Expert system for claims of ground water and soil conditions'

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Taking as many factors of differing Site conditions as possible into consideration helps in completing the construction project on time, and with in the estimated budget. Differing site Conditions are all unforeseen conditions that are unpredictable or unexpected by owner and contractor. These conditions lead in many cases to claims. Solving claims requires many years of experience and requires following certain procedures and collecting as much data as possible to help the arbitrators reach a fair judgment. In this research, two types of claims were considered to build an expert system to help engineers and arbitrators reaching a fair solution. These types are: existence of unexpected ground water and unsuitability of the Soil for foundations claims. The questions used for collecting data and decisions were built using a questionnaire distributed to experienced professional who judged a good number of cases, according to which, the decision trees were constructed and expert system was developed. An expert system program (GWSFC) was developed using the level-5 objective shell. The reasons for choosing level-5, design of the program and how to use the program are presented.

ظروف الموقع المغيرة عامل هام في انهاء المشاريع في الزمن المحدد و بالميزانية المخططة. واعتبار اكثر عدد من هذه الظروف يساعد على التحكم في الزمن و التكلفة للمشروع. و تعتبر ظروف الموقع المغيرة هي الظروف الغير مرئية و التي يصعب التنبؤ بها او توقعها من قبل المالك والمقاول. وهذه الظروف المغيرة للعلاقة بين المالك و المقاول تؤدي في كثير من الاحيان الى ظهور الدعاوى و من ثم النزاعات. وحل هذه النزاعات يتطلب سنوات عديدة من خبرة المحكمين وعديد من الاجراءات و الخطوات المتبعة وكذلك يتطلب تجميع اكبرقدر من المعلومات و ذلك لتمكين المحكمين للوصول الى الحكم العادل. في هذا البحث تم اعتبار نوعين من ظروف الموقع المغيرة لبناء نظام خبرة لمساعدة المحكمين و المهندسين للوصول الى الحكم الاكثر عدلا. وهذان النوعان من الظروف هما: وجود مياه جوفية غير متوقعة و عدم صلاحية التربة للتأسيس حسب ما هو موضح في تقرير التربة. الاسئلة التي استخدمت في تجميع المعلومات و اتخاذ القرارات تم وضعها في استبانة ووزعت على اشخاص ذوي خبرة قاموا بفض العديد مثل هذه النزاعات و من ثم تم بناء شجرة القرارات و عمل نظام الخبرة المطلوب. وتم عمل نظام الخبرة GWSFC باستخدام Level-5 objective shell و الاسباب في اختيار هذا البرنامج و التصميم وكيفية الاستخدام تم عرضها في البحث.

Keywords: Expert system, Construction claims, Differing site conditions

1. Introduction and review

The meaning of Differing Site Conditions is all unforeseen conditions that are unpredictable or unexpected by both the owner and the contractor. They are considered as a category of influential factors in the success of a construction project. Taking as many as possible of these conditions into consideration, helps in completing the project on time, with the estimated budget. Various Differing Site Conditions can be considered during site investigations. Two types of site conditions are considered in many references [1-3]. The first type represents the core differ-ence between the unforeseen materials and those mentioned in the contract. The second type represents the core difference between actual site conditions and those well known by default or nature [2].

Examples of the first type are: Ground soil conditions which include composition and classification; Ground water conditions which include water table level; existence of saturated soil; Unknown underground utilities like water, sewer, telephone, and electricity networks. Examples of the second type are: Very hard rocks which make excavation more difficult than expected; Existence of saturated soil with high percentage of water which needs compacting operation more than expected; Existence of water in the project site with

specifications that differ than the well-known water specifications such as high sulphate content, which causes harm to dewatering equipment.

Discovering a logical solution to transfer risks to their right place requires giving considerable attention to differing site conditions [4]. The two main parties in a construction contract share in neglecting site investigation [4]. Dealing with differing site conditions differs from one country to another according to the contract clauses and according to the construction laws and rules in each country. To have the contractor be responsible for all the differing site conditions, all the expected results must be studied using the scientific techniques such as prevention of these risks by insurance [5].

The US Corps of Engineers [1] includes some of the differing site conditions in technical specifications and drawings of their projects. The contractor should consider these conditions in his account before bidding. Regarding the differing site conditions which are not included and could not be predicted prior contracting, the contractors are instructed to neglect them in their offers and that they will be compensated timely and monetarily should these conditions take place [1].

In the State Counsel of France, the theory of governor and emergency conditions [6] is implemented. The aim of this theory is to fulfill nothing but justice instead of money saving for the state.

In a study in the USA aimed at introducing a tool to solve the disputes due to differing site conditions, a suggested mechanism was introduced and implemented on ten claims [7]. These ten claims had reached final judgment and when the suggested mechanism was implemented, they found complete concordance between the results of the mechanism and the final judgment.

The contract language, which is always on the owner side, throws the responsibility due to differing site conditions on the contractor. Despite the contractor's agreement to the contract, he will claim for the differing site conditions and he will get a great part of his claim [8, 9].

In this research an expert system used to define the responsibility for two types of differing site conditions under various factors was designed and developed. A computer program was developed using level 5 object oriented shell as will be shown in the article.

2. Review of using expert system in construction claims

Expert system is widely used in civil engineering in many applications. In construction management, many applications are presented by Hojatt Adeli [10] in many different fields. But expert system had not been used previously to find solutions for disputes between owners and contractors. The reason might be attributed to the large number of decisions that should be taken for each case of disputes. As mentioned before, in this research, two types of differing site conditions were considered in building the expert system. The main reasons of choosing these two types of differing site conditions will be discussed in the coming paragraphs.

3. The Area covered by the system

Differing site conditions include many factors. In a previous study [11,12] it was found that there are six main causes of claims in Saudi Arabia. Differing site conditions claims are the most important cause. These causes are listed in tables 1 and 2 [11]. Table 1 shows the causes of claims after studying 432 cases. Table 2 shows the nine causes of the differing site conditions claims. As seen in table 2, suitability of soil for foundation and ground water conditions are the most frequent claims that cause disputes.

