investigations and tests, the modifications are an adventure and a gamble whose results are not guaranteed and may lead to serious defects in the structure or collapse. [10].

Unthoughtful modifications and change of use without ensuring the tolerance of the soil and the structure and its resistance to the new use and under the newly developed operating conditions has a destructive effect on the safety of the structure and reduces the life of its use, and a full review must be made before allowing this.

### 2.2.3 Unexpected catastrophes

It is customary for unexpected disasters to be summarized in earthquakes, hurricanes, volcanoes, floods, fires and explosions. If the disaster is repeated, it is included in the item of expected events and must be taken into account in the various stages of construction.

If we take earthquakes as an example, their occurrence is expected - the most likely areas of their occurrence and their potential intensity have been identified - and therefore it has been included in the Egyptian codes of practice since 1989 AD how to design taking earthquake loads into account. Considering the October 1992 earthquake, it is necessary to work on two axes, one of which is to put the possibilities of earthquakes in the design of new facilities, and the other axis is to study the means of protecting existing facilities from an upcoming earthquake [10].

Fires are expected in some facilities that contain flammable materials, such as some factories, hotels, cinemas and theaters. At present, a fire protection code is being prepared to include recommendations for certain materials for construction and protection, an architectural design for the facility, and alarms and extinguishing means, etc.

### 2-3 Conclusion:

There is no doubt that the work of quality control, which is the so-called **preventive maintenance**, represents the

cornerstone in the production of strong and solid facilities, and attention and commitment to the clauses of standard specifications in the selection of materials and practice codes in design and implementation will have the greatest impact in this field. And periodic maintenance after the completion of the facility is an integral and essential part to maintain the facilities and extend their life.

Through a comprehensive and careful view of the causes and forms of defects in facilities, and with full knowledge of them, in addition to knowledge of non-destructive tests and how to conduct them on facilities and how to prepare technical reports, it is possible to start forming teams capable of participating in the evaluation of existing facilities in preparation for setting maintenance programs for them.

### 3- Maintenance of educational buildings

Preserving educational buildings and extending their life to serve many generations to come must take a great deal of importance, which dictates dealing with buildings through a scientific and organized method of the maintenance process to ensure the continuation of the functional and constructional efficiency of the building, and to achieve security and safety standards.

Maintenance is a vital and essential process and an integral part of the process of constructing and constructing these buildings. It is a continuous process that starts from the design stage, study the soil, select construction materials and implementation, and continues through an administrative and technical system covering minor maintenance and urgent maintenance in the event of faults and damages, and the main maintenance that is carried out to restore the facility to its safety. Building, restoring the efficiency of its services, protecting it, improving its job performance, and maintaining its general appearance. The buildings for basic, technical and commercial education affiliated with the Ministry of Education include more than 18,000 (eighteen thousand) schools and educational institutions other than educational institutions affiliated with private education and Azhar education, and educa-



tional facilities set by the General Authority for Educational Buildings are limited to no more than twenty-five models [11].

In general, educational buildings can be divided based on the structural condition of the buildings into the following four sections [11]:

#### **A. old buildings:**

They are the buildings that were built before 1950 AD, and a large number of these buildings are of bearing walls and the condition of the buildings is poor except for some of them, which were built in special ways that help them withstand the factors of erosion and heavy use.

#### **B. middle-aged buildings:**

It was built in the period from 1950 to 1975 AD. These buildings are divided into two parts: the first part is in good condition, and the second part is in poor condition or close to that. Most of these buildings are built with the reinforced concrete structure system.

#### **C. new buildings:**

These are the buildings that were built in the period from 1975 AD to 2010. Although the condition of these buildings so far is good, some construction problems are expected in the future due to the use of some building materials that violate specifications during the period of economic openness and the lack of application of quality control and testing elements and clauses.

#### **D. Buildings constructed after the earthquake:**

These buildings were built after October 1992 with a high degree of quality and perfection. It is expected that the maintenance of these buildings will be limited in the coming years due to the good supervision and application of specifications on the technical materials used during implementation.

### **3.1 Maintenance Strategy**

The maintenance strategy is based on several foundations, including [12]:

1. Awareness of the importance of maintenance and the danger of neglecting it.
2. Training those responsible for the application of maintenance systems at their various levels on inspection work and determining the quality of defects, their causes and how to deal with them.
3. Training of sufficient number of technical workers to carry out minor maintenance works.
4. Managing the necessary budgets for maintenance work.
5. Procurement of inspection equipment, tools and equipment for minor repair means of communication and means of transportation for those implementing maintenance systems.
6. To carry out maintenance work on an ongoing basis as well as repair work to prevent the situation from worsening and to preserve the building.
7. Carrying out technical or advisory reports as well as repair work through experts in this field.
8. Sudden inspection of schools with review of maintenance books.

