CIVIL ENGINEERING

An expert system to manage dispute resolutions in construction projects in Egypt

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Abstract This study attempts to shed a great deal of light on the problem of construction disputes in the Egyptian projects. This paper presents a comprehensive review of the available literature on analysis of disputes. The objective of this paper was to provide an expert system can evaluate the overall dispute settlement procedures at company's projects. A questionnaire has been used to study dispute sources and resolution methods. Four case study applications have been provided to check the validity of the proposed system. Results confirmed that the most important source of disputes was contract management 74.04%, the second was contract documents 71.49%, the third was financial issues 67.80%, the fourth was project related issues 63.92%, and the lowest one was other sources (such as force majeure) 61.58%. Finally, the expert program facilitates dispute resolution by using alternative dispute resolution methods instead of going direct to arbitration or litigation.
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1. Introduction

Construction industry in Egypt suffers from the misunderstanding of dispute resolution management; many factors affect the development of dispute resolution. Over the last years, there has been a breakdown in the relations between parties involved in the construction processes. Several studies have been reviewed which present the disputes' definitions, nature, parties, classification, causes and resolution in construction projects. Richard [1], defined a dispute as "a specific disagreement concerning a matter of fact, law or policy in which a claim or assertion of one party is met with refusal, counter – claim or denial by another", Diekmann and Girard [2], described dispute as "any contract question or controversy that must be settled beyond the jobsite management

staff'', Corby [3], defined dispute as ''a difference between the parties after the internal procedure has been exhausted'', and Cheung and Yiu [4], stated that dispute is ''a regular feature in construction and consumes resources that would otherwise be used in a more productive manner''. It can be said that a dispute only appears after a claim has been made and been rejected , Ndekugri and Russell [5].

Bunni [6], specified that one of the main reasons that can affect the completion of projects is disputes. It is normal to have disputes in construction projects related to contract nature. Thomas [7], stated that the nature of disputes arising from engineering contracts may range from trivial disputes to disputes that threaten the viability of the underlying transaction. Steen [8], stated that the construction industry has become known as one of the most adversarial and problem-prone, with claims and disputes on construction projects frequently the rule rather than the exception. The large risk that can be resulted from disputes existing, requires fair resolution methods.

Roxene [9], stated that in a typical construction project, the owners, donor agencies, project managers, field engineers, general contractors, subcontractors, and suppliers are the primary stakeholders. So when disputes arise in a construction project, some or all of the stakeholders are the dispute parties. Without exception, disputes involve, misunderstandings, conflicting solutions on the issues, and communication dynamics between the parties. Bunni [6], said that disputes are a reality in any construction project, as the construction contracts always have many parties. Construction contracts are different from other contracts in many points such as; the large number of contract parties, numerous tasks to be implemented, and the large period of execution. UNITAR [10], suggested that in case of dissimilarity the parties have a choice to select the laws and jurisdiction of courts of the country to which either of the parties belong to or of a neutral or third country. Such a choice is made at the time of entering into the contract.

Shin and Molenaar [11], made classification for disputes based on definition of disputes and analyses of disputes for his related research, and the proposed three major types of disputes are contractual, organizational and technical disputes. Contractual disputes include definitions, interpretation, and clarification of the contract. Contractual issues cause a significant portion of disputes in many projects. Organizational disputes are related to human behavior in project operations and include human interactions, personality, cultures, and professional background among project stakeholders. Technical disputes are considered as the most common issues in project operation and include engineering clarification, which is a part of engineering decision making processes.

Fenn, Hall, and Carmicheal [12–14], have identified the causes of construction disputes that are caused by client, designer and contractor. Fenn and Speek [12], identified the following factors for the client as failure to respond in timely manner, poor communication among members of the team, inadequate tracing mechanism for request of information, deficient management, supervision and coordination efforts on the part of the project, lowest price mentality in engagement of contractors and designers, the absence of team spirit among the participants, reluctance to check for constructability, clarity and completeness, failure to appoint a project manager and ambiguities in contract documents. Hall [13], identified causes of construction disputes caused by the consultant such as

failure to understand the responsibilities under the design team contract, over design and underestimating the costs involved, late information delivery and cumbersome approach to request for information, design and specification oversights and errors or omissions resulting from uncoordinated civil, structural, architectural, mechanical and electrical designs and incompleteness of drawings and specifications. Carmicheal [14], identified causes of construction disputes caused by the contractor as follows: inadequate contractors' management, supervision and coordination, delay/suspension of works, failure to understand and correctly bid or price the works, Inadequate CPM scheduling and update requirements.

Zakzok [15], mentioned peaceful resolution of the dispute which passes before reaching the judiciary or international arbitration that those responsible for the project have to be aware of the causes of conflict and work to avoid them in the beginning of the project and the speed of handling and decision-making with their claims. Nosair [16], provided a sound solution to the construction disputes problem. This will be through the development of an expert system that can materially help to reduce the likelihood of construction disputes. The output of the proposed system is a reliable prediction for the expected causes of disputes for any future project. Nicholas Gould [17], searched for how disputes arise and then taking proactive steps to avoid them communicating well and looking for objective solutions and avoiding conflict can also help once the project is under way. A commercially based settlement, either in negotiation or by mediation, is now frequently used in the construction industry. Use of a mediator or some other ADR process can resolve disputes more quickly, saving time and money. If all of this fails, there are of course the procedures of arbitration and litigation. While they are applicable occasionally, they are best avoided if possible. Howard Klein [18], looked at all procedures currently being used by UK employers, professional advisors, project managers and contractors to resolve their disputes. All of them normally at lower cost and reduced time than would be incurred in Arbitration or Litigation, to ensure that contractors benefit from prompt ensuing cash flow necessary for their survival and well being, and thereby the UK's construction. Verster [19], showed the professional how by communicating effectively and continuously, disputes can be minimized. It also proposes some procedures to enable all functionaries and parties to the contract to focus on achieving the project objectives. It is advised that the building blocks for resolving differences should be communication, conciliation, adjudication and mediation, with arbitration or litigation as a last resort. El-Adaway and Ezeldin [20], investigated how arbitration is used as a dispute resolution mechanism in Egyptian large scale
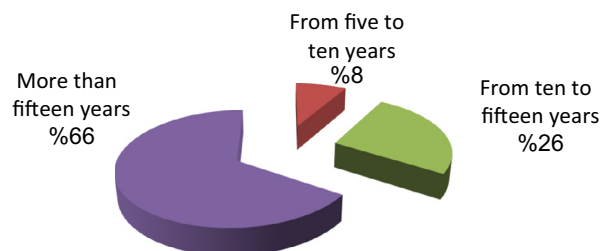

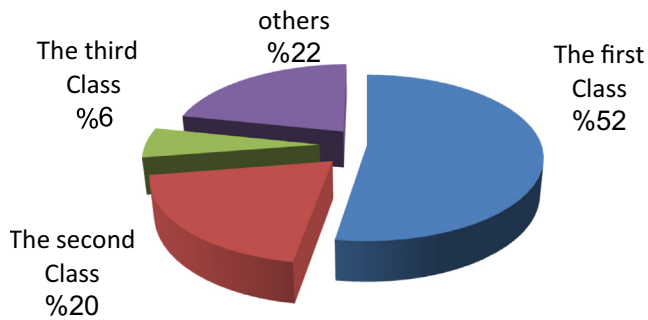**Figure 1** Ranges of respondent companies' experiences.