Table 1
Number and percentage of types of claims [11]

Claim type	Percentage
Delay claims	28.70
Change order claims	23.84
Differing site conditions claims	17.82
Additional work claims	15.74
Contractual claims	10.41
Accelerating claims	3.47
Total	100

Table 2

Types of differing site conditions claims [11]

Type No	Type of claim	Percentage
1	Soil is unsuitable for foundation	38.96
2	Existence of ground water	20.77
3	Existence of underground utilities	11.68
4	Existence of hard rocks	14.28
5	Existence of sewage	2.59
6	Existence of cemeteries	2.59
7	Existence of filling materials	2.59
8	Existence of chemicals and salts	2.59
9	Existence of cavities	3.89
Total		100

4. Resource of data and data collection

Two groups of experts were selected as resources of data and helped in collecting information for the expert system:
Group 1: *Chairmen of the judicious circles*
Meetings with three chairmen of the judicious circle were organized to reach the types of questions needed for these types of claims. These selected chairmen have 27, 25, and 20 years experience in the field of judging of similar construction claims. Other meetings were carried out to take their opinions regarding suggested questions. The suggested questions were related to the rights of the contractors for claims and compensations. The main aim of referring to those experts is to compile practical questions that were judged during their long years of involvement in judicious circles.
Group 2: *Experienced Engineers*
Five experienced engineers were selected with high level of experience in governmental construction projects with supervision and management positions. Their answers were used in completing the system design.

5. Questions related to ground water table

The questions of the ground water table were divided into eight groups:
Group 1: Asking about the contractor's information about ground water generally. These questions are about:
- If the site is close to any natural water resource (sea, lakes, water streams, swamps and everglades).
- If there are any indicators of water existence.

- If the contractor was informed by the owner about the ground water table or not.
This group is intended to ensure that the contractor is not ignorant about water existence
Group 2: This group is to know if the owner told the contractor about the ground water table or there are any indicators about it in the contract documents. The questions are about:
- If there is mention about ground water table in the contract documents.
- If there are explicit indications of ground water
This group is to ensure that the contractor has knowledge about the ground water.
Group 3: To ensure that there is no surprise on the contractor side i.e. what the contractor finds in the site is totally expected. In some contracts, there is no need to mention the existence of water because of the well known nature of the site. The questions are about:
- If the contractor expects the existence of the ground water.
Group 4: To ensure that the ground water table is defined. This means that the contractor knows about the water and its level. The question is about:
-Definition of the level of the ground water table.
Group 5: To know what conditions the contractor has met during construction for comparison with those introduced before construction. The question is about:
If the level of the water was found higher than the level included in the contract.
Group 6: To know the costs that the contractor has paid to avoid the ground water table problem. These questions are according to the

case which the contractor faces; either these costs affect the monetary balance of the contract or not?

Group 7: To determine the required time to avoid the obstacle and to see if the existence of ground water will affect the schedule of the project and affect the critical path of activities network.

Group 8: Asking about the possibility of continuing the work.

Questions and decisions for this type of obstacles (existence of ground water table) are shown in Appendix A.

6. Questions related to suitability of soil for foundation

In this type of claims there are two possibilities, either,

1. a soil report was given to the contractor and during construction he discovered that the actual conditions differ from those mentioned in the report. Or,

2. the design is based on assumptions of certain value of soil bearing capacity which is different from the actual value with big difference.

Questions are divided into six groups:

Group 1: To know if there are reference standards that apply to the contractor situation then compensation would be approved.

Group 2: Asking about the impossibility to know the suitability for foundation through the site visit.

Group 3: Asking about the need to redesign for the Differing Site Conditions

Group 4: Asking about the additional costs due to GWSFC and/or redesign

Group 5: Asking about the effect of this obstacle on the project duration

Group 6: Asking about the continuity of work questions and decisions for this kind of obstacles are shown in Appendix B.

7. Decisions for ground water and soil suitability

The decision trees consist of 135 paths for ground water and 118 paths for soil unsuitability for foundation. Because of the decision trees are too large to be presented, the trees, questions and decisions are shown and tabulated using the developed code in Appendices A and B.

8. Expert system for ground water and soil unsuitability for foundation claims - GWSFC

Level 5 object oriented was used to develop an expert system program for the differing site conditions (ground water and soil conditions). In Level-5, there are Classes and Attributes [13]. Classes mean models for general specifications and attributes mean specific properties and specifications. In current code "GWSFC" the class is called QTS.

The documentation of the differing site conditions in governmental projects consists of three different sections; WHY: It gives a brief introduction as to why we use Level 5 Object.

DESIGN. Explains how the differing site condition program was developed. The *DESIGN* is divided into four sections *Classes, Displays, Methods and Data.* Each one has a hyperlink.

USING GWSFC. Explains how to use the GWSFC program for making the decision is explained.

TUTORIAL. A brief description of LEVEL5 OBJECT software and an example of the GWSFC (Differing Site Condition) is demonstrated.

9. Why level-5 objective for GWSFC

The main advantages of using level-5 objective in developing GWSFC are:

1. Easy to use by the Users.

2. Easy to install, operate and it occupies less memory.

3. The software price is comparatively reasonable.

4. Other technical hints could be easily obtained using the software manual [13]. Some of these major hints are as follows:

• Creates complex applications in an easy, consistent and maintainable fashion.

• Contains an integrated set of editors that help in creating effective software solutions

from rapid prototypes to large, mission-critical applications.

• Once an application has been created using the development system, it can be delivered to end users with the LEVEL5 AGENT (run-only) system.

• Built-in access to over 60 local and remote databases and servers, interfaces to external programs, communication paradigms, text files, timers and custom interfacing options.

