Diagnosis of Fire Simple R.C Building Members Damages By Using Expert System

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الخلاصة :

شهدت العقود الاربعة الاخيرة حالات فشل كثيرة في المنشاءات الخرسانية المسلحة ولاسباب متعددة كزيادة احمال الخدمة ،حوادث الحروب ، الحرائق الكبيرة و مشاكل المتانة ، مما سبب خسائر اقتصادية عالية. أن حجم وبرامج اعمال التصليح في ازدياد وتوسع مع زيادة حجم الاضرار . يعتبر نظام الخبير اداة قرار تعتمد على الحاسوب مبنية على الحقائق والخبرات لحل مشاكل القرار الصعب مستندة على المعرفة المكتسبة من الخبرة العملية . لجعل متطلبات التصليح اكثر واقعية استخدمت البرامج الحاسوبية لتكون اكثر قابلية للتنفيذ مع التقنيات العملية، هذا وقد بنيت البرامج على الحقائق ومجالات المعرفة العملية والنظرية . أن نظام الخبير المستخدم في البحث هو لتشخيص اضرار الحرائق على اعضاء المنشاءات الخرسانية المسلحة وقد طور للتشخيص من خلال استخدام برنامج حاسوبي بلغة برولوك "Prolog " وللاستخدام كبديل عن الخبير "الشخص الخبير" وذلك لاعطاء قرار تقني في التشخيص لاضرار الحرائق في الاعضاء الانشائية " الاعتاب والسقوف والاعمدة ".

Abstract

During the last four decades, incidence of failure of reinforced concrete structures has been seen widely for many reasons, such as increasing service loads ,war accidents, fire and/or durability problems and the economic losses due to such failures are costly. Nowadays, the size and the form of repair and rehabilitation market are too large since there has been an increased emphasis on repair and retrofitting of defected structures over demolition and new construction. An *expert system* is an interactive computer-based decision tool that uses both facts and heuristics to solve difficult decision problems based on knowledge acquired from an expert. To realize these requirements, a logic programming Prolog language was utilized together with diagnosis technology. The logic programming language formalizes the domain knowledge. The expert system Diagnosis of Fire Simple R.C Building Members Damages **(DFSRCMD)** developed in this paper is a diagnostic advisory system, which can be used as an alternative to the human expert, to give technical decisions in diagnosing fire damages in R.C. structural elements: beams, columns and slabs.

Keywords: Expert System, R.C Building Damage.

The Objective:

The main objectives of this study are formulated as follows:

1. Classification of deteriorations likely to occur in reinforced concrete structural elements, according to available literatures and the expert's opinions.

2. Construction of a knowledge base that incorporates the gathered information in a form of rules suitable to be implemented in an expert system environment of a diagnostic advisory nature.

1. Introduction

The major problems in accessing a human expert in a particular field are unavailability and scarcity of real experts and if the human expert is available then there may be problem for common people in making contact with him. Consultation may be very expensive and human expert may feel the repetitive job uninteresting. This in turn may affect expert's efficiency, day by day, new knowledge in enormous amount is being added in every discipline and thus more relevant and accurate advice can be taken from a human expert if his own knowledge is updated which is not an easy task. Human experts are bounded by limitations and it is quite difficult for a human expert to consider all the essential factors while taking decision. Something is always escaped and remains unattended. Thus some tool or assistance is needed even for an expert to update his knowledge and get help in decision making process. In the researches and developments in science and technology, attempts have been always made to overcome the problems of people. The advancements made in the discipline of Artificial Intelligence and Computer Science and Engineering. Have tackled the problems related to mental and intellectual processes of the people. Gradual advancements in these disciplines have enhanced our cognitive capabilities. From very beginning scientists and researchers of AI have been trying to produce systems that can behave like an intelligent being. In course of such developments scientists, researchers and other related resource persons realized the clue of human expertise in a particular field and tried to encode and assimilate the knowledge and experience of human experts in computer that led to the notion of development of expert systems in different domains. An expert system is a computer-based program that uses knowledge, facts and different reasoning techniques to solve problems that normally require the abilities of human experts. The program asks series of questions about the concerned problem and gives appropriate advice based on its store of knowledge. The knowledge, the expert system uses is made up of either rules or experience information about the behavior of elements of a particular subject domain. Such systems can be designed for specific hardware and software configurations, or they can be software systems that are designed to run on a general-purpose computer.

2. Expert Systems (ES)

Since the World War II, computer scientists tried to develop techniques that would allow computers to act more like humans. The entire effort including decision-making systems, robotics, and various approaches to computer speech is usually termed Artificial Intelligence (AI). A collection of Artificial Intelligence techniques that enables computers to assist people in analyzing problems and making decisions, called "Knowledge-Based Systems". Expert system is a part of the knowledge-based systems family. Expert systems are developed to assist people in many fields, for example (Engineering, Trouble shooting, diagnosing… etc.) [1].

Expert systems are developed to support end users in accessing a domain expert's domain knowledge whenever an expert is not available in person. These systems focus on simulating the domain experts' problem solving abilities, i.e., they simulate human reasoning in performing some portion of the relevant tasks. Furthermore, they perform reasoning about the representations of human knowledge and solve problems by heuristics or approximate methods [2].

The benefit of these systems is their performance of many different functions. The use of expert systems can improve production operations, increase output and help to standardize approaches to problems that require expertise and utilize incomplete and uncertain information [3].

Zain Al Abideen and Sharaf Eldin, developed a knowledge-based system for the evaluation of concrete cracks and damages of building in the kingdom of Saudi Arabia. The goal is to produce a system that integrates two major technologies: database and expert systems in order to mimic experts' actions for the considered problems. The system has to identify the probable causes of cracks in concrete based on their shape, pattern, density,…etc [4].

Failures and damages in concrete structures and/or the possible reasons for repairing and strengthening buildings can be placed into five main categories [5]:

1. Structural deficiency resulting from such causes as errors in design, errors in construction, impact, explosions, and change of use resulting in higher live loading than was originally allowed for in the design.
2. Fire damage; this often results in some weakening in the structure as a whole, as well as severe physical damage to the individual concrete members (floor slabs, beams, columns etc.).
3. Deterioration due to poor quality concrete, inadequate cover to reinforcement, and the presence of chlorides in the concrete.
4. Chemical attack on the concrete and/or reinforcement.
5. Physical damage caused by the use to which the building or part of the building was put, such as the abrasion of a floor slab in a factory and the abrasion of silos and hoppers holding coarse granular material.

The structural engineer often faces the problem of strengthening existing building or repairing different members of damaged concrete structure. The decision on such a repair is a technical matter involving five basic steps [6, 7]:

1. Finding the deterioration.
2. Determining the cause.
3. Evaluating the strength of the existing structure.
4. Evaluating the need for repair.
5. Selecting and implementing a repair procedure.

3. Deteriorations in Concrete Structures:

1. Cracking

Deterioration of a concrete structure was invariably accompanied by cracking to a greater and lesser degree. Cracks in concrete have many causes. They may affect appearance only, or they may indicate significant structural distress or a lack of durability. Their significance depends on the type of structure, as well as the nature of the cracking [8], as shown at Figure (B1) in Appendix B.

2. Spalling

Spalling is a fragment, usually in the shape of flake, detached from a layer mass by a blow; a small spall involves a roughly circular depression not greater than 20mm in depth or 150mm in any dimension; a large spall may be roughly circular or oval or in some cases elongated, more than 20mm in depth and 150mm in the greatest dimension [9].

3. Deflection

Deflection is a variation in position or shape of a structure or structural element (not within the limitation of the specific codes of practice) due to effect of loads or volume change.If the deflection exceeds the limitations of the specified codes of practice, it does not increase more than 1/100 from the total span. Then, the beam is considered to be still adequate [9].

4. Buckling

Buckling is a failure by lateral or torsion instability of a structural member, which occurs with stresses below the yield or ultimate values .There are no limitations in the case of columns buckling (i.e. at what limit or distance, the column can be considered damaged or failed [9].

4. Classification of Building Damages

The building damages can be classified into [10]:

1. Minor damages: include the interior and exterior fallings, which form about 10% of the total building volume.
2. Moderate damages: in addition to what is mentioned in (1) above; these damages include falling the fibers of the false ceilings, breaking the interior partitions and some doors and windows in addition to service system. These damages form about 60% of the building volume.
3. Great damages: in addition to the damages mentioned in (2), there are apparent cracks and deflection of slabs and beams and wide cracks in columns and concrete walls, which form about 8% (from element area).
4. Overall damages: these include the overall falling of some parts of the building as columns, beams, slabs and concrete walls, which form about 17% (from element area).

Concrete structural certainly suffer damage when there is severe fire ,but some times it there are many uncertainties about the behavior of concrete subjected to fire, because the effect of fire depends on the temperature reached and length of time, that temperature is maintained ,as well as the characterizes of concrete in terms of cement type, cement amount ,aggregate type &thickness of concrete cover to steel reinforced .concrete made with different materials so that show change in color with rise temperature that depend on the maximum temperature during fire [2].

Damages in R.C. structural elements are classified into several types depending on many cause(s) for each element. These elements are classified into three main groups, which are beams, columns, and slabs. Each element has several types of damages, as shown in Figure (2).