### **3.2 Maintenance systems**

The maintenance systems for educational buildings are divided into [12]:

- **Preventive maintenance.**
- **Continuous simple maintenance.**
- **Urgent maintenance.**
- **Major maintenance.**

#### **3.2.1 Preventive maintenance**

This type of maintenance is intended to work on the production of a structure characterized by strength and durability and to meet the requirements of use from all aspects of construction, architecture and others, by careful study of the soil, design with efficiency and high accuracy, and the selection of materials that conform to the standard specifications and appropriate to the nature of use and the

surrounding climatic conditions, and proper implementation according to technical conditions with Take all safety precautions into account [13].

The protection of educational buildings against the factors that deteriorate them and reduce their life, will not only work to keep these buildings intact and free from defects, but will also work to ensure that the buildings do not need major repairs during their life, and protection works include protecting surfaces, especially concrete against penetration With harmful substances, moisture and sewage leakage, and protection of steel reinforcement against rust [13].

The leakage of water from outside to inside buildings such as basements and final roofs or from inside to any other internal or external elements such as toilets, tanks, wells and manholes causes many problems that are not limited to the external shape of the facilities and what they cause of radiation, salts, staining and distortion of the general view, but it exceeds them to Deterioration in the resistance and durability of elements exposed to moisture, rusting of steel reinforcement, cracks in elements and uneven subsidence of the structure in some cases as a result of changing the condition of the soil under the foundations and increasing the moisture content or its decomposition [13].

Accordingly, one of the most important items of preventive maintenance is to carry out sanitary and insulation works, whether on roofs, primary toilets, or basements to the fullest extent, while performing all protection measures in the correct manner and with the correct materials.

### 3.2.2 Simple and continuous maintenance

The plan for this type of maintenance is to specify a certain amount for each school allocated to spend on these simple works, along with a stock of the needs of this type of maintenance.

This type of maintenance includes the following works:

- Simple plumbing work.
- Simple carpentry work.
- Simple paint works.

- Minor electrical work.
- Some miscellaneous work such as planting gardens or flower beds and others.

#### 2.2.3 Urgent maintenance:

Through the daily inspection of the condition of the building and the apparent complementary works, it may become clear that there are defects that require expertise that exceed the expertise of the responsible teacher or technical worker, which requires informing the school principal with filling out a simplified form (form) to describe the defects, provided that he informs the educational administration and the Directorate of Education in a letter attached with the form And the matter is transferred to the branch of the General Authority for Educational Buildings, which in turn sends one of its specialized engineers to conduct an inspection and determine the nature and causes of defects, methods and materials for repair with an assessment of works, provided that the authority's branch in the governorate assigns the works immediately to one of the annual contractors registered in the branch [13].

**This type of maintenance includes the following works [13]:**

#### A- Plumbing work:

- Changing the drainage / feeding / gas damaged lines.
- Adding new exchange/feeding lines.
- Replace plumbing devices instead of damaged ones.
- Installation/repair of water tanks.
- Establishing a firefighting network.



Figure (12) a, b, c: Poor condition of plumbing devices and bathrooms, which requires maintenance work (Source: ref. [13]).

**B- Electrical Works:**

- Replacing some damaged electrical lines.
- Replacing the damaged and lost electric headlights.
- Replacing circuit breakers with distribution boards.

**C- Carpentry work:**

- Installing damaged or missing doors and windows.

**D-. Metal work:**

- Replacing and repairing damaged school equipment.

**E- Some structural and architectural works repairs.****F-Insulation works for bathroom floors.****G - painting works.****H - Tile works for floors and walls.****3.2.4 Main maintenance:**

Within the framework of the integrated maintenance plan for the General Authority for Educational Buildings, the directors of the Authority's branches in the governorate must make a plan to determine the state of the schools in their current state in all aspects of construction and architecture, and the state of plumbing works, electricity and the rest of the supplementary works and external facilities of the schools. . . Through this, an integrated record is made for the school, and accordingly, a traffic plan and accurate inspections are drawn up for the existing schools in the governorate to inspect their condition and determine their needs for major maintenance work. A preliminary inspection report is prepared by the branch engineer, to be completed by the branch consultant and under his guidance, which is completed by making an accurate assessment of the required work. This is followed by the presentation of major maintenance work by the authority to companies and contractors specialized in carrying out this type of maintenance with distinguished precedents [14].