• Is an expert system and can be used to create "smart" systems. It can solve the real-world problem that can't be solved with any other means.

• Contains a set of powerful tools a) True objects providing the efficiency of object-oriented programming, b) Graphical User Interface Development Editors, forms and display builders and controls over all aspects of the user interface. c) Complex logic capabilities, business rules, triggers, agendas, procedural and non-procedural modules. d) A set of debugging tools, including stepping, break points, traces, and reasoning. e) Compiled execution for efficient application speed and size.

10. Design of GWSFC

The following sections describe the design of GWSFC. As mentioned before the design is divided into classes, displays, methods, and data.

I. Classes. The term Class can be understood as a template or a model being developed by a programmer for reuse. The class is comprised of attributes or features. The different classes used in the program development of differing site conditions in governmental projects are as shown in fig. 1 below.

- Library class. The class created is used for the purpose of providing the online help during the program execution and it consists of two attributes. Fig. 1 shows Library class which includes:

CODE: Code is type of string and used to hold the values for the help code.

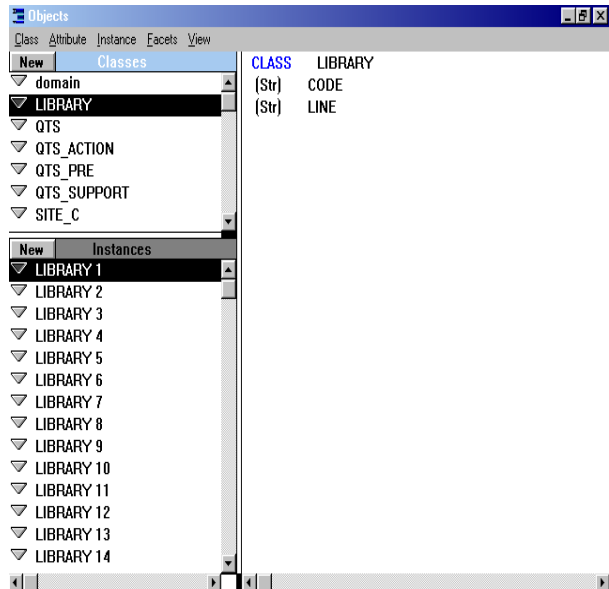*LINE:* Line is the description for each individual code.

Fig. 1. Library class.

- QTS class. The QTS class helps us in functionality of achieving a Goal of providing an expert system. The different attributes available for QTS class and their functionality are given by fig. 2.

CODE: Responsible for assigning a unique code to each question and answer.

OPT1: Consists of the CODE of the first option just after the current question as designed by questionnaire diagram to be asked to the users.

OPT2: Consists of the CODE of the second option just after the current question as designed by questionnaire diagram to be asked to the users.

BACK: Consists of the CODE of the question asked before the current question.

ANS: Contains the value "Y" if the first option of the current question is an answer.

ANSB: Contains the value "Y" if the second option of the current question is an answer.

FIRST: Contains the value "Y" if the current question is the first question of a group such as Ground Water, Different Soil Conditions, etc.

LINE1: Contains the heading for respective groups such as "Ground Water" for the questions of Ground Water problem. It also
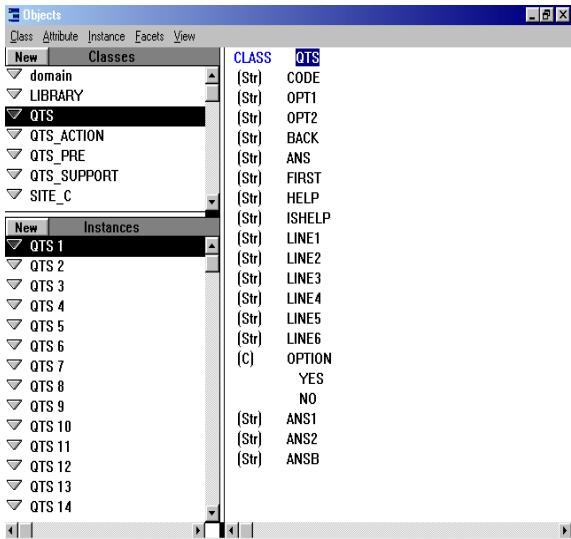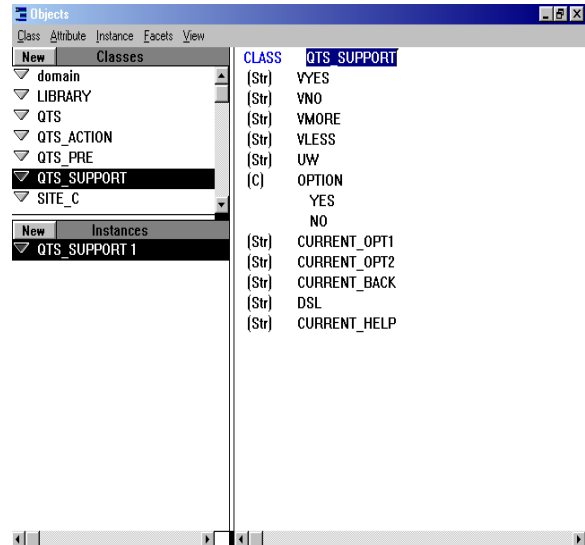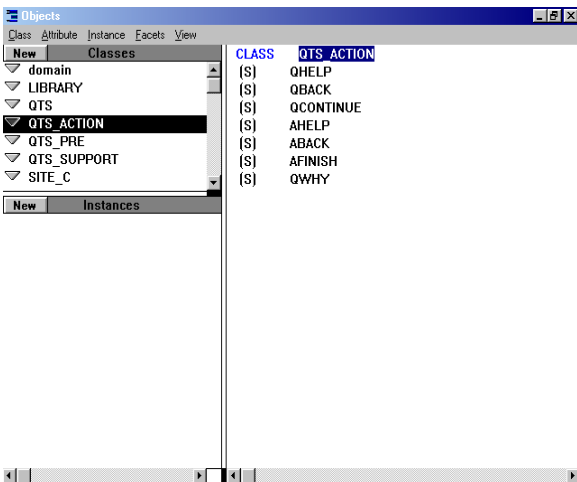
Fig. 2. QTS class.