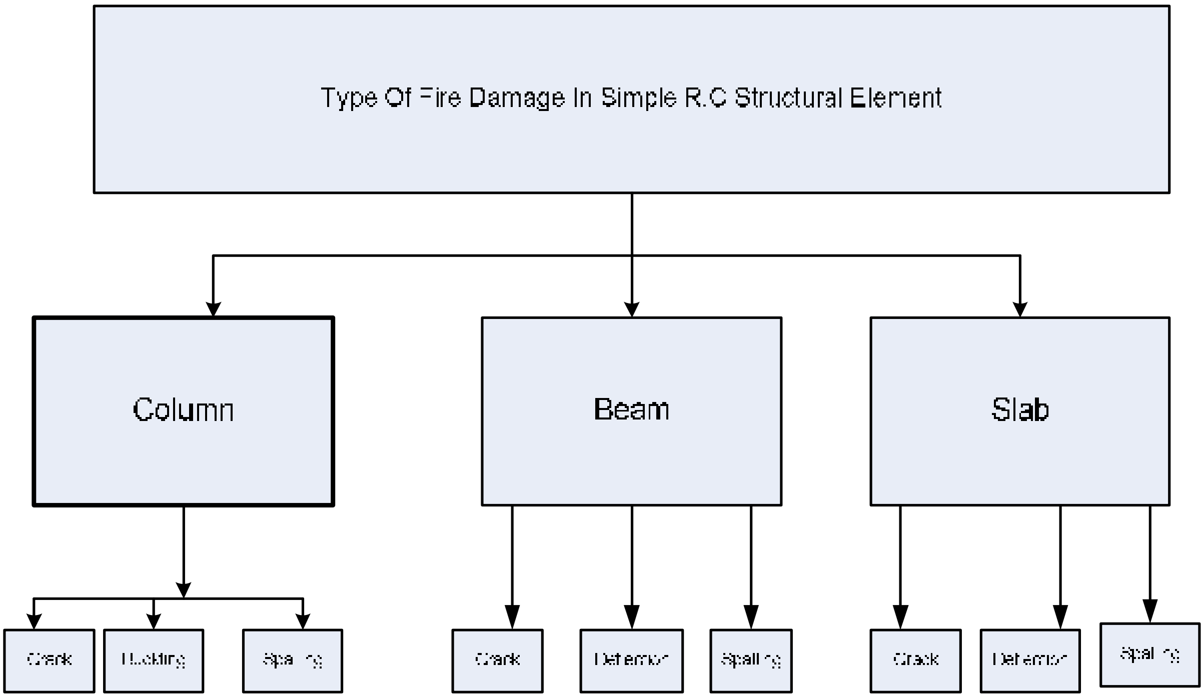

Figure (2): Classification of Fire damages in R.C. structural elements

General, in this study there are three results for diagnosis:

1. Simple damage, which achieved by the following criteria:

- There are not found spalling and deflection at the structural element
- The color of structural element is ordinary
- The cracks type is hair crack.
- The strength without any reduction

Hint : -The fire temperature is less than 250 C°
-can be seen at Figure(B5) in Appendix B.

2. Moderate damage , which achieved by the following criteria:

- There are found spalling without any corrosion in steel .
- The color of structural element is brown to pinkish
- The cracks width is near to 0.13 mm.
- The small reduction in strength .

Hint : -The temperature is between 300° to 500 C°
-can be seen at Figure (B3) in Appendix B.

3. Severe Damage , which achieved by the following criteria:

- There are found spalling and deflection with corrosion in steel.
- The color of structural element is grey to buff
- The width of crack is more 0.35 mm
- The strength is more reduction.

Hint :- The temperature is more than 700 C°
-can be seen at Figure (B4) in Appendix B.

5. Identification of the Problem

Many questions may arise about the use of expert system for the limited of damaged R.C. structural elements, which are:

- Do damages in R.C. structural elements exist?
- Is it necessary to give the attention to these damages and this technique?
- Is the expert system technique suitable for this domain?
- What are the results of applying such technique to this domain?

In order to answer these questions the following justifications are stated:

- Damages in R.C. structural elements may arise for many reasons even in well-built structures.
- The nature of domain problems is suitable for expert system technology since the problem-solving method does not use or need an explicit algorithm.
- The result of applying the selected technique to domain problems is a diagnostic-advisory expert system, which is an effective tool in providing consultation in different sites.

6. Knowledge Acquisition

Expert systems derive their power from knowledge, and it is the effective use of knowledge that makes its reasoning successful [11].

Knowledge acquisition is the collection of information from one or more domain expert, as well as any other sources, leading to the production of a number of documents, which form the basis of a functioning knowledge base [12, 13].

The three basic approaches are as follows [14]:

a. *Interviewing:* In this approach a knowledge engineer obtains knowledge from the human expert through a series of interviews and encodes it in the expert system. Here the knowledge engineer plays a central role in the knowledge acquisition process, and the quality of the expert system greatly depends on the skills of the knowledge engineer.

b. *Learning by Interaction:* This approach often relies on computer-assisted knowledge acquisition. Experts directly interact with a computer program that helps to capture their knowledge. The need for a knowledge engineer can be significantly diminished here and the program often helps experts clarify their own thoughts.

c. *Learning by Induction:* In this approach a computer program distills knowledge by examining data and examples. Here the dependence on both the expert and the knowledge engineer is again diminished. The main problem here is the identification of the suitable characteristics or attributes on which induction would be performed.

The process is performed in two stages. The first is collecting knowledge from literature, whereas, the second is collecting knowledge from Iraqi experts in the domain of concrete structure repair. The two stages are explained in the following articles.

7. Investigation of Reinforced Concrete Deterioration

Experience has shown that a number of testing methods are of proven value in determining the extent of deterioration of a concrete structure and in identifying those areas where remedial measures are necessary.

1. Stage Approach

Any investigation can conveniently be split into two stages:-
Stage 1 - An initial survey to identify the cause of the problems.
Stage 2 - An extension of the stage 1 survey, perhaps using a limited number of techniques to identify the extent of the defects revealed by stage 1.

2. Visual Survey

After collecting as much background data as possible, any testing problem should begin with a thorough visual survey of the structure. This may conveniently be recorded on a developed elevation giving particular attention to the following defects:

- Cracks or crazing
- Spalling
- Corrosion of steel and rust staining
- Hollow surfaces
- Honeycombing due to poor compaction or grout loss
- Varying color or texture
- Areas in which remedial finishing work had already been carried out
- External contamination or surface deposits
- Wet or damp surfaces

8. Knowledge Analysis

The analysis process to the acquired knowledge has been done continuously together with acquisition process. The process of the diagnosis of the damages is applied as a menu-driven and question-and-answer, where from the menu we choose the element of the R.C. Structure, then from submenu choose the type of the damage may be occur in the element, finally, the execution is done as question-and-answer, into reach to the diagnostic damage. The process is composed of all steps as abstracted in the data flow diagram in the Appendix A.

9. Knowledge Representation

The knowledge used by an expert system needs to be represented and employed in a form that can be used for reasoning. This is in contrast to most computer programs that work with data. Thus, knowledge structures are used to store knowledge and reason with it, just as data structures are used to store and deal with data [14, 11].

In this study, rules are used because they are the most common forms of statement in representing the knowledge. Each rule consists of one or more conditions, which, if satisfied, gives rise to one or more actions [13]. A rule can be expressed in the general form:

IF (condition)
THEN (conclusion or action)

Such rules are sometimes called “Production Rules” since they produce a result. For example:-
IF the type of damages in the beam is “cracking” AND the cracks appear on both the “side and the bottom faces of the beam” AND the cracks are “longitudinal” AND the cracks “follow the pattern of the reinforcement” THEN CAUSES.

This flowchart starts with the main menu that includes the main types of structural elements to be repaired. Each type of structural element leads to a branch menu that contains the damages possibly happen in this element. For every type of these damages there are several choices and questions from which the type of the happened damage is specified. These steps or methods in chaining used from the beginning of the flowchart to the end are known as “backward chaining”. This method begins from the conditions or events until reaching the goals. See Appendix A.

10. Case Study

1. Location

The houses buildings at Fallujah city. Al-Anbar rehabilitation Office is responsible for the Estimate the damage at this building that was damaged by direct hits in war at 28\11\2004. According to the Anbar Rebuilding Institute, there are more than 26,660 houses (units) which damaged in Fallujah.

2. Description of the Building

The building consists of 1-2 floors. The average height of the buildings is 6-10 m and the average area is between 150-400 m^2. Number of houses that survived equal to 50.

These damages are attributed to one of the following [15]:

1. Direct effect of bombardment on the building.
2. Indirect effect of the bombardment on the building, which includes structural members affected by their stress redistribution due to failure of nearby members, or due to the effect of bombs blast on the remote finishing.
3. Fire that took place due to bombardment and caused great damages in finishing and in the structural frame, especially in the concrete cover.

11. Results of the System

The user interacts with the system through a user interface that simplifies communication and hides much of the complexity, such as the internal structure of the rule base. Expert system interfaces employ a variety of user styles, including question-and-answer, menu-driven, or graphics interfaces. The final decision on the interface type is a compromise between user needs and the requirements of the knowledge base and inferencing system.

The heart of the expert system is the knowledge base, which contains the knowledge of a particular application domain. In a rule-based expert system this knowledge is represented in the form of if... then... rules. The knowledge base contains both general knowledge as well as case-specific information.