**a. Sketch of the layout and floor plans of the buildings:**

- A sketch should be prepared with a suitable scale for the general layout of the school, showing the school's

boundaries, surrounding areas, and all internal buildings.

- Drawings are prepared for all plans of the different floors of all school buildings.
- Code numbers are placed in all the spaces to facilitate the work of the maintenance work forms.

**B. Minor maintenance data and follow-up forms:**

A set of forms has been prepared to assist in carrying out the work of those in charge of simple continuous maintenance in a simplified and fast way, through which the volume of work needed for simple maintenance works at the level of each educational building can be determined. These forms include the following:

**1- Periodic Inspection Form for Continuous Simple Maintenance:**

It contains the school's data in terms of name, stage, address, telephone, and inspection date and code number. It also shows the method of inspection followed and the inspector, the required workers, the repairs that have been made, their dates, the person performing them, and their cost in terms of tasks and employment. This form also includes serious defects that require reporting to the administration education to take positive steps towards it [15].

- **Continuous simple maintenance work form for plumbing work.**
- **Continuous simple maintenance work form for carpentry work.**
- **Continuous simple maintenance work form for electrical work.**
- **Continuous simple maintenance work form for paint work.**

**2- Daily form periodic inspection for simple continuous maintenance:**

It is a daily follow-up form for the different spaces and types of maintenance required, as well as the date of repair, the actual cost, the name of the technician performing the repair and any notes that are mentioned.

**3- Annual registration form for minor maintenance works:**

It is a form that summarizes the works that have been carried out in terms of plumbing, carpentry, electricity, paints and floors for the various spaces of the building, and the data is recorded in it every month separately throughout the year.

**C. Data form and follow-up urgent maintenance work:**

Two basic forms have been prepared for urgent maintenance work, a report will be written by the engineer of the educational buildings branch in the governorate, the required work is recorded from two basic forms, as follows:

**1- The first form:**

It includes the sanitary works that may have defects, such as drain lines, feeding lines, gas lines, water tanks, sanitary equipment, water tanks, fire networks and any other elements, with an accurate description of the type of work and the code number of the space that this work will occupy.

**2- The second form:**

It includes electrical works such as replacing damaged power lines and replacing circuit breakers with distribution boards and any other work, with an indication also of the code number of the space in which this work will be carried out. It also includes carpentry and metal works such as installing doors or windows, replacing or repairing school equipment, and any work with the data of the code number of the space in which this work will be carried out.

**3- Engineering and technical record for educational buildings:**

The engineering and technical record for educational buildings must include an integrated copy of all construction and architectural drawings, sanitary and electrical works, gas network, general location, and survey reports that have actually been carried out by nature, A record of the various maintenance works on its three axes, whether continuous, urgent or major, must be prepared, which is a record of the building’s life so that it can be preserved in its best form and in its strongest strength and durability

over the coming long years [15].

**4- Qualification of workers in the field of maintenance:**

Training the teacher responsible for the activity group, as well as the technician, on simple works such as plumbing, carpentry, painting and electrical work, while providing them with the simple expertise needed for these works.

Also, the engineers of the Educational Buildings Authority branches must be trained on how to prepare an integrated technical report that includes an accurate recording of the defects’ forms and the results of the discussions on the date and conditions of the occurrence of defects in the building under study and the required documents.

Non-destructive testing and reviews and good knowledge of different repair materials and methods. On top of all this, how to determine the severity of the case under study, the necessary precautions, and the speed of reporting to the responsible authorities.

As a result of the importance of the contractor's annual role in the quality of work completion, training and introducing all that is modern in methods and materials for maintenance and minor repairs to these contractors may extend [16].

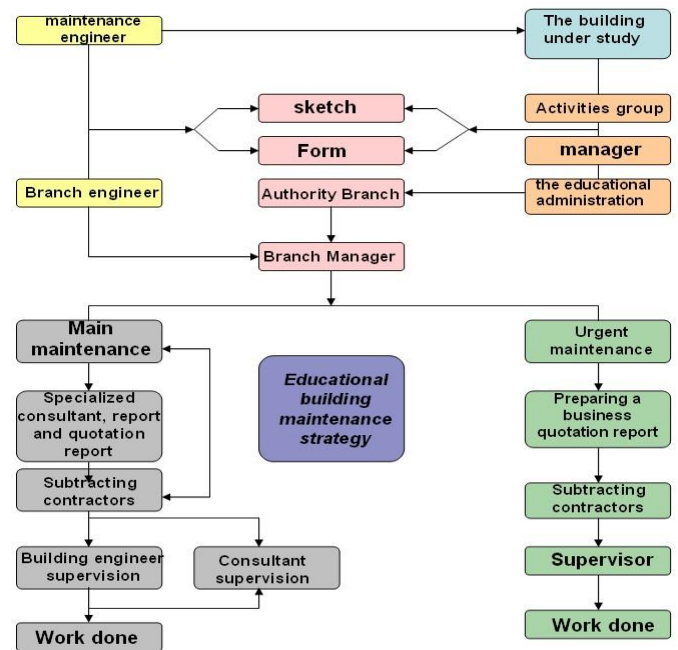


Figure (13): A diagram showing the steps of the proposed strategy for the maintenance of educational buildings (Source: Author).