Fig. 3. QTS action class.
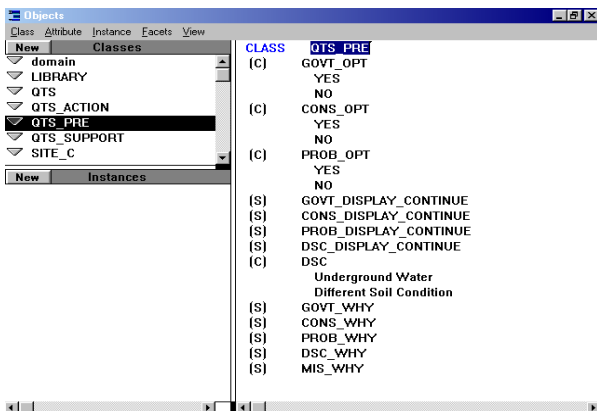

Fig. 4. QTS pre class.

Fig. 5. QTS support class.

has headings such as "Results of Ground Water" for answers.

LINE2 – LINE6: The attributes from QTS2 to QTS6 consist of the different questions available for a particular group such as "Is this site close to natural source of water?" which can be inserted in the QTS2 of one instance. Similarly, these attributes also have different Lines of Answers in the attributes from QTS2 to QTS6 for the Answers of a particular group such as "Not our mission" which can be inserted in the QTS2 of another instance.

OPTION: Contains the options available to the users for selection at the time of asking questions.

ANS1: Contains the first available choice to be displayed to the user for selection like "YES" or "More".

ANS2: Contains the second available choice to be displayed to the user for selection like "NO" or "Less".

- QTS action class. The QTS action fig. 3 class is used for controlling the navigation during the program execution. The attributes are:

Qback and qcontinue: These two attributes are responsible for the back word and forward navigation during the program execution, i.e. these two attributes hold the code for the previous and next question, respectively.
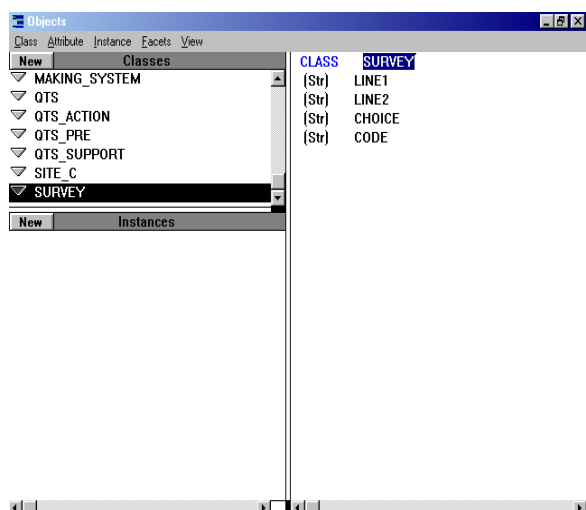
Fig. 6. Survey class.

QWHY: This attribute contains the code for the help to be displayed for each question during the program execution when the "WHY-button" is pressed.

AHELP: When an answer is displayed followed a number of questions, if the user presses the "WHY- button", then the user will get all history of its question.

ABACK: This attribute contains the code for the back questions.

- QTS_pre class. In QTS_PRE class, we have different attributes which help us in the functionality of checking and verifying the pre-requisite of the program, e.g. "for checking whether it is government contract or it is related to construction or not". fig. 4 shows QTS PRE CLASS. The attributes are as follows:

GOVT_OPT: It is a compound attribute which has two options "YES and NO". This is for checking whether it is a government contract or not.

CONS_OPT: It is a compound attribute which has two options "YES and NO". This is for checking whether it is a construction work or not.

PROB_OPT: It is a compound attribute which has two options "YES and NO". This is for checking whether the problem is for Differing Site Conditions or not.

GWSFC: It is a compound attributes which has two values "Different Soil Conditions and Ground Water". This is for selecting an option

from the provided two options.

GOVT_WHY: Along with each pre-requisite question there is a help for why this question is asked. This attribute is for the help for "government contract" question and is displayed when the "WHY-button" is pressed.

CONS_WHY: This attribute helps for "construction contract" question and is displayed when the "WHY-button" is pressed.

PROB_WHY: This attribute helps for "differing site conditions" question and is displayed when the "WHY-button" is pressed.

GWSFC_WHY: This attribute helps for options screen and is displayed when the "WHY-button" is pressed.

-QTS_support. This class is used as a support class to the QTS class. This class contains the information about the code of the first question to be asked for both options. Fig. 5 shows QTS Support Class. The attributes are as follows:

VYES AND VNO: These two attributes hold the values 'YES' and 'NO' which are used for labeling during the program execution.

VLESS AND VMORE: These two attributes hold the values 'LESS' and 'MORE' which are used for labeling during the program execution.

UW AND DSL: These two attributes hold the initial values for both options of Ground Water and "Different Soil Conditions.

OPTION: It is a compound attribute having the values 'YES' or 'NO' which are displayed along with each question. It acts as a result of the question which is asked and according which the navigation is done.

CURRENT_OPT1: It holds the value of the 'opt1' of QTS class during execution.

CURRENT_OPT2: It holds the value of the 'opt2' of QTS class during execution.

CURRENT_BACK: It holds the value of the 'back' of QTS class during execution.

CURRENT_HELP: It holds the value of the 'help' of QTS class during execution.

- Survey class. This Class is used for the history purpose during the program execution. The questions the user selected during its questionnaire, all the questions are kept as a history and is displayed when "WHY-button" on the answer display screen is pressed. Fig. 6 shows this class. The attributes are:

Fig. 7. Data of QTS.