The knowledge of the (DFSRCMD) expert system is represented as tree of rules contain all questions that user may be ask it to lead to the solution. The constructed tree is the space of problem of the (DFSRCMD) expert system.

The inference engine applies the knowledge to the solution of actual problems. It is essentially an interpreter for the knowledge base. In the production system, the inference engine performs the recognize-act control cycle. The procedures that implement the control cycle are separate from the production rules themselves.

The following photos represent the displayed screens for applying the presented expert system to the problem of the study case.
In this (DFSRCMD) expert system we considered the Expert System Lifecycle. The procedure of the execution is begun with menu-driven to select the type of the simple R.C building element such as Beam, Column or Slab. After this step there are a submenu used to select the type of the damage occur in the simple R.C building element. The next step represents the scenario and dialog between the (DFSRCMD) expert system and the user. The scenario is done by the question-and-answer, where the expert system asks and the user answer until reach to the goal of the diagnosis. The interfaces of the implementation of the DFSRCMD expert system are obtained in Appendix C.

13. Conclusions

From the present theoretical study and depending on its results the following points are concluded:

1. The expert system (DFSRCMD) developed in this work is a diagnostic advisory system, that can be used as an alternative to the human expert, to give technical decisions in diagnosing fire damages in R.C. structural elements (Beams, columns and slabs).
2. The most difficult stage of expert system development is knowledge acquisition because the effectiveness, efficiency and reliability of the developed system highly depend on the quality and quantity of its knowledge base.
3. The decision on the type of fire damage taken by the system, is a multitask process which requires the user to provide the necessary information about the condition of the structural element gathered by both visual as well as technical tests.
4. The using of the (DFSRCMD) expert system is easy, fast and give successful answer for engineer, because we take almost the perhaps damages in consideration.
5. The development of the (DFSRCMD) expert system may be done by updating the knowledge base in the system without changing the inference engine.

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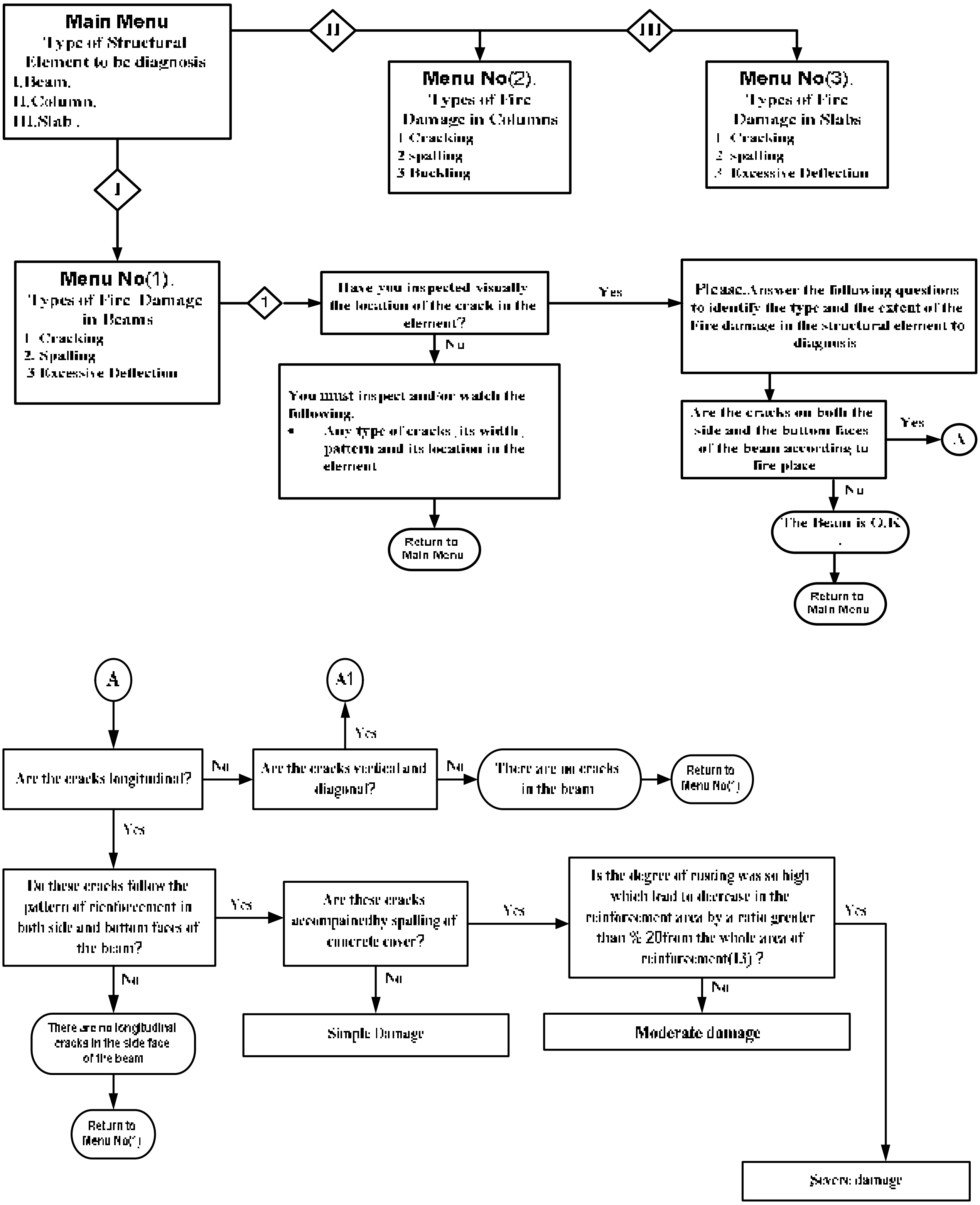
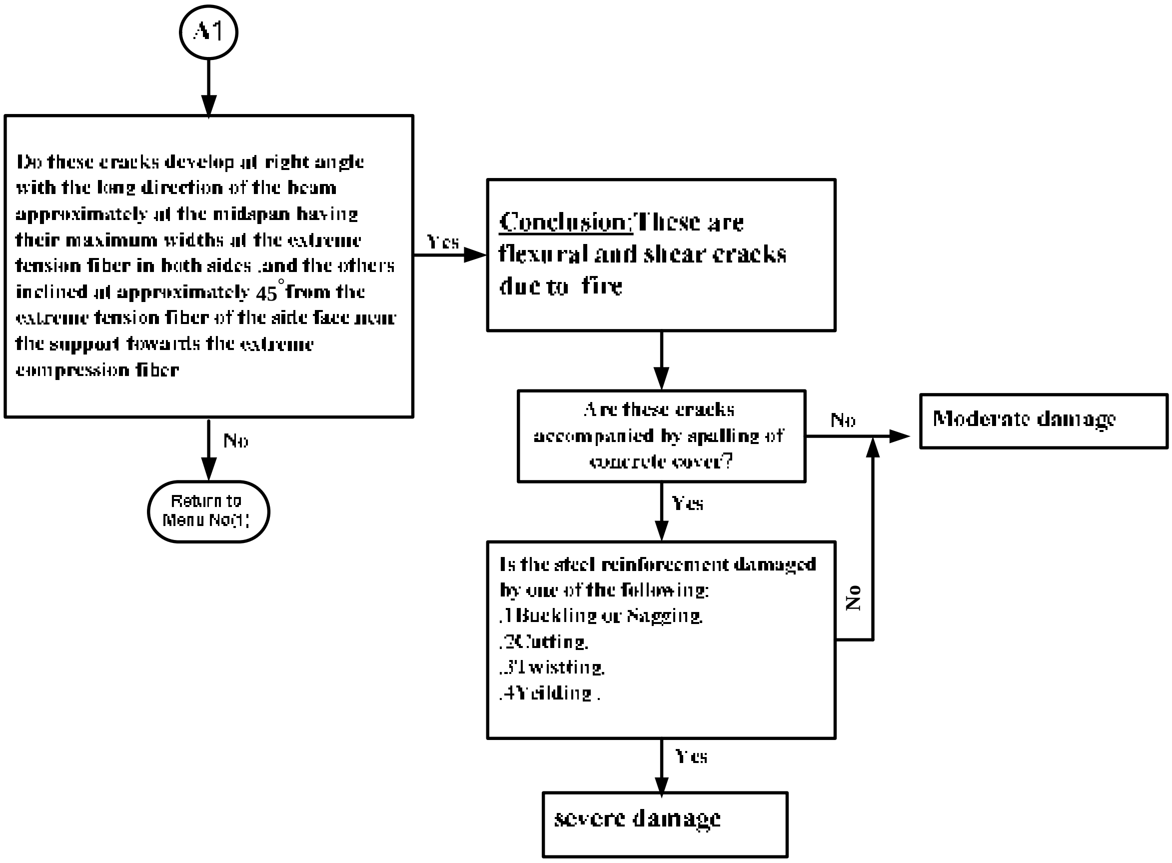
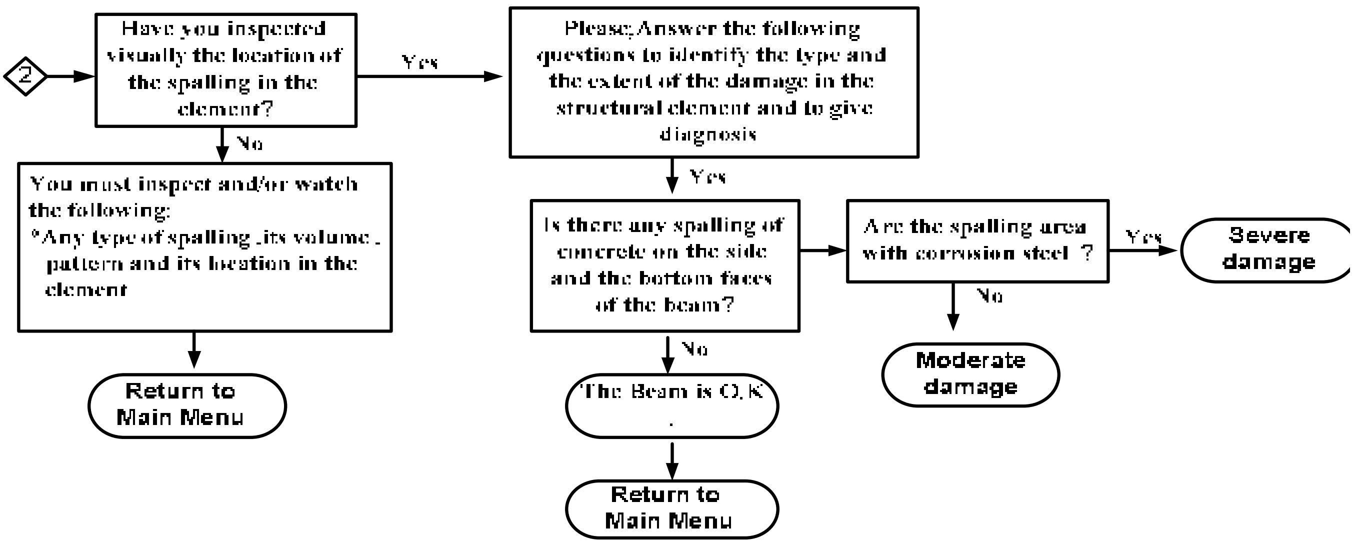
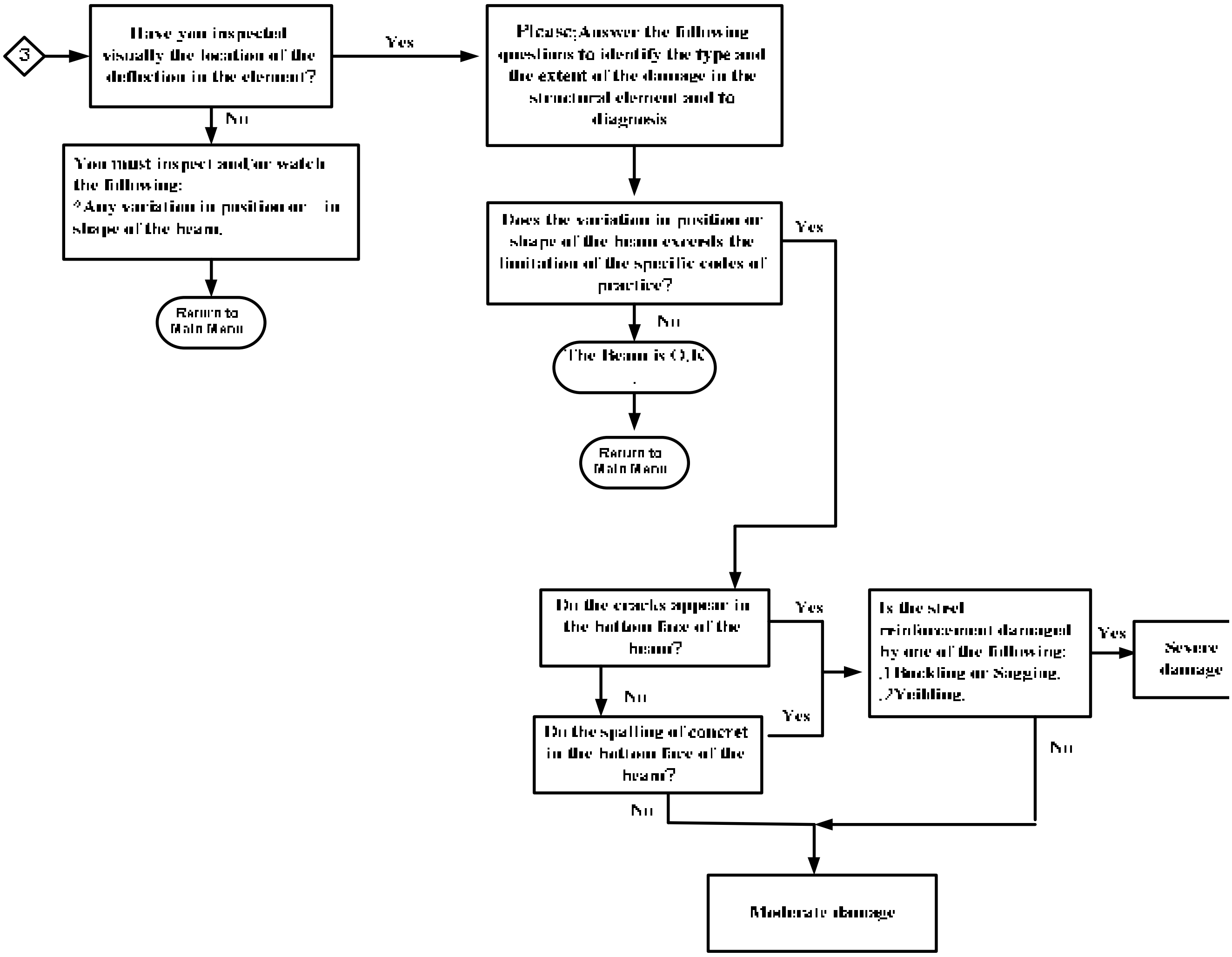
Appendix A

