Journal of Applied Sciences Research, 6(12): 2074-2080, 2010

Developing an Expert System to Prioritize Monument Restoration

[1]Ahmed K. Abdel Gawad, [2]Walid Attia, [3]Mahmoud El-Rayes

[1]Associate prof, Civil. Eng. Dept., National Research Center, Egypt.
[2]Associate prof., Structural Eng. Dept., Faculty of Eng, Cairo Univ., Egypt.
[3]Research assistant, National Research Center, Egypt.

Abstract: Nowadays, developing countries cannot assign the resources to remedy all its ancient structures at one stage, so they must set priorities and devise selecting methodologies for which construction will receive attention before the others. This is a very complicated operation which depends not only on the defects of the construction and its safety but also the historical value, sociological factors, and economic effects. An expert system is introduced to handle the prioritizing process. The expert system duties are divided into handling two major branches. The first is assessing the construction safety, and the second branch contains the evaluation of cultural importance of the construction. The assessing of the construction safety is done by visual inspection as an easy, fast and non-expensive first stage. According to its results, it is decided wither there is a need to perform the second stage of the system, which is structural analysis and materials testing, being a stage that consumes resources such as money, time, and qualified persons. The second branch contains the evaluation of cultural importance, being descriptive factors and difficult to measure, was handled with a combination of analytical hierarchy process and scoring method. The output of the system is developed after integrating the previous two branches in the form of two lists. One for the constructions that require immediate interference (based on the structural assessment), and the other is for the structures that require interferences to remedy defects that do not threaten the safety of the structure in the short term. In both lists the constructions are arranged descending according to their cultural score

Key words: Monument, assessment, restoration, evaluation, cultural

INTRODUCTION

From early times, man has attached importance to particular places or buildings; sometimes this importance was due to religious association, their intrinsic beauty or in other cases it was their association with historic events. Such importance was accompanied with the will to preserve them, in some cases this preservation occurs ,in other cases it doesn't, leaving shrines, communities and even empires disappeared and forgotten until their remains were found and excavated by archaeologists, other cases were completely destroyed and lost[1].

However much as one might like to, there could be no question of saving all the structures of the past. New requirements, more growth and change, condemn and discard much of the past. Items which would merit saving under ordinary circumstances are condemned because of the greater economic or social claims or importance of what replaces them[2].

The loss aesthetic or historical may be minimized without increasing the budgets and the efforts; by noticing that parts of that heritage possess exceptional qualities, can be considered to be of outstanding universal value and as such worthy of special protection against the dangers which increasingly threaten them.

The decision can be extremely difficult. At times, sites and monuments are sacrificed despite their importance because of the magnitude of the task or of the budget required to save them. In too many parts of the world people realize what they have lost only after the slow almost unnoticed disappearance of one structure after another, until finally hardly any survive[3,4].

The danger is frequently accompanied with the lack of any planned, coherent program, or at least short term, one angled program. Such programs concentrate on one attribute for the present –it could be the wealth, the welfare or the productivity of a certain people in certain time– make sacrifices of other attributes, like the environmental and the heritage safety, that affect the future generations, and despise the gifts from the past ones, therefore the planning that is based on the multidisciplinary efforts is essential.

Corresponding Author: Ahmed K. Abdel Gawad, Associate prof, Civil. Eng. Dept., National Research Center, Egypt.

2. The Structural Integrety Evaluation: The analysis of ancient constructions poses important challenges because of the complexity of their geometry, the variability of the properties of traditional materials, the different building techniques, the absence of knowledge on the existing damage from the actions which affected the constructions throughout their life, and the lack of codes. In addition, restrictions in the inspection and the removal of specimens in buildings of historical value, as well as the high costs involved in inspection and diagnosis, often result in limited information about the internal constructive system or the properties of existing materials[5].

Nevertheless, significant advances occurred in the last decade concerning the development of adequate tools for the numerical analyses of historical structures and international recommendations have been recently made available[6].