Figure (14) a,b: The front facade of Bahtem Secondary School for Girls (Source: Author).

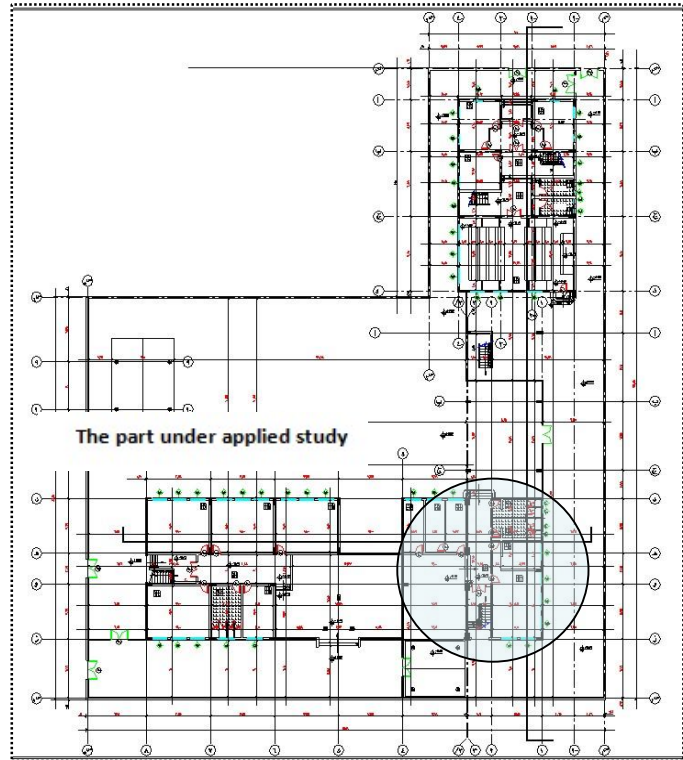


Figure (15) : ground floor plan of the school showing the part of applied (Source: Author).

#### 4- Applied study

##### (case study Maintenance and restoration project of Bahtem Secondary School for Girls).

Bahtem Secondary School for Girls was chosen as a model for one of the educational buildings affiliated with the Educational Buildings Authority to implement the proposed maintenance strategy deduced from the theoretical study, Where a set of evaluation forms for the simple and urgent maintenance strategy was designed and applied to the applied model, which are forms designed by the a with the aim of identifying shortcomings and making recommendations in order to develop and rehabilitate the school as one of the applied models for educational buildings **figure (14) & figure (15)**.

Through the initial examination of the school, it was found that there was a crack in the front facade as a result of poor studies conducted on the soil of the foundation,

Which resulted in an uneven landing of the building, which led to the crack in the front elevation **figure (16) & figure (17)**.

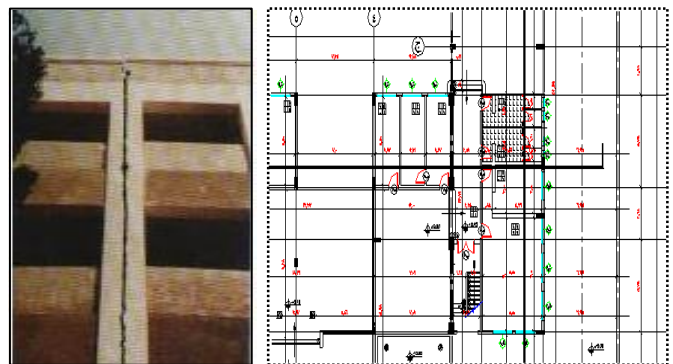


Figure (16): Crack in the front façade of Bahtem School **Figure (17):** plan showing the part of the maintenance application and the location of the apparent crack on the facade (Source: Author).

Through the application of maintenance forms designed for the applied study to monitor the damages and short

comings of the school under study with the aim of developing and rehabilitating it, and from the results of the visual examination, It was observed that there were cracks in the concrete slabs, the appearance of reinforcing steel, the presence of a layer of rust covering from the bottom, and the concrete falling from the beams and the appearance of the reinforcing steel **figure (18)**.