Fig. 8. Data of QTS (cont.).

LINE1 AND LINE2: Contains the question itself that was asked to the user during the questionnaire.
CODE: Contains the code for the question.
CHOICE: The choice selected by the user for each question during the questionnaire as 'YES' or 'NO' or 'LESS' or 'MORE'.
II. Displays:
A display is an interactive visual form in a window. A display can contain text, pictures, buttons, animation, lists, tables, video, file data and current information from the application itself. More important the user

interacts with LEVEL5 OBJECT applications primarily through displays. The displays will be shown in using GWSFC.
III. Methods
A method is a series of commands that are associated with an attribute. In LEVEL5 OBJECT, we can write methods for a specific attribute in order to determine the attribute's value or execute a series of actions when the attribute's value changes. There are two types of methods WHEN-NEEDED and WHEN-CHANGED method. The methods which are related to the program are as shown below.
IV. Data
Differing site conditions program contains a class called QTS. In the class QTS, different attributes exist which help in functionality of achieving a goal of providing an expert system. All the data pertaining to our questions and answers are stored in the objects of QTS class. The attributes of the QTS class with the data that is used in the differing site conditions program are shown below. Figs. 7 and 8 show the data of QTS class.

11. Using GWSFC

As the program runs automatically, the program user will get the main menu of the *differing site conditions* application. The menu consists of the three options, start program, documentation and exit. The start program option is activated when user clicks the start program option then, *differing site conditions* program will run.

The documentation option will navigate the user through the documentation of this application. The documentation contains all the information of the *differing site conditions* application, such as how it is designed, developed and how to use the application. The exit option, upon clicking this option the user will come out of this application.

The differing site conditions program is a decision making software, which helps the user of this application in making decisions as quickly as possible. This program is related to governmental organizations and those highly specialized in construction claims in the areas of Ground Water and Different Soil Conditions.

When the user clicks start program option then, a title menu of the program will appear which consists of three options 'BACK', 'CONTINUE' and 'WHY'. The 'BACK' option always navigates the user in the backward direction of the program. The 'CONTINUE' option always navigates the user in the forward direction of the program. The third option 'WHY', displays the user, information regarding the question such as, 'why this question is asked'. The three options along with the answer choice 'YES/MORE' or 'NO/LESS' is displayed on every question. The user must choose the answer, and then click either 'CONTINUE' to navigate to the next question or 'BACK' to navigate to the previous question or click 'WHY' to see information about why this question is asked.

The program has three basic questions that will be asked as soon as the program starts, these questions are related to the project. As, this project deals only with the Governmental Organizations in their construction contracts related to the *Differing Site Conditions* specialization in the 'Ground Water & Different Soil Conditions'. These are the three basic questions that will be asked to the user of this program, the user must select the answer of these three basic questions always 'YES' to navigate in forward direction, if the answer selected is 'NO', then the program answer 'NOT OUR MISSION' will appear.

After the three basic questions, the user will be given two options which indicate the type of problem i.e. either 'Ground Water or Different Soil Conditions' as shown in fig. 9. The user must select one of the problems and then click 'CONTINUE'. Now, the user will get the first question related to the option he selected, along with the two answers i.e. 'YES/MORE' or 'NO/LESS' and three options as shown in fig. B when the user selects the 'Ground Water' option.

Here the user can select the answer as either 'YES' or 'NO' and must click continue to navigate to the next question. If the user clicks 'WHY' he gets a window showing the user information regarding why this question is asked as shown in fig. 10. Depending on the answer of the user, the program will navigate in the forward direction if the user clicks 'CONTINUE' by selecting the answer of every

question asked. After a series of questions, the 'result' of the program depending on the answers will appear at the end of the last question. The 'result' of the program is shown in a separate display which consists of the 'result' and the four options 'BACK', 'WHY', 'FINISH' &'OPTION' as shown in fig. 11. If the user clicks 'WHY' he will get another window giving all the questions he has selected during the questionnaire as shown in fig. 12. The click on 'FINISH' navigates the user to the title screen, and click on 'OPTION' navigates the user to the type of problem screen as shown in fig. 9.
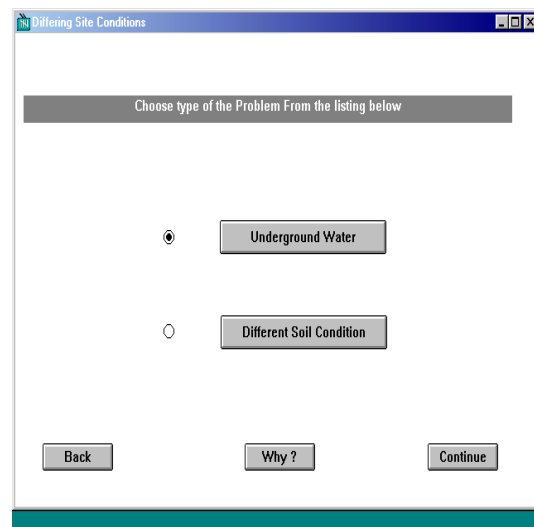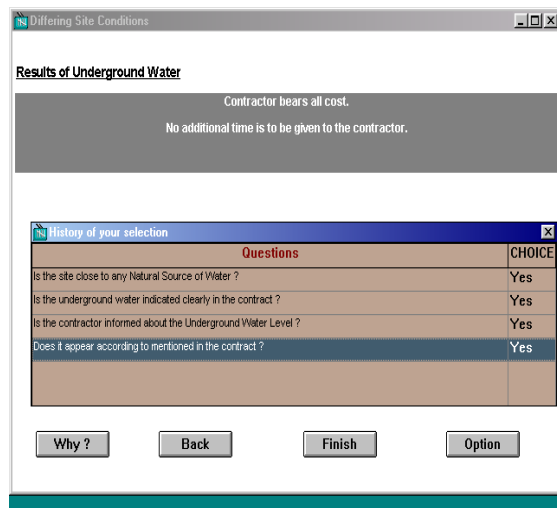

Fig. 9. Two option to choose.