These recommendations are intended to be useful to all those involved in conservation and restoration problems of structures, and contain basic concepts of conservation, together with the rules and methodology that a designer should follow[5,7,8].

The application of the techniques of modern structural analysis to the study of historical monuments has contributed significantly, particularly over the past decade, both to the architectural–historical methodology and to the art of building restoration. [Tulay Aksu Ozkul], More comprehensive information on techniques and specific knowledge can be found, e.g. [Adel Abdel Mohsen; Khalil Ibrahim; and Robert G.Drysdale]. But structures of architectural heritage, by their very nature and history (material and assembly), present significant challenges in conservation, diagnosis, analysis, monitoring and strengthening. These aspects call for qualified analysts that combine advanced knowledge in the area and engineering reasoning, as well as a careful, humble and time-consuming approach[9].

The Visual Inspection: This still is the cheapest and often also the most efficient, non-destructive test method. However, unless this is carried out in an organized and comprehensive manner, much information may be missed, difficult to interpret, or lost through lack of a proper recording and reference system. The human mind has the capacity to simultaneously consider only a limited number of factors. Therefore, checklists or other aids may be helpful to ensure getting the full benefit from the visual examination. Signs of distress, deterioration, and unsatisfactory performance should be searched for and any indication of construction that differs from the plans should be noted. Also, any prior repairs should be documented. The Compressive stresses close to the capacity of the materials can cause vertical cracks as the first sign of damage eventually leading to large lateral deformations, spalling, etc. In-plane lateral loads can cause diagonal cracks or sliding. Out-of-plane or eccentric loads may cause separation of the leaves in a multi-leaf wall or rotation of an entire wall about its base. Where the latter occurs, horizontal cracks at the base might be seen before overturning occurs. Following are typical indicators of problems or potential problems. This step guides the next steps i.e. tests and analysis.

The Tests: The schedule of tests should be based on a clear preliminary view of which phenomena are the most important to understand. Tests usually aim to identify the mechanical (strength, deformability, etc.), physical (porosity, etc.) and chemical (composition, etc.) characteristics of the materials, the stresses and deformations of the structure and the presence of any discontinuities within the structure. As a rule, non-destructive tests should be preferred to those that involve any alterations to a structure. The program stores the results of the performed tests in its database.

The Analysis: The structural behavior depends on the characteristics of the materials, the dimensions of the structure, the connections between different elements, the soil conditions, etc. The real behavior of a building is usually too complex to fully model so that we are obliged to represent it with a simplified 'structural scheme', i.e. an idealization of the building which shows, to the required degree of precision, how it resists the various actions, and shows how the building transforms actions into stresses and ensures stability.

A building may be represented by different schemes with different complexity and different degrees of approximation to reality.

The original structural scheme may have changed as a result of to damage (cracks, etc.), reinforcements, or other modifications of the building. The scheme used in the structural analysis is usually a compromise between one close to reality but too complex for calculation and one easy to calculate but too far from the reality of the building.

The scheme used has to take into account any alterations and weakening, such as cracks, disconnections, crushing, leanings, etc., whose effect may significantly influence the structural behavior.

3. The Cultural Evaluation: The main objective of this part is to determine whether a certain monument is more valuable than another or not. Although the main idea is that all monuments are valuable, one must admit that there are certain monuments that possess an exceptional cultural value, for example the pyramids or the citadel, that encompass other monuments, and by

admitting that they are not of the same importance the next logical conclusion is that there is an order of importance for the monuments. This importance is vital to the main goal of the program, in some extreme cases where the limitation of resources (time, money, manpower…) forces the decision maker to set priorities.

Cultural significance is a concept which helps in estimating the value of places. The places that are likely to be of significance are those which help an understanding of the past or enrich the present, and which will be of value to future generations.

Cultural significance means aesthetic, historic, scientific, social or spiritual value for past, present or future generations

The Methodology: By the definition of the cultural significance , it can be noticed that the attributes are the same around the world, the importance and the weight of each attribute on the other side changes from country to another and from time to time

The definition of the attributes were searched and found in more than a published document by the UNESCO and the ICOMOS[14-16].