**Figure (18) a,b,c,d** : From the results of the visual examination of the defects of the school, we note the presence of cracks in the concrete slabs, columns and beams (**Source: Author**).

The concrete slabs were treated by removing the concrete from the bottom of the reinforcing steel and removing the rust from the attic, then covering it with a layer of concrete with a concrete spray gun **figure (19)**. In some slabs, the reinforcing steel was increased by adding a bottom steel meshes **figure (20)**, and by conducting tests on some columns with cracks, it was found that the reinforcing steel is irregular Distribution shirts were made for these columns, and the beams were treated by increasing

The reinforcing steel at the shear areas in the camera through the presence of an external iron shirt surrounded by concrete. **Figure (21), figure (22)**.



**Figure (19) a, b**: covering the slab with a layer of concrete with a concrete spray gun **Figure (20) a, b**: adding a bottom steel meshes to the slab & the Concrete slab after maintenance and rehabilitation (**Source: Author**).

Work steps to add steel strips to reinforce the concrete slabs in order to maintain and rehabilitate the old slabs:

- 1- Roughing the surface.
- 2- Install screws.
- 3- Apply adhesive mortar.
- 4- Laying steel strips.
- 5- Fixing the slides with additional screws with adhesive.
- 6- Paint steel to prevent rust.

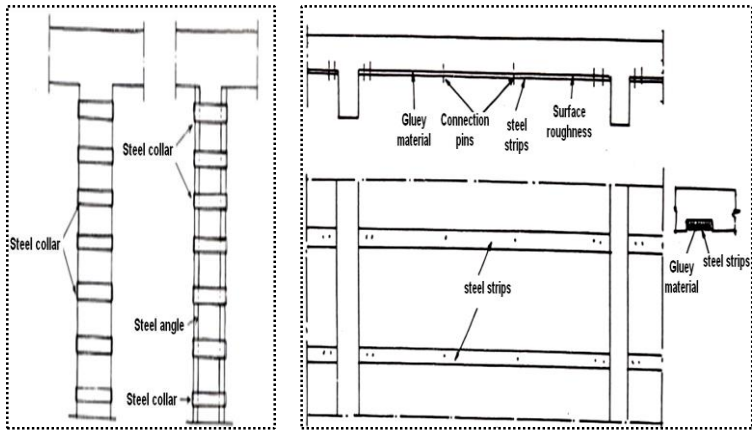


Figure (21): sketch showing the steps for supporting concrete columns using Steel collar  
 Figure (22): sketch showing the steps for supporting reinforcing concrete slabs using Steel Strips (Source: Author).

Work steps to add steel bars to reinforce the concrete beams in order to maintain and rehabilitate the old beams: **(Increasing depth and adding new steel)**

- 1- Roughing the surface of the longitudinal beam.
- 2- Installing Steel bars at the beginning of the beam.
- 3- Add new Steel bars and install them.
- 4- Installing the new cross steel stirrups.
- 5- Paint the steel bars.
- 6- Paint the old concrete surface with materials that help in cohesion.
- 7- Pouring new concrete with a concrete pump gun.

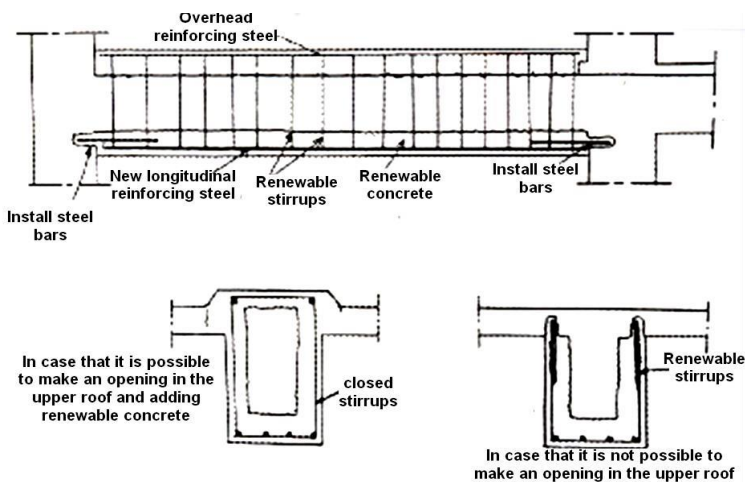


Figure (23): Sketch showing the steps for supporting Reinforcing Concrete beams using renewable Steel (Source: Author).