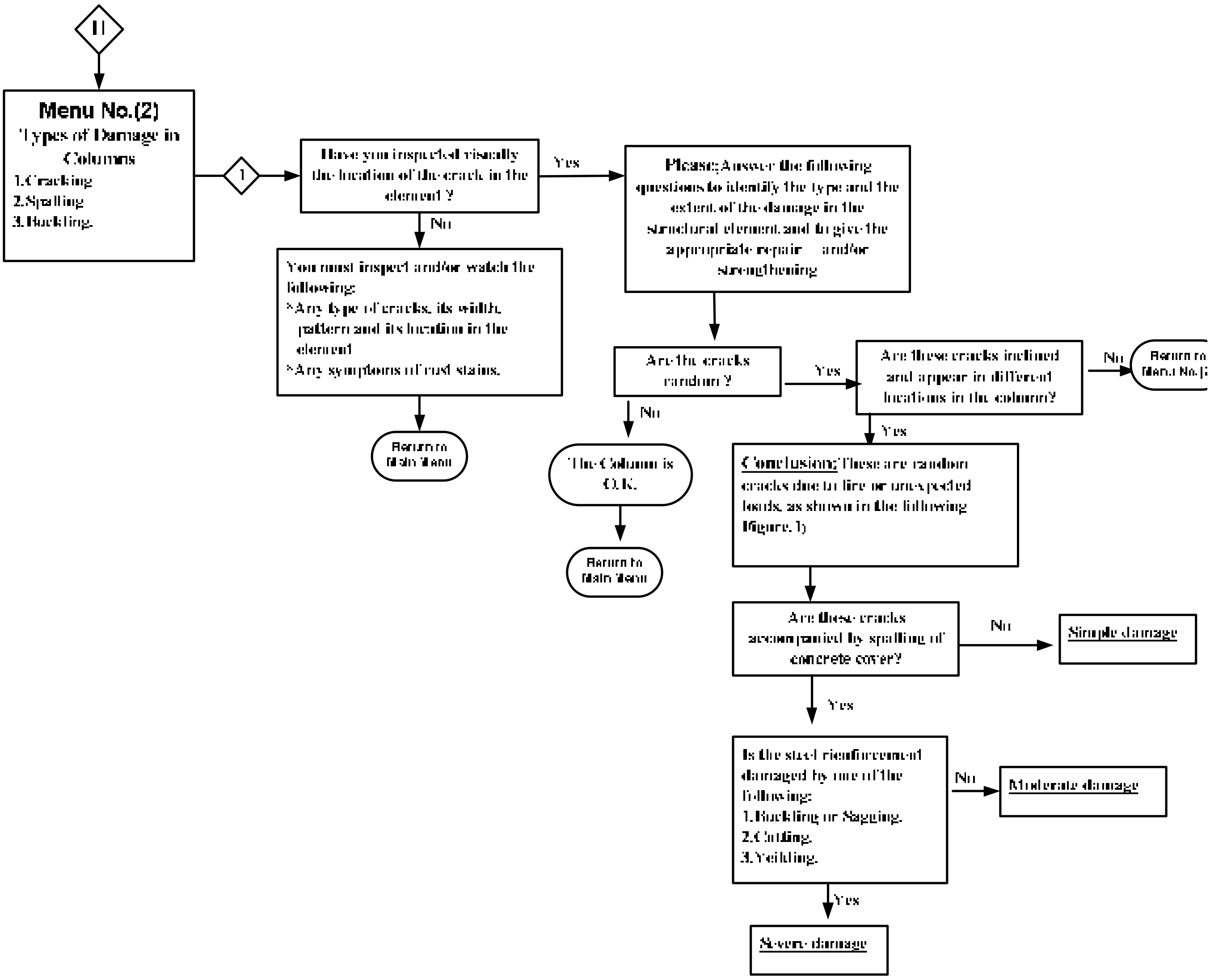
The appendix (A) included the program **(DFSRCMD)** flow chart .