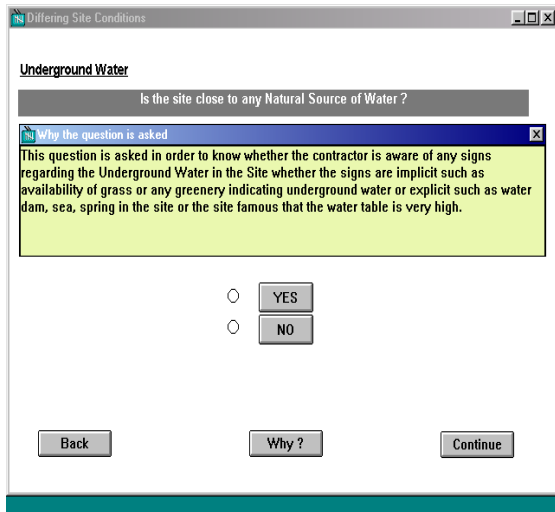
Fig. 10. 1st screen in ground water.
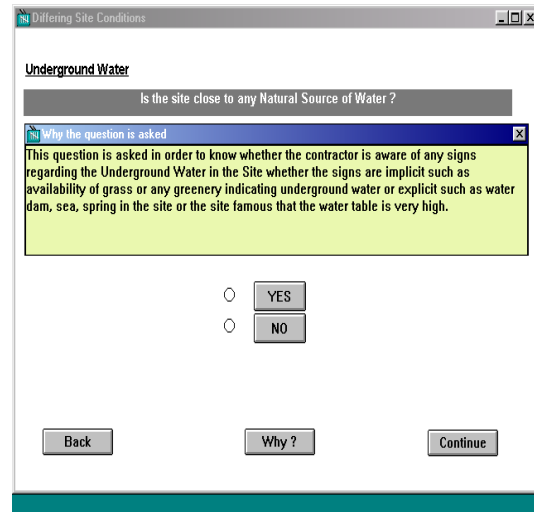
Fig. 11. Result display.

Fig. 12. Review of all questions in specific situation.

12. Conclusions

Differing site conditions are widely variable. Ground water and unsuitability of the soil for foundations are two of the differing site conditions which lead to claims in high percentages. Solving claims need the arbitrator to know all technical and legal terms of the case. However, there are some common procedures which can be followed in solving claims of ground water and Soil Unsuitability for foundations. The data and decisions of two different site conditions were investigated using questionnaires that were filled out during official meetings with groups of experts in claim solving. The type of questions and the suitable answers were collected from the experts and the decision trees for both conditions are presented (135 paths for ground water and 118 paths for unsuitability the soil for foundation). An Expert System program GWSFC was developed using level-5 objective. The reasons for choosing level-5, design of the program, development of GWSEC, and how to use the program are presented.

Appendix A

Table A
Flowchart of existence of ground water is tabulated by the following table

QUESTIONS			
Code	Description	Code	Description
A1	Is the site close to any natural source of water?	A2	No- Is there any indications of existence of GW?
A3	No- Is the GW indicated clearly in the contract?	A53	No-Is there any illegal expedition?
A84	Yes- Is the GW indicated clearly in the contract?	A7	Yes-Is such indication clearly mentioned in the contract?
A5,9,11,14,17,19,21,68,87,96,110,130	No-Does this affect the schedule of the project?	A10	No-Is there any unexpected cost?
A52,64,74,90,101,113,118,129	Yes-Does this affect the schedule of the project?		
A23,44	Yes-Was the level of GW indicated in the contract?	A13,43,106	Yes-Is the contractor informed about the GW level?
A24	No-Was the level of GW indicated in the contract?	A15,16	Yes-Does this affect the schedule of the project?
A18,20,27,35,39,41,48,55,59,65,69,75,78,82,89,93,99,104	Yes- Will the contractor continue the project?	A25,28,31,34,37,38,40,42,50,51,56,61,62,63,66,	No-Is it impossible to continue the project?

,112,116,124, 131		71,72,73,76,79, 81,83,92,94,98, 100,103,105,115 ,117,120,127, 128,133,134	
A26,36,49,57,60,67 ,70,80,88,91,97,10 2,111,114,119,125, 132	No-Will the contractor continue the project?	A29,32,46,122	No-Is the ground water level higher than that was indicated in the contract or less?
A30,33	More- Will the contractor continue the project?	A45,85,107,	No-Is the GW expected to exist the project site?
A47	More-Does this affect the schedule of the project?	A4,8,12,58,108	No-Does this affect the financial balance of the contract?
A6,109	No-Was there any additional cost claimed by the contractor?	A54,95,126	Yes-Does this affect the financial equilibrium of the contract?
A77	Yes-Was there any additional cost claimed by the contractor?	A22,	Yes-Is there any unexpected cost?
A121	Yes-Does it appear according to mentioned in the contract?	A86	No-Is there any unexpected cost?
A123	More-Does this affect the schedule of the project		
1	Is it a governmental project	2	Not our mission
3	Is it construction project	4	Not our mission
5	Is it the problem considered as Differing Site Conditions?	6	Not our mission
7	Choose the type of the problem from the list below -Ground Water - Soil Condition	8	Ground Water
DECISIONS			
Code	Description	Code	Description
AR1,8,26,36,38,55, 67,80,84,104,113, 123,134	-Contractor bears all costs -No extension of time is given to the contractor	AR4,9,39	-Contractor will be paid according to the contract.
AR3,7,12,15,18,20, 23,25, 27,29,32,35, 37,42,45,48, 51,54,57,60, 63,66,69,72,75,79, 83,88,91,95,98,101 ,103,105,108,111,1 16,119,122,125, 128,131,133,135	-Contractor will be given the allowable period and in case of discontinuation, the penalty item in contract will be applied.	AR2,6,11,14,1 7,22,28,31,34, 41,44,47,50,53 ,56,59,62,65,6 8,71,74,78,82, 87,90,94,97,10 7,115,118,121, 124127,130	-Contractor will be given the actual cost with expected profit plus all losses
AR5,30,58,92,96	-Contractor will be compensated for the cost of difference of water elevation plus the profit. -Contractor will be given extension of time.	AR10	-Contractor will be compensated for the cost of difference of elevation plus the profit. -No extension of time is to be given to Contractor.
AR13	-Contractor will be given the actual cost. -Contractor will be given extension of time.	AR16	-Contractor will be given the actual cost. -No additional time is to be given to contractor.
AR19,24,49,64,77,1 02,112,120,132	-Contractor bears all costs. -Contractor will be given extension of time.	AR21	-Contractor will be paid all his costs. -Contractor will be given the actual time.
AR33,93	-Contractor will be given the difference in value logically. -Contractor will be compensated for the severe losses.	AR40	-Contractor will be compensated for the cost of difference in elevation. -Contractor will be given extension of time.
AR43,89	-Contractor will be compensated for the cost of difference in elevation. - No extension of time is to be	AR46	-Contractor will be compensated for the severe losses. -Contractor will be given the extension of time.