By visual inspection of the bathrooms, it was found that they are in bad condition, as it was found that the drainage

and supply network had defects that led to water leakage, which resulted in blooming on the outside elevation, and by conducting a white smoke test, it was found that there was a leak in the pipes, so a complete replacement was made for the bathrooms and the drainage and supply lines **Figure (24).**



Figure (24) a, b, c, D: Visual inspection and the application of maintenance checkups proved the poor condition of the bathrooms, which required the complete replacement and change of the bathrooms (Source: Author).

The walls with cracks were treated by replacing those walls by demolishing them and rebuilding them, or by stapling them with steel stirrups, and then they were plastered and painted **Figure (25).**

A replacement was made for all electrical work inside the school, as well as carpentry work. The school was repainted and a replacement was made for the internal tiling of the school. The school became subject to periodic maintenance of the Educational Buildings Institution, and a file was created for it in the Institution **Figure (26).**

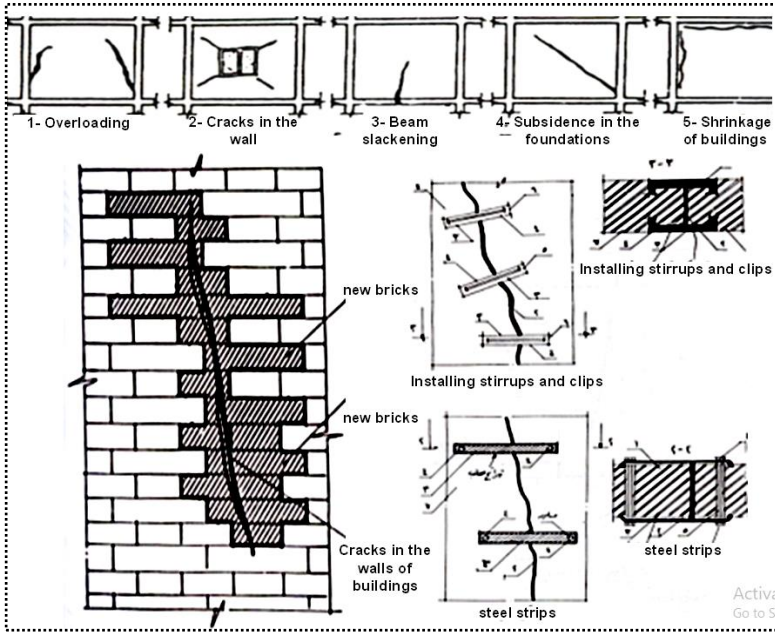


Figure (25): Different ways to treat cracks in the walls of educational buildings (Source: Author).



Figure (26): External perspective of the school after the process of maintenance, development and rehabilitation (Source: Author).

### 5- Results

5-1 The study concluded the importance of preventive maintenance work, which is quality control in the pre-construction stages of studies of the site, soil, good architectural and structural design, and during construction of quality control work in implementation, starting from ensuring the quality of

materials and their conformity to the limits of standard specifications, and passing through the various implementation items according to the requirements of specialized practice codes. For all works, including the concrete structure, buildings, sanitary works, paints, insulation, electrical works, tiling, carpentry, and others. The study also showed the importance of performing simple, urgent, and major continuous maintenance works when needed. The study also concluded with the design of some maintenance forms for lifting and monitoring work for the various implemented items to apply the integrated maintenance strategy to the building, whether simple continuous maintenance or scheduled or programmed annual or monthly maintenance (urgent or when needed) to ensure the preservation of the school building during the operation phase.

5-2 The study also showed the importance of qualifying workers specialized in various maintenance works, whether they carry out inspection and evaluation work or guidance at different levels of workers, technicians and engineers, through specialized training courses in various business items such as plumbing, carpentry, electricity and others. Recommending to officials the preparation of an operation and maintenance department within the school, along with holding training courses and technical lectures to train the various elements within the school on the concept of continuous simple maintenance and programmed annual maintenance.

5-3 The study summarized that the most common reasons behind the emergence of defects in facilities may be due to deficiencies in the study



of the soil, deficiencies in design and protection, materials, or implementation. This may also be due to misuse or heightening and unconsidered changes or maintenance. The study also showed that unexpected disasters may be behind the appearance of defects in facilities, including earthquakes, floods, fires, explosions and hurricanes. The study included a summary of the forms of defects in the various structural elements and buildings with Reinforcement with realistic images of cases studied from multiple buildings. Various types of maintenance were reviewed, which included preventive maintenance, simple periodic maintenance, urgent maintenance, and major maintenance. A proposal was made for administrative and executive steps to carry out these maintenance and their requirements of workers and tools, with the preparation of simplified forms for the completion of these works. And report and record it for your reference.