The attributes were categorized in three main branches, socially related, economically related and pure culturally and each branch was divided as shown in figure (1).

The calibration of each attribute was done by asking Egyptian personnel with the experience with the monuments, and monument restoration to give each attribute its importance in the process of cultural evaluation, done by a questionnaire, but the attributes that synthesize the importance of a construction are numerous, most of them are qualitative, and some of them are more influential in determining the importance than the others.

The Analytic Hierarchy Process technique was chosen for manipulating the data. The Analytic Hierarchy Process (AHP) is a powerful and flexible decision making process to help people set priorities and make the best decision when both qualitative and quantitative aspects of a decision need to be considered. By reducing complex decisions to a series of one-on-one comparisons, then synthesizing the results, AHP not only helps decision makers arrive at the best decision, but also provides a clear rationale that it is the best.

The Questionnaire: Asking the experts to compare between the importance of the factors was done using a questionnaire, first it was done using paper sheet, but it was found long and distracting. So it was done by using a small computer program ,using Visual Basic, reducing the effort required from the experts to clicking on the right choices, also grouping each group in a single window helped reducing distraction, See Figure (2)

The questionnaire showed that the most important factors are the historic value and the ability to use the monument in cultural tourism (around 40%), then the authenticity and the architectural relevance (around 25%) while the other ten factors took the rest (35%)

4. The Program Description: The sequence of the process of judgment was intended to mimic the human behavior not only in the final decision making but also in comparing and prioritizing matters, see figure (3)

The program handles each monument separately, the data required to achieve a successful, and explainable decision of conservation can be divided into two main categories, in each category these data is processed to reach certain information. The first category of information is the structural evaluation, and the second one is the cultural significance evaluation. See figure (4).

After completing the data for each monument, the program handles all of them and set the priorities of the restoration according to their cultural significance and the urgency of their structural condition.

The program components can be summarized in four steps as in table 1, first assessing the cultural significance, then Preliminary structural evaluation and the Structural analysis, and finally the prioritizing of the restoration process.

5. Application: The following example shows the procedure that the program takes to reach the decision of monument restoration priorities.

The monuments are:

1- Mosque (mehrab) of Amr Ben Elas(monument numbering Egyptian record 319).
2- Mosque of Mohamed Ali ElKabir(monument number 503).
3- Kasr Bashtak(monument number 34).
4- Bayt ElSehemy(monument number 339).
5- School and mosque of Barqoq(monument number 187).
6- Hamam of Soltan Moaed(monument number 410).

6. Conclusion: Developing countries cannot assign the resources to remedy all its ancient structures at one stage, so they must set priorities and devise selecting methodologies for which construction will receive attention before the others. This is a very complicated operation which depends not only on the defects of the construction and its safety but also the historical value, sociological factors, and economic effects. The need for a system that can perform the task of prioritizing considering all this factors and without wasting a lot of