|			
	given to contractor.		
AR52,117	-Contractor will be compensated for the severe losses. -No additional time to be given to contractor.	AR61,99,129	-Contractor will be given the difference in value. -No extension of time to be given to contractor.
AR70	-Contractor will be given all his lost profits and compensated for all losses -Contractor will be given extension of time	AR73	Contractor will be given all his lost benefits and compensated for all losses
AR76	-Contractor will be given actual cost with profit -Contractor will be given extension of time	AR81	Contractor will be given actual cost with profit -No extension of time to be given to the contractor
AR85	Contractor will be paid according to the contract	AR86	-Contractor will be compensated for the cost of difference in water elevation. - Contractor will be given extension of time.
AR100	Contractor will be given the actual cost for what he has accomplished	AR106,114	Contractor will be compensated for the severe losses. -Contractor will be given extension of time
AR110	Contractor will be given the actual cost only	AR126	-Contractor will be given the difference in value. -Contractor will be given extension of time
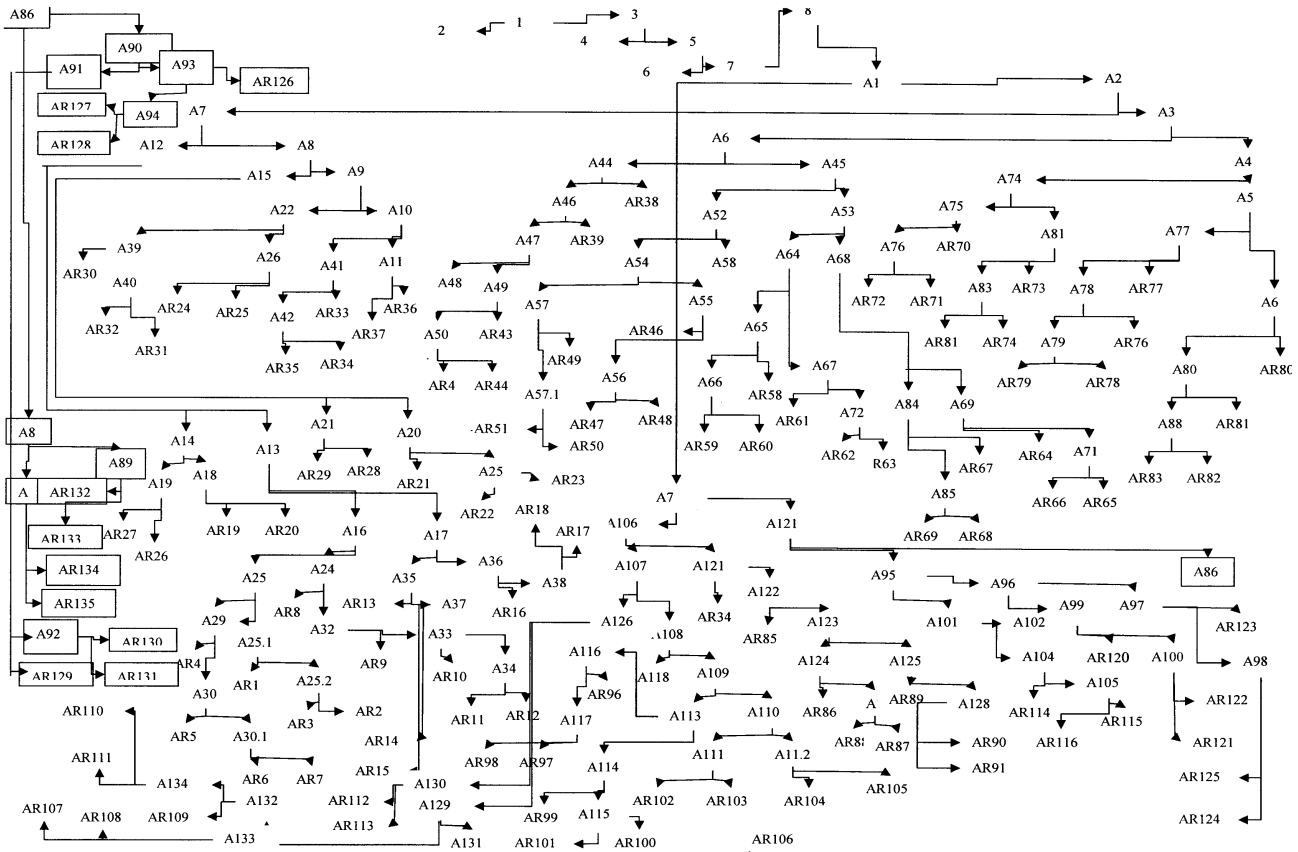
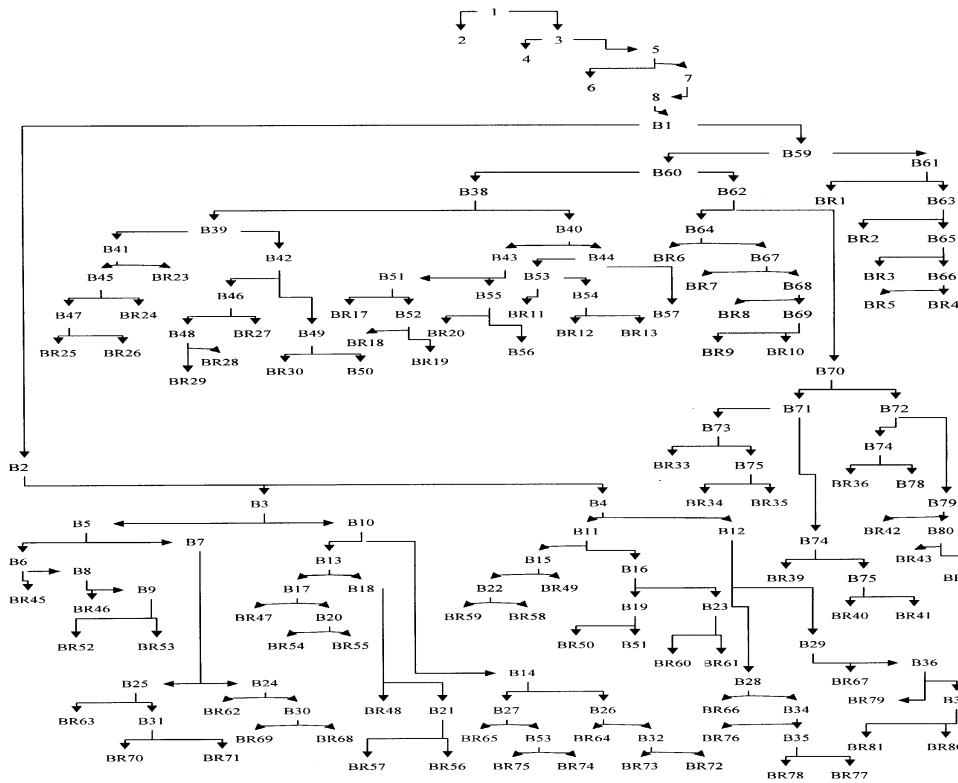Fig. A. Decision tree for ground water condition.