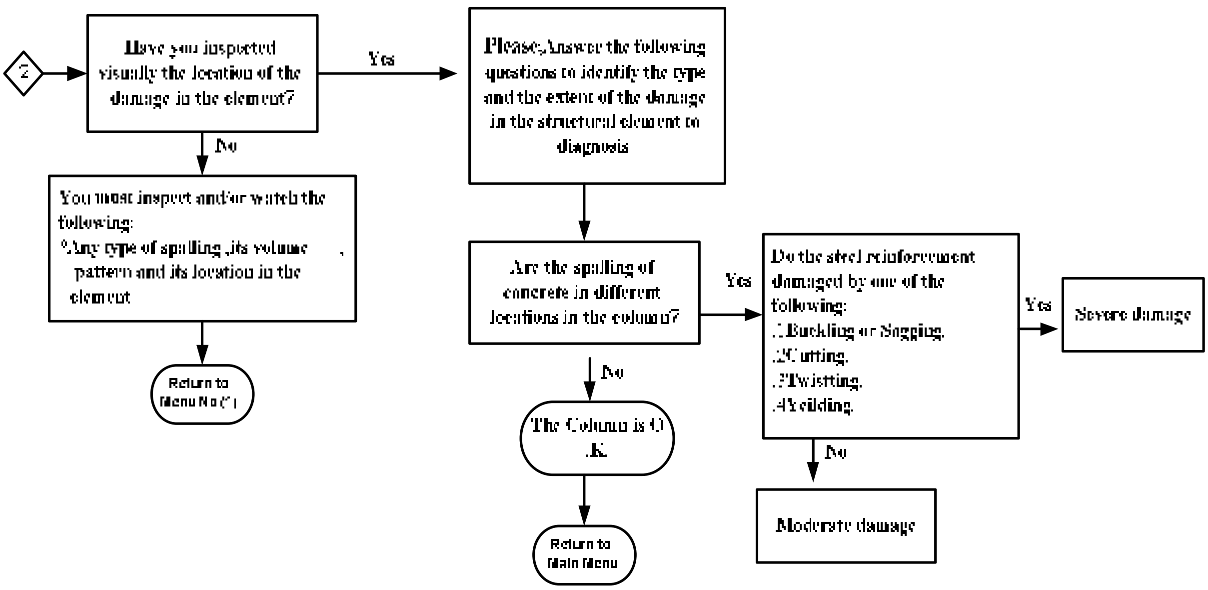


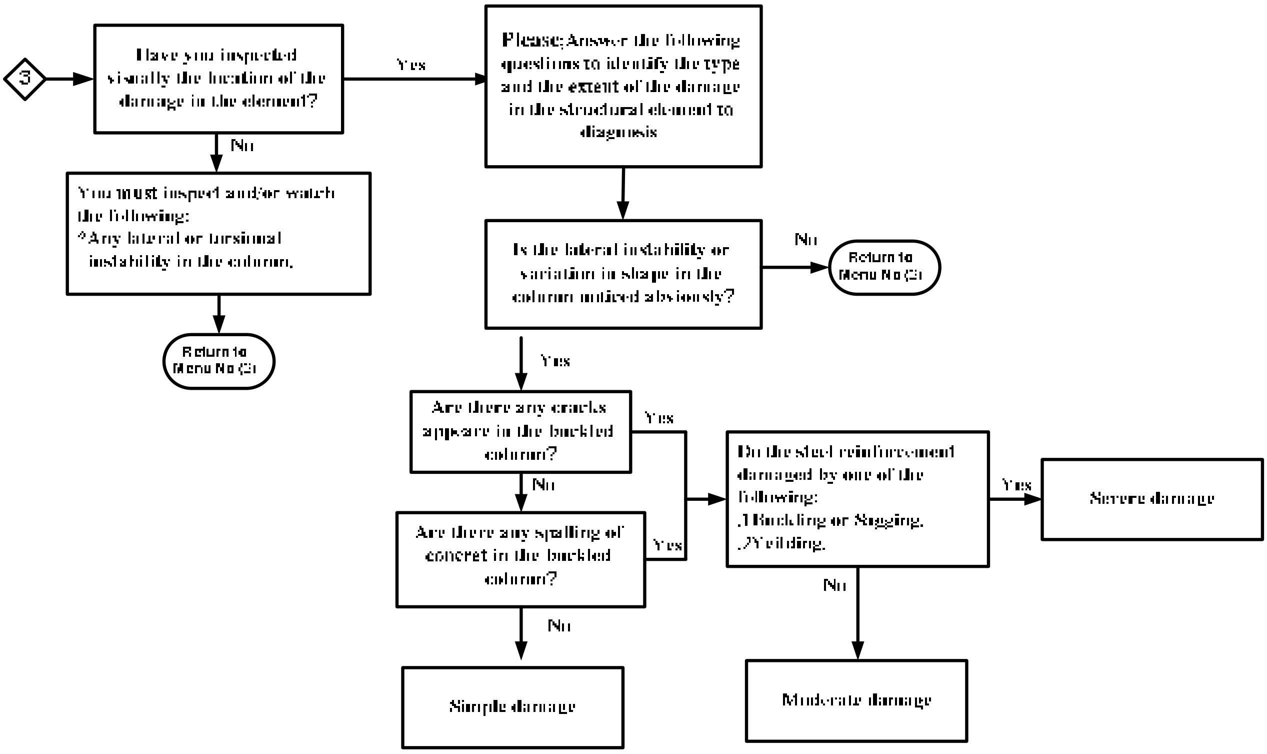

A1
Do these cracks develop at right angle with the long direction of the beam approximately at the midspan having their maximum widths at the extreme tension fiber in both sides ,and the others inclined at approximately 45° from the extreme tension fiber of the side face near the support towards the extreme compression fiber
Yes
No
Return to Menu No(1)
Conclusion:These are flexural and shear cracks due to fire
Are these cracks accompanied by spalling of concrete cover?
No
Moderate damage
Yes
Is the steel reinforcement damaged by one of the following:
.1Buckling or Sagging.
.2Cutting.
.3Twistting.
.4Yeilding .
No
Yes
severe damage

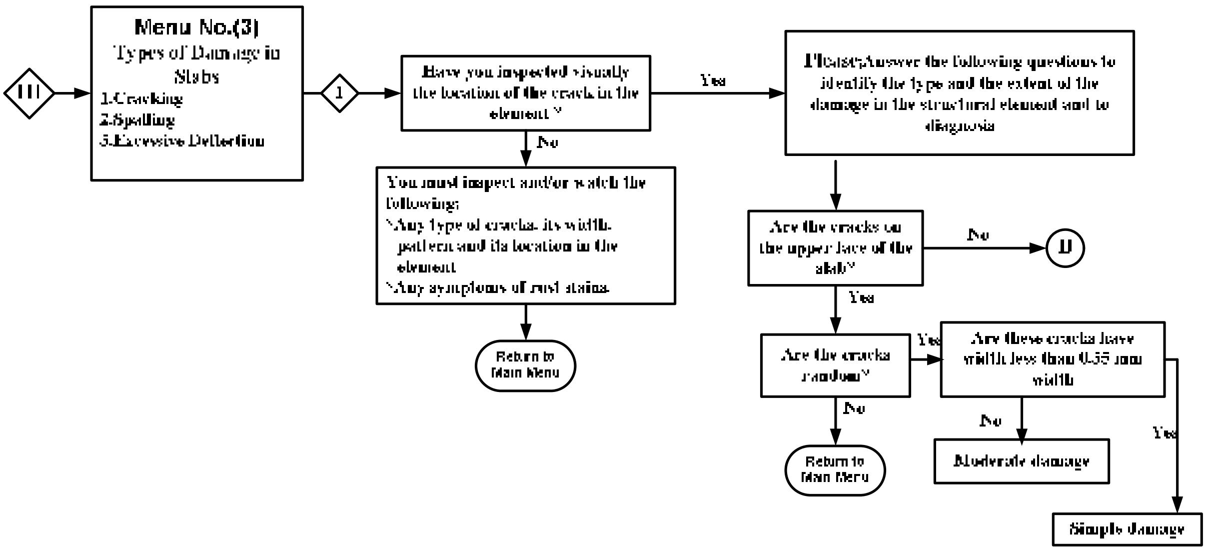

2
Have you inspected visually the location of the spalling in the element?
Yes
No
Please,Answer the following questions to identify the type and the extent of the damage in the structural element and to give diagnosis
You must inspect and/or watch the following:
*Any type of spalling ,its volume , pattern and its location in the element
Return to Main Menu
Yes
Is there any spalling of concrete on the side and the bottom faces of the beam?
Are the spalling area with corrosion steel ?
Yes
Severe damage
No
Moderate damage
No
The Beam is O.K .
Return to Main Menu