5-4 The study included a simplified explanation of the non-destructive test devices, how to determine the safety of the different works, and then a review of the areas and limits of using the different devices and the precautions required when using them, in an easy way, with simple sketches and pictures of commonly used devices. The set of repair and strengthening methods for the various structural elements such as slabs, beams, columns and foundations, as well as buildings, has been summarized with a simplified explanation of the repair steps to be a guide for engineers. The study concluded that the integrated technical report for a building should contain a detailed description of the building and the surrounding area, an accurate recording of apparent defects, directed discussions with users and builders if possible, and access to building documents such as architectural and construction

drawings, sanitary works, etc., including any reports. A precedent for the condition of the building, as well as, the results of tests directed according to the requirements of the study, whether from confirmatory tests for the soil if necessary, or disclosures about the condition of reinforcing steel or concrete, its chemical analysis and resistance, or load tests for the elements, and reference must be made to the limits stipulated in the standard specifications and codes of practice to determine the extent matching.

5-5 The study concluded the factors leading to the emergence of defects and problems in educational facilities ( school building ), which requires the conduct of different types of maintenance:

1. Not studying the project well.
2. The lack of sufficient information about the site before implementation leads to the occurrence of many defects and problems in the structure.
3. Failure to study the circumstances surrounding the building, as well as the nature of its use and the extent to which it is exposed to harsh climates and other things.
4. Inaccuracy in conducting soil surveys and knowing its type.
5. Non-conformity of the properties of the materials used to the limits stipulated in the standard specifications.
6. Poor implementation leads to defects in the building.
  - Defects related to efficiency such as cracking.
  - Defects related to the security of the building and threaten to collapse.
7. Errors in design, selection of the structural system, and basic assumptions.
8. The use of different types of cement or steel is prohibited by the Egyptian code.
9. Unconsidered modifications and change of use without making sure that the soil and the foundation will

bear it and its resistance to the new use will have a destructive effect on the safety of the foundation and reduce its life of use.

10. Lack of periodic maintenance after the completion of the building.
11. Failure to train those responsible for applying maintenance systems at different levels.
12. Not to carry out technical or advisory reports through experts in this field.
13. Negligence in all maintenance and protection procedures with the correct method and materials, especially sanitary and insulation works.
14. Negligence in the daily inspection of the condition of the building and the apparent complementary works.
15. Lack of training and introduction of all that is modern in the methods and materials of maintenance and minor repairs.
16. Failure to address problems and damages in the building immediately upon discovery.

## 6- Recommendations

The research study recommended the following:

- 6-1 The necessity of determining an appropriate budget for building maintenance works that are considered an integral part of the construction costs.
- 6-2 The need to pay attention to the training of specialists and different levels of workers, technicians and engineers on simple maintenance work and the process of inspection, registration and reporting of defects.
- 6-3 The necessity to carry out simple maintenance work on an ongoing basis, with the recording of these works, as well as urgent and major maintenance works in the building records.
- 6-4 preparing complete files in schools and a copy of them in the branches of the Educational Buildings Authority, with all the engineering documents related to the school buildings.
- 6-5 unannounced inspection to ensure the implementation of various maintenance works with the need to

apply the principle of reward and punishment to ensure the continuity and seriousness of maintenance work.

- 6-6 Constant awareness of the importance of maintenance and building preservation.
- 6-7 Creating a strategic plan to cover all educational buildings in all governorates, through inspection and making integrated engineering files for them, determining their condition and the maintenance work they need.
- 6-8 Compilation of all inspections annually at the level of each governorate and make a statistical study to determine the reasons behind the emergence of defects and the most common ones to determine how to overcome them.
- 6-9 Carrying out a statistical study to determine the actual cost of various maintenance works at the level of different schools in the governorates in order to reach the actual cost and the supplies that must be available to carry out maintenance work.

## References

### Arabic references:

- ( 1 ) - حبيب زين العابدين ، "الحكم على سلامة المنشآت الخرسانية " طبع بشركة العبيكان للطباعة والنشر ، المملكة العربية السعودية ، عام 2002 م .
- ( 2 ) - شريف أبو المجد- منير كمال " ، تصدع المنشآت وطرق إصلاحها ، " دار الوفاء للطباعة والنشر ، القاهرة ، الطبعة الثانية ، عام 2008 م .
- ( 3 ) - الكتيبات الفنية لشركة كيماويات البناء الحديثة ، 2010 م ، القاهرة .
- ( 4 ) - الكود المصرى لأسس تقييم وشروط التنفيذ لهندسة التركيبات الصحية ، قرار السيد وزير الإسكان رقم 289 لسنة 1992 م ، الطبعة الثانية ، عام 2015 م .
- ( 5 ) - عمرو سلامة – شادية نجا " ، أعمال الصيانة وبرامج الوقاية ، " القاهرة ، الطبعة الأولى 2018 م .
- ( 6 ) – الزيارة الميدانية ، ( عام 2021 : عام 2022 م ) الإدارة الهندسية والدعم الفنى ، إدارة شبرا الخيمة التعليمية ، محافظة القليوبية ، مدرسة بهتم الثانوية للبنات .
- ( 7 ) - وزارة التربية والتعليم ، الهيئة العامة للأبنية التعليمية ، الشروط والمعايير التصميمية لمدارس التعليم الأساسى ، الإدارة الهندسية ، عام 2022 م .