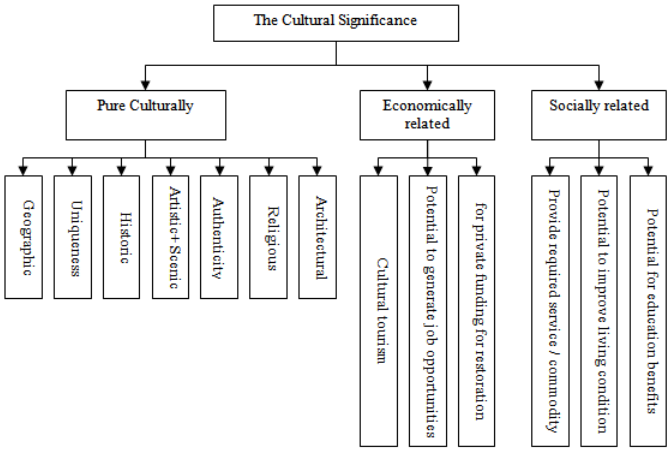

Fig. 1: Factors of the cultural significance

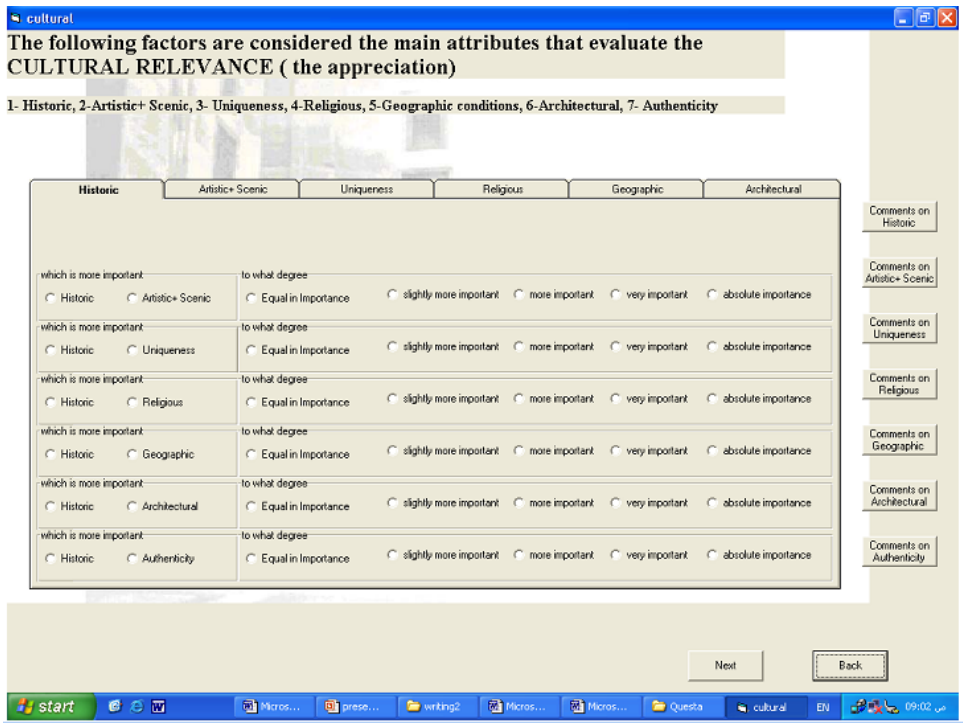

Fig. 2: The Questionnaire

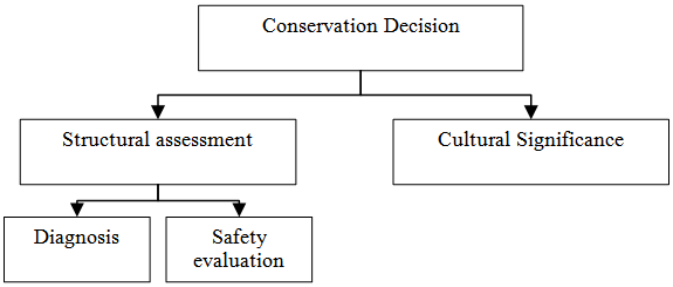

Fig. 3: Hierarchy of the conservation decision

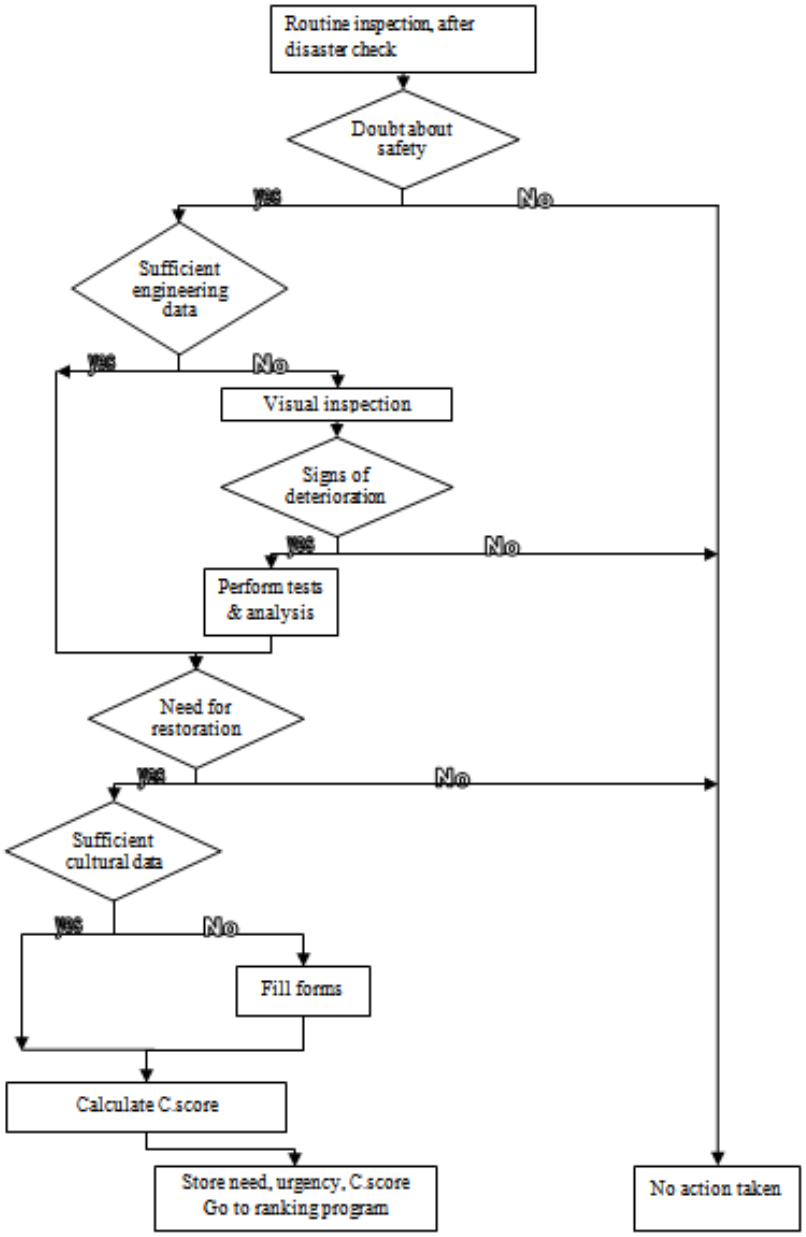

Fig. 4: Steps of determining the need for intervention

Table 1: The components of the program

	Input	The intended user	Process	Output
Assessing cultural significance	Score of the predefined factors	The monument Inspector	Multiply by the relative weight	The total score for the monument
Preliminary structural evaluation	The defects of each member of the structure	The monument Inspector	Compare to database of defects	Recommend action (do nothing, monitor, proceed to next level)
Structural analysis	Test results, members geometry	Engineer	Simple Structural analysis	Determine wither it is safe or not
Prioritize	All the above	High managerial personnel	Arrange the monuments according to 1st ,2nd and 3rd steps	The priorities of the restoration

First step: structural evaluation for each monument.
The results were defined as shown in the following table.

	Name	Need for intervention	urgency
1	Mosque(mehrab) of Amr Ben Elas	Yes	No
2	Mosque of Mohamed Ali ElKabir	No	No
3	Kasr Bashtak	Yes	No
4	Bayt ElSehemy	No	No
5	School and mosque of Barqoq	Yes	No
6	Hamam of Soltan Moaed	yes	Yes

Second step: cultural evaluation
Filling the forms gives the following result as shown in the next table

	Name	Pure Culturally	Total cultural evaluation
1	Mosque(mehrab) of Amr Ben Elas	37.7309	73.9109
2	Mosque of Mohamed Ali ElKabir	35.89766	71.77766
3	Kasr Bashtak	19.8943	45.8743
4	Bayt ElSehemy	29.9187	60.1487
5	School and mosque of Barqoq	24.08529	44.37529
6	Hamam of Soltan Moaed	13.6428	24.9328

Third step: deciding the actions, and setting priorities of restoration
The results are shown in the following table