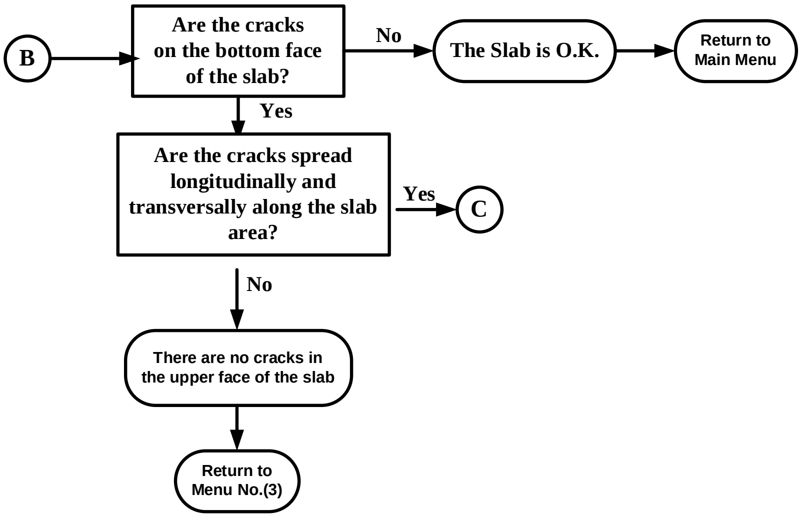

3
Have you inspected visually the location of the deflection in the element?
Yes
No
Please; Answer the following questions to identify the type and the extent of the damage in the structural element and to diagnosis
You must inspect and/or watch the following:
* Any variation in position or in shape of the beam.
Return to Main Menu
Does the variation in position or shape of the beam exceeds the limitation of the specific codes of practice?
Yes
No
The Beam is O.K .
Return to Main Menu
Do the cracks appear in the bottom face of the beam?
Yes
No
Is the steel reinforcement damaged by one of the following: .1 Buckling or Sagging. .2Yielding.
Yes
Severe damage
No
Do the spalling of concret in the bottom face of the beam?
Yes
No
Moderate damage

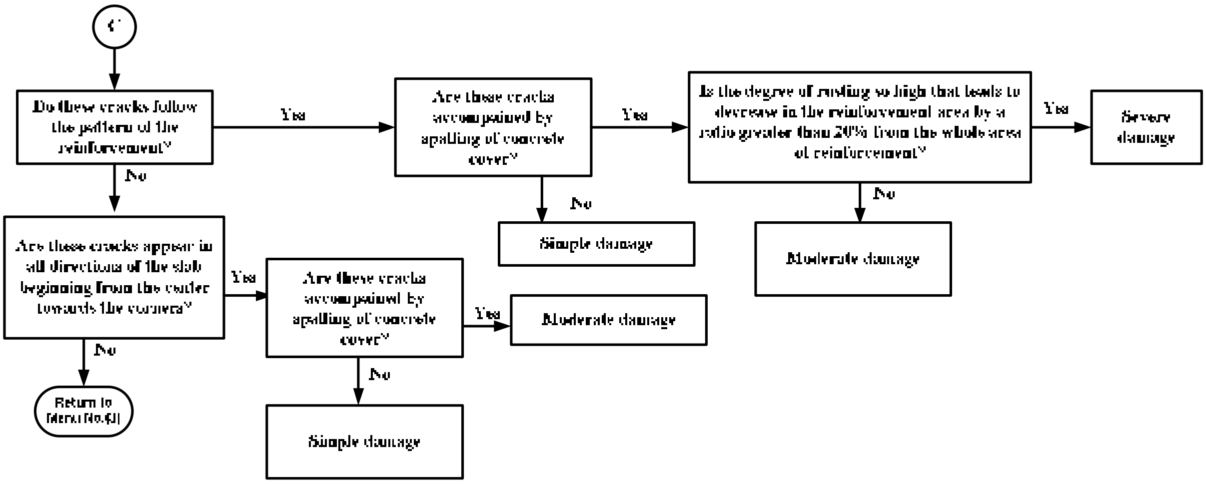

II
Menu No.(2)
Types of Damage in Columns
1.Cracking
2.Spalling
3.Buckling
1
Have you inspected visually the location of the crack in the element ?
Yes
No
Please;Answer the following questions to identify the type and the extent of the damage in the structural element and to give the appropriate repair and/or strengthening
You must inspect and/or watch the following:
*Any type of cracks, its width, pattern and its location in the element
*Any symptoms of rust stains.
Return to Main Menu
Are the cracks random ?
Yes
No
Are these cracks inclined and appear in different locations in the column?
No
Return to Menu No.(2)
Yes
The Column is O.K.
Return to Main Menu
Conclusion; These are random cracks due to fire or unexpected loads, as shown in the following figure.1)
Are these cracks accompanied by spalling of concrete cover?
No
Simple damage
Yes
Is the steel rienforcement damaged by one of the following:
1.Buckling or Sagging.
2.Cutting.
3.Yeilding.
No
Moderate damage
Yes
Severe damage

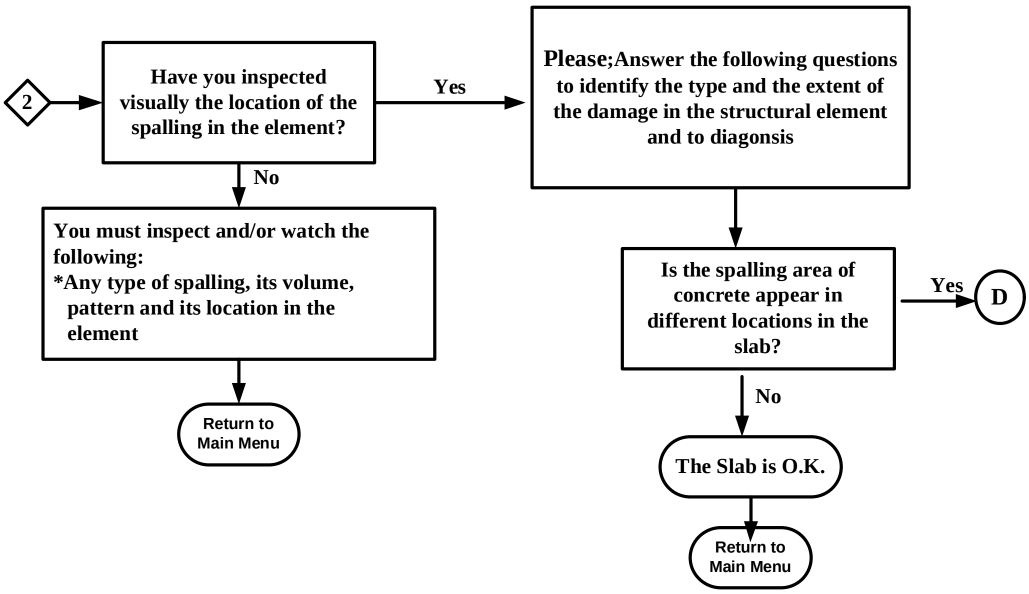

2
Have you inspected visually the location of the damage in the element?
Yes
Please;Answer the following questions to identify the type and the extent of the damage in the structural element to diagnosis
No
You must inspect and/or watch the following:
*Any type of spalling ,its volume , pattern and its location in the element
Return to Menu No.(1)
Are the spalling of concrete in different locations in the column?
Yes
Do the steel reinforcement damaged by one of the following:
.1Buckling or Sagging.
.2Cutting.
.3Twisting.
.4Yeilding.
Yes
Severe damage
No
The Column is O.K.
Return to Main Menu
No
Moderate damage

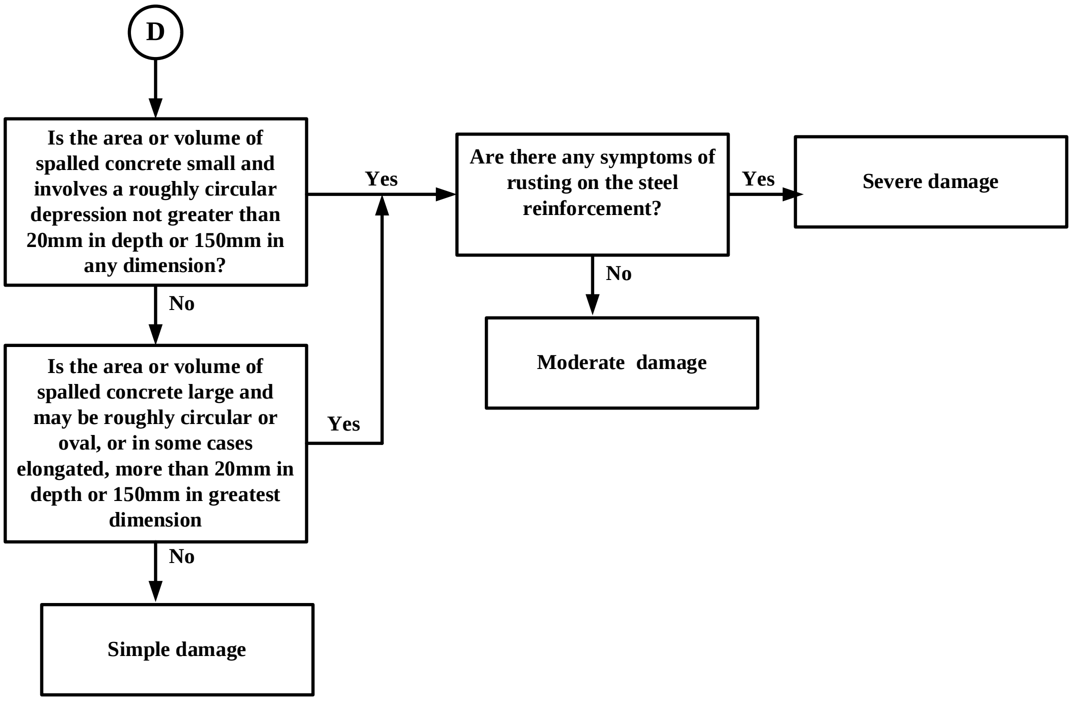

3
Have you inspected visually the location of the damage in the element?
Yes
No
Please;Answer the following questions to identify the type and the extent of the damage in the structural element to diagnosis
You must inspect and/or watch the following:
*Any lateral or torsional instability in the column.
Return to Menu No (3)
Is the lateral instability or variation in shape in the column noticed obviously?
No
Return to Menu No (3)
Yes
Are there any cracks appeare in the buckled column?
Yes
No
Are there any spalling of concret in the buckled column?
Yes
Do the steel reinforcement damaged by one of the following:
.1Buckling or Sagging.
.2Yeilding.
Yes
Severe damage
No
No
Simple damage
Moderate damage