Appendix B

Fig. B. Decision tree for unsuitability of the soil for foundation.

Table B
Flowchart of unsuitability the soil for foundation

QUESTIONS			
Code	Description	Code	Description
B1	Is the soil report handed to the contractor?	B2	Is it impossible to know the suitability of the soil by visit?
B3,4,38,62	Do we need to redesign the structure if the soil report differs from the assumption	B60	Is it impossible to know the difference during site visit?
B5,64,70	Is there additional cost due to the change?	B6,7,13,14,15,16, 28,29,41,42,43,44 ,61,63,67,71,72	Does this affect the schedule of the project?
B8,17,18,19,22,23 ,24,25,26,27,34,3 6,45,46,49,51,53, 55,57,65,68,73,74 ,76,79	Does the contractor decide to continue the project?	B9,20,21,30,31,32 ,33,35,37,47,48,5 0,52,54,56,58,66, 69,75,77,78,80	Is it impossible to continue the project?
B10,12,40	Is there any other cost aside from redesigning?	B11,39	Does the change constitute additional cost?
B59	Was the soil conditions disclosed by contractor included in the report?		
DECISION			
Code	Description	Code	Description
BR1,3,6,23 ,45,49	-Contractor bears all costs -No extension of time to be given	BR2.46	Contractor will be given extension of time

	to contractor		
BR4,9,12,15,18,21,25,28,31,34,37,40,43,50,52,54,56,58,60,68,70,72,74,77,80	Contractor will be given the necessary period and in case of discontinuation the penalty item will be applied	BR5,10,13,16,19,22,24,26,29,32,35,38,41,44,51,53,55,57,59,69,71,73,75,78,81	Contractor will be given the actual cost with expected profit plus all losses
BR7,27	-Contractor will be given the actual cost plus profit - No extension of time to be given	BR8	-Contractor will be given the actual cost -Additional time to be given to contractor
BR11,14	-Contractor will be given the actual cost plus profit -Contractor will be given cost of redesign and time required for redesign -No extension of time to be given	BR17,47	Contractor will be given additional time and cost of redesign only
BR20	-Contractor will be given extension of time and cost of redesign -Contractor will be given extension of time.	BR30	-Contractor will be given the actual cost plus profit - Contractor will be given additional time.
BR33	-Contractor will bear the redesign cost - Contractor will bear all costs - No extension time	BR36,67	-Contractor will bear the redesign cost -Contractor will be given the actual cost plus profit -No extension of time
BR39	-Contractor will bear the redesign cost -Contractor will be given extension of time logically	BR42,79	Contractor will bear the redesign cost -Contractor will be given the actual cost plus profit - Extension of time will be given
BR48	-Contractor will be given redesigning cost -Extension of time will be given	BR61	-Contractor will bear the additional cost -Contractor will be given extension of time
BR62	-Contractor will be given the additional cost due to changes -No extension of time to be given	BR63	-Contractor will be given the additional cost due to changes -Extension of time will be given
BR65	-Contractor will be given the extension of time aside of redesigning plus the profit -Contractor will be given redesign cost	BR64	-Contractor will be given the cost of redesigning plus the profit -Contractor will be given redesign cost
BR66	-Contractor will bear the redesign cost -No extension of time	BR76	Contractor will bear the redesign cost -Extension of time will be given

Note:
Sever loss = dramatic loss i.e. big amount of loss happened to the contractor

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