	Name	action	priority
1	Mosque(mehrab) of Amr Ben Elas	restore	2
2	Mosque of Mohamed Ali ElKabir	Do nothing	-
3	Kasr Bashtak	Restore	3
4	Bayt ElSehemy	Do nothing	-
5	School and mosque of Barqoq	Restore	4
6	Hamam of Soltan Moaed	Temporary strengthen	1

- The monument number 6 will take the first priority because the structural evaluation showed that it needed urgent intervention, but because it has low cultural evaluation the intervention will not be restoration it will be temporary strengthen.
- The monuments number 2 and 4 will not require restoration
- The monuments number 1, 3 and5 require restoration and their arrangement based on the cultural evaluation is as shown.

time is crucial, and developing a computer algorithm to perform this task will help preserving the monuments in crisis times as well as in the normal circumstances.

The suitability of expert systems in restoration of historical buildings is undeniable because the process of restoration has a large number of parameters and data, moreover each project of restoration has unlike manufacturing, construction is non-repetitive, each project being different in design, layout, materials used, construction methods, time, crews, weather, and management. Ready algorithmic solutions are therefore not applicable to the day-to-day construction problems. Adding the social, cultural and economical factors to the engineering point of view gives a more broaden perspective and more reasonable decisions. As shown in the discussed expert system, it helps the user to arrange the list of monuments into two main categories, the ones that need urgent interference and the ones that need it in low importance or don't. Each category is arranged ascendingly according to their cultural significance. This arrangement is the list of priorities.

REFERENCES

1. Hiroshi Daifuku , 1968, " Monument Conservation Programs in Preserving and restoring monuments and historic building", Museums and Monuments, X, UNESCO ,Paris, France.

2. Mahmoud ElRayes, 2006, "Establishing an expert system to encode the restoration priorities of monuments ", M.Sc. Thesis, faculty of Engineering, Cairo University, Cairo, Egypt.
3. ICOMOS, 1988, “Australia ICOMOS Guidelines to the burra charter Conservation policy”,http://icomos.org/ Australia/ Conservation.Html.
4. ICOMOS, 1988, “Australia ICOMOS Guidelines to the burra charter cultural significance ”,http://icomos.org/ Australia/ cultural significance.Html.
5. P.B. Lourenc, 2005, " Assessment, diagnosis and strengthening of Outeiro Church, Portugal", construction and building materials journal.
6. ICOMOS, 2001 “Recommendations for the analysis, conservation and structural restoration of architectural heritage”.
7. J. Antonion, Stephano Bianca, 1980, “The Conservation of Old City of Cairo”. United Nations Educational, Scientific and Cultural Organization (UNESCO),
8. E. d'Errico , 1997, "Conservation of Historic Monuments in the old city of Cairo: Specific Remedial Measures where Necessary". United Nations Educational, Scientific and Cultural Organization (UNESCO) , Paris, France.
9. Tulay Aksu Ozkul, 2006, "Structural characteristics of Hagia Sophia: I—A finite element formulation for static analysis", Building and nvironment Journal.
10. Adel Abdel Mohsen , 2003, "An expert system for the restoration of infra-structure of historical buildings ", M.Sc. Thesis, faculty of Engineering, Cairo University, Egypt.
11. Khalil Ibrahim, 1997, "structural design of mosques", scientific book house.
12. Robert G.Drysdale and Ahmed A. Hamid, 1990, “Masonry Structures Behavior and Design”. The masonry society ,Colorado, U.S.A.
13. ICOMOS, 2007, “Principles For the Recording of Monuments, Groups of Buildings and Sites” http://icomos.org/recording.Html.
14. Australia ICOMOS Guidelines to the burra charter Conservation policy”,http://icomos.org/ Australia/ Conservation.Html,1988.
15. S. Del Saz Sal, 2004," Valuing cultural heritage: the social benefits of restoring and old Arab tower", journal of cultural heritage.
16. E.C.M. Ruijgrok, 2006" The three economic values of cultural heritage:a case study in the Netherlands", journal of cultural heritage.