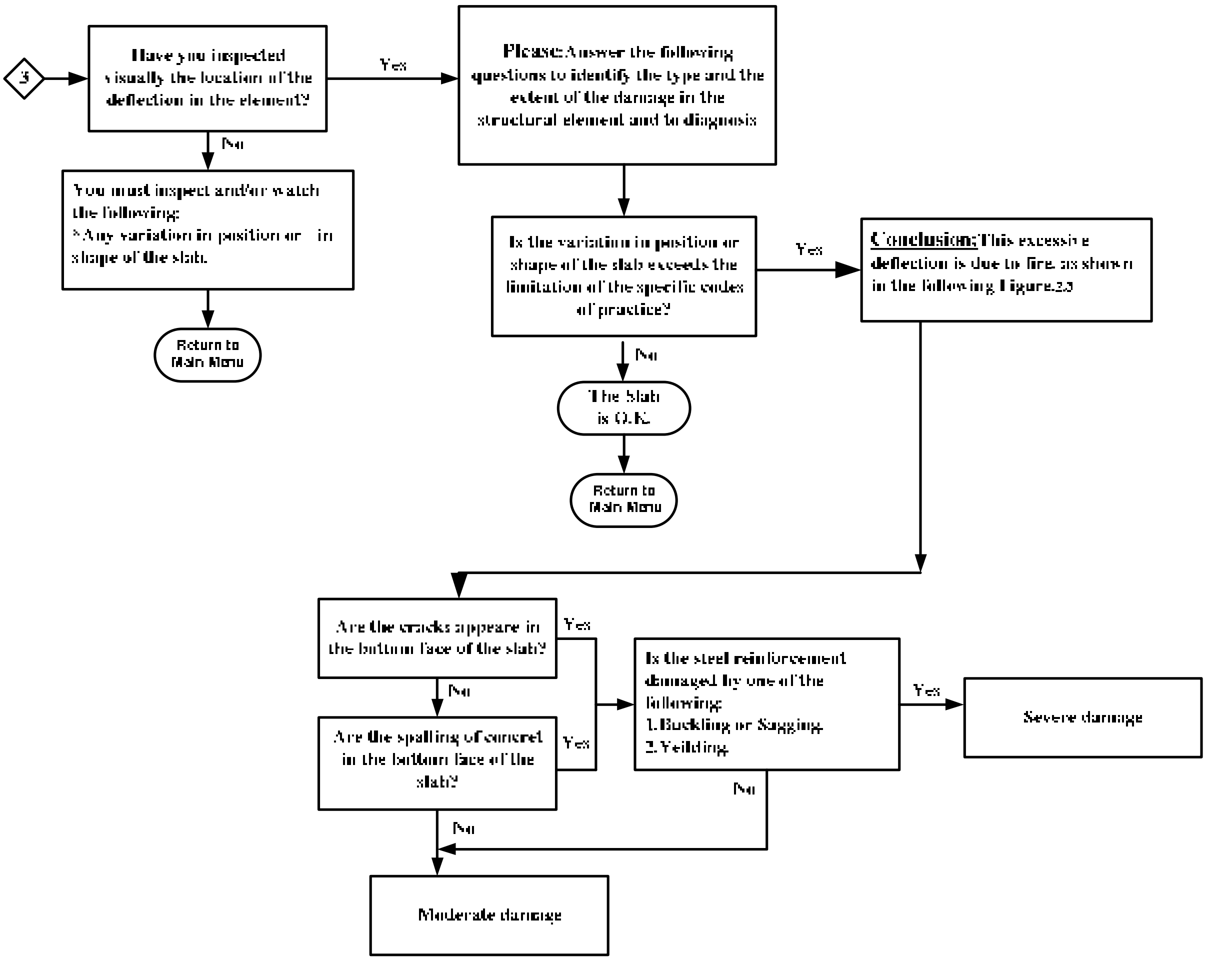

III
Menu No.(3)
Types of Damage in Slabs
1.Cracking
2.Spalling
3.Excessive Deflection
1
Have you inspected visually the location of the crack in the element ?
Yes
Please;Answer the following questions to identify the type and the extent of the damage in the structural element and to diagnosis
No
You must inspect and/or watch the following:
*Any type of cracks, its width, pattern and its location in the element
*Any symptoms of rust stains
Return to Main Menu
Are the cracks on the upper face of the slab?
No
II
Yes
Are the cracks random?
Yes
Are these cracks have width less than 0.35 mm width
No
No
Yes
Return to Main Menu
Moderate damage
Simple damage


B
Are the cracks on the bottom face of the slab?
No
The Slab is O.K.
Return to Main Menu
Yes
Are the cracks spread longitudinally and transversally along the slab area?
Yes
C
No
There are no cracks in the upper face of the slab
Return to Menu No.(3)


C
Do these cracks follow the pattern of the reinforcement?
Yes
Are these cracks accompanied by spalling of concrete cover?
Yes
Is the degree of rusting so high that leads to decrease in the reinforcement area by a ratio greater than 20% from the whole area of reinforcement?
Yes
Severe damage
No
Moderate damage
No
Simple damage
No
Are these cracks appear in all directions of the slab beginning from the center towards the corners?
Yes
Are these cracks accompanied by spalling of concrete cover?
Yes
Moderate damage
No
Simple damage
No
Return to


2
Have you inspected visually the location of the spalling in the element?
Yes
Please;Answer the following questions to identify the type and the extent of the damage in the structural element and to diagonsis
No
You must inspect and/or watch the following:
*Any type of spalling, its volume, pattern and its location in the element
Return to Main Menu
Is the spalling area of concrete appear in different locations in the slab?
Yes
D
No
The Slab is O.K.
Return to Main Menu


D
Is the area or volume of spalled concrete small and involves a roughly circular depression not greater than 20mm in depth or 150mm in any dimension?
Yes
No
Are there any symptoms of rusting on the steel reinforcement?
Yes
Severe damage
No
Moderate damage
Is the area or volume of spalled concrete large and may be roughly circular or oval, or in some cases elongated, more than 20mm in depth or 150mm in greatest dimension
Yes
No
Simple damage


3
Have you inspected visually the location of the deflection in the element?
Yes
Please: Answer the following questions to identify the type and the extent of the damage in the structural element and to diagnosis
No
You must inspect and/or watch the following:
* Any variation in position or in shape of the slab.
Return to Main Menu
Is the variation in position or shape of the slab exceeds the limitation of the specific codes of practice?
Yes
Conclusion: This excessive deflection is due to fire as shown in the following Figure.2.3
No
The Slab is O.K.
Return to Main Menu
Are the cracks appeare in the bottom face of the slab?
Yes
No
Are the spalling of concret in the bottom face of the slab?
Yes
Is the steel reinforcement damaged by one of the following:
1. Buckling or Sagging.
2. Yeilding.
Yes
Severe damage
No
No
Moderate damage