### English references:

- [8]- DE Vekay, R.C., Majumdar, A.J., "Durability of cement pastes modified by polymer dispersions" RILEM. July – August. 2000.
- [9]- Ohama, Y., "Comparison of properties with various

polymer – modified mortars”. International RILEM symposium” Experimental research on new developments brought by synthetic resins to building techniques Paris, September, 2004.

[10]- Dutron, P., and Collet Y.: “Etude des proprietes physiques at techniques des mortars de cement rezone”. International RILEM symposium “improvement of concrete and mortars by adding resins”, RILEM May – June 2006.

[11]- Cherkinsky, Ju. S., “Practice and Theory of polymer concrete”. International RILEM symposium” experimental research on new developments brought by synthetic resis to building techniques”, pairs, September, 2011.



[12]- Desov, A.E., “The Effect of polyvinyl acetate emulsion and symhctic rubber latex on the strength and durability of mortars”. International RILEM symposium “Experimental research on new developments brought by synthetic resins to building techniques”, pairs, September, 2015.

[13]- Wagner, H., “Properties of cement mortars modified by polymer emulsions”, ACI., June, 2016

[14]- Schulze, W., lange, H..“The effect of bitumen emulsion and synthetic resin additives on the behavior” , London , 2018 .

[15]- Arredondo, F., Fontan, J., Fedoz, M., Madruga, J. : “Polymerized concrete” VII international congress of the precast coerct industry, BIBM. 2020.

[16]- ACI Committee 503, “Standard Specification for repairing concrete with Epoxy Mortars” ACI 503.4-79, American concrete institute, Detroit, 2020.

Evaluation of maintenance work at Bahtim Secondary School for Girls (a model of a secondary school building)										
Maintenance type		Simple maintenance	annual maintenance	Development and rehabilitation	demolition and removal					
Date of construction	1985	School before maintenance work		School after maintenance work						
Date of development	2020 - 2022									
Design and supervision	Armed Forces Engineering council									
capacity	40 educational classes									
Maintenance work included	Development and strengthening of the concrete structure Wall stapling and repair work Complete bathroom replacement work Complete electromechanical replacement work Complete replacement work for interior finishes									
Concrete structure maintenance	development work for the school structure	development work		v. weak	weak	medium	good	V.good	excellent	
		supporting concrete columns using Steel collar								
		supporting reinforcing concrete slabs using Steel Strips								
		supporting reinforcing Concrete beams using renewable steel								
		covering the slab with a layer of concrete with a concrete spray gun								
		adding a bottom steel meshes to the slab								
Maintenance of internal and external walls	development work for the internal and external walls	The walls with cracks were treated by replacing those walls by demolishing them and rebuilding them, or by stapling them with steel strips, and then they Were plastered and painted								
		The walls of the external fence were replaced and rebuilt, while the school's external walls were reinforced with metal structures, with a complete replacement of the external paint and the use of graffiti to paint the external facades to protect against weather factors								
Maintenance of internal finishing materials	development work of finishing materials	The interior walls of the classrooms were re-plastered and repainted with plastic paints								
		The walls of the external corridors were painted using cement paints that resist dust and weather factors								
		The activity halls were painted using plastic paints with wooden cladding for the walls								
		Music, drawing and games hall: Plastic paints with sound-absorbing resins were used								
Develop the electro-mechanic systems	development work of electro-mechanic systems	As for the entrance hall of the school, integrated units of marble were installed								
		Developing lighting systems (Complete replacement of all power cables)								
		Development of acoustics systems and fire lighting system								
School bathroom maintenance	development work of school bathroom maintenance	Relying on the installation of separate energy-saving air conditioning systems								
		Complete replacement of drainage pipes, in addition to hot and cold water supply inside the bathrooms								
		Complete replacement and reinstallation of ceramic tiles for all school bathrooms								
Complete replacement of all sanitary equipment in school bathrooms										
Development and maintenance work of Bahtim Secondary School for Girls										