Appendix B

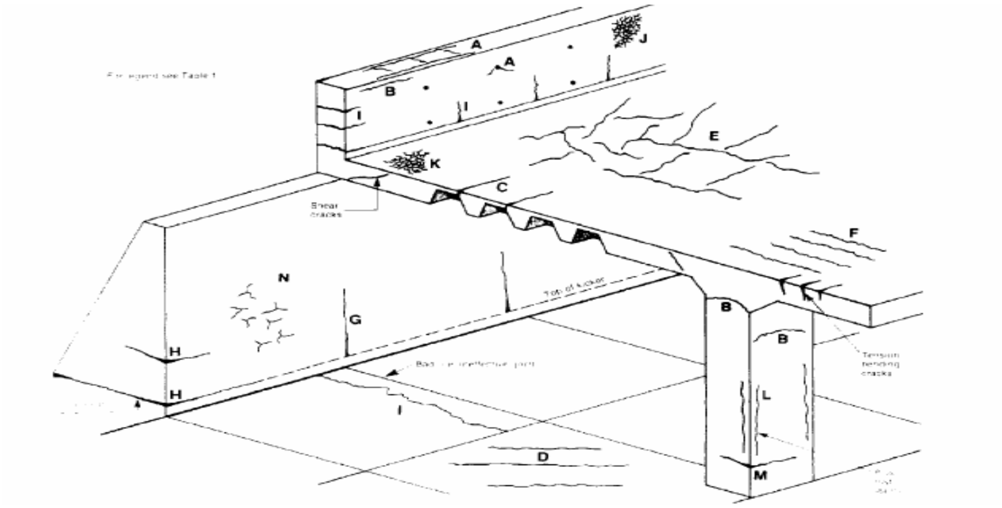
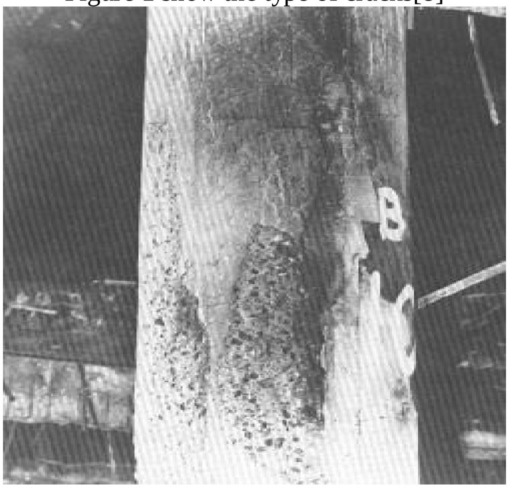


Figure 1 show the type of cracks[8]



Figuer 2 show the cracks and spalling in column [Anbar Rehabilitation unite]

Figure 3 show the moderate damage in slabs [Anbar Rehabilitation unite]

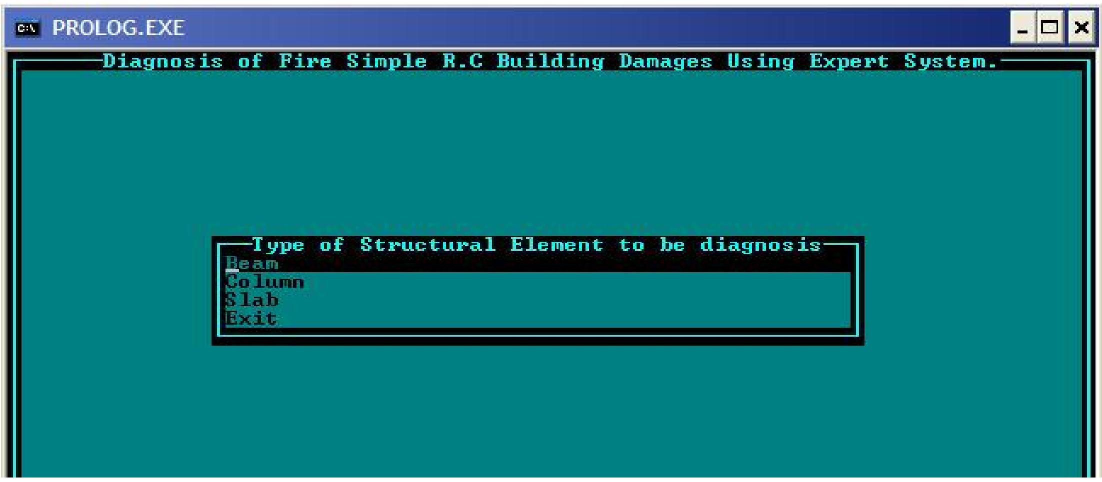

Figure 4 show the severe damage in slabs [Anbar Rehabilitation unite]


Figure 5 show the Simple damage in slabs [Anbar Rehabilitation unite]

Appendix C

This appendix shows the Diagnosis of Fire Simple R.C Building Members Damages Expert System, it is programmed by Turbo Prolog programming Language. The program takes all cases and questions as shown as in appendix B.

The system is work as follows:

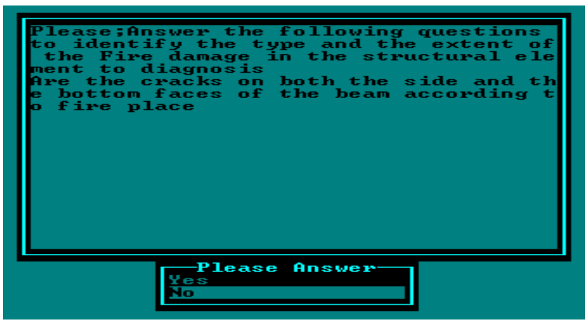


The Main Menu of the system is shown in the following figure:

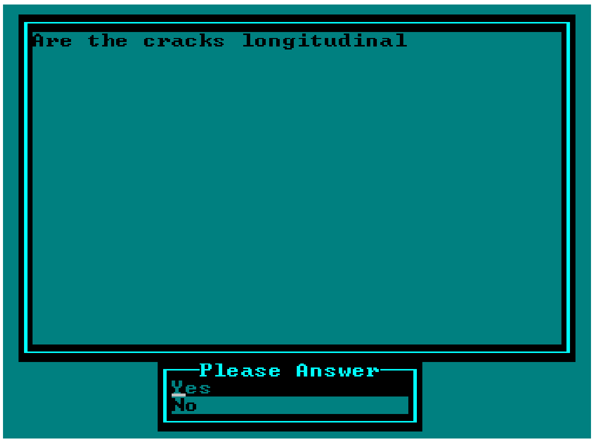
There are four choices (Beam, Column, Slab, and Exit), we select one of them according to the type of element that has a damage or exit from the system. If we select Beam. The following figure is shown:

There are four choices also (Cracking, Spalling, Excessive Deflection, or Return to Main Menu), we select one of them according to the damage type.If we select Cracking the following figure is shown:

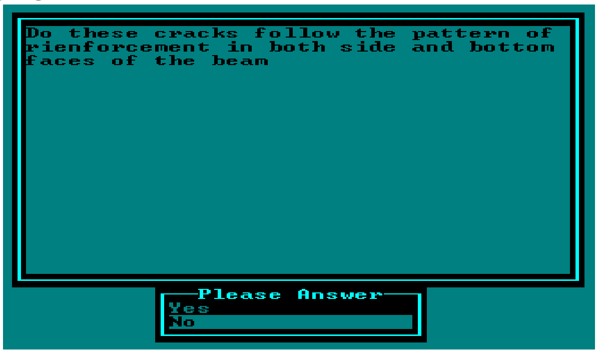
If we select Yes the following figure is shown:



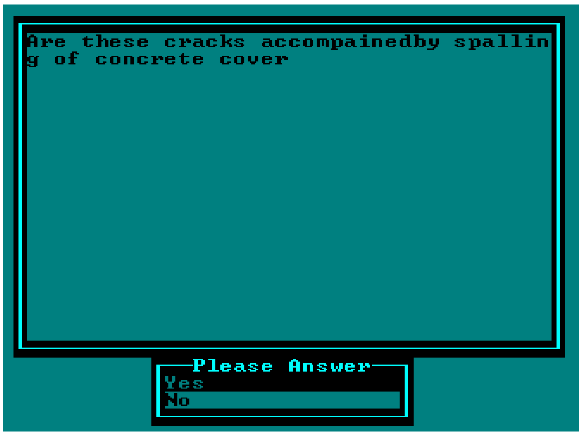
If we select Yes the following figure is shown:



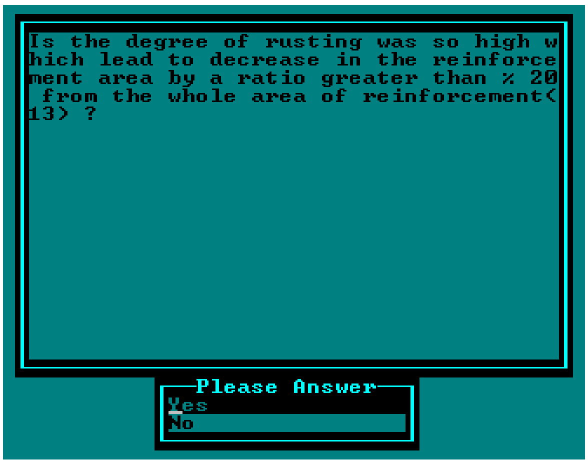
If we select Yes the following figure is shown:



If we select Yes the following figure is shown:

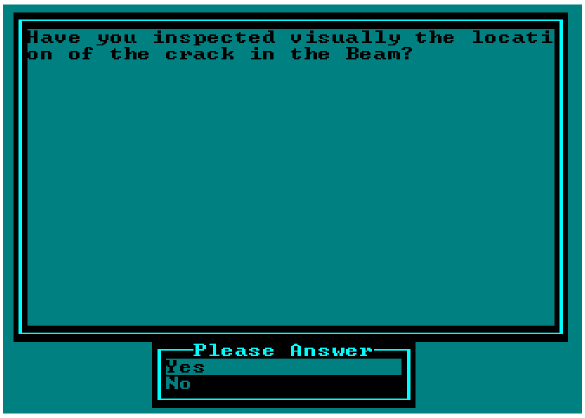


If we select Yes the following figure is shown:



If we select Yes the following figure is shown:

After of all question the system is answer that the damage is Severe Damage.
When we select the No answer in the fist question of the Cracking Damage as shows in the following figure:



The answer is shown in the following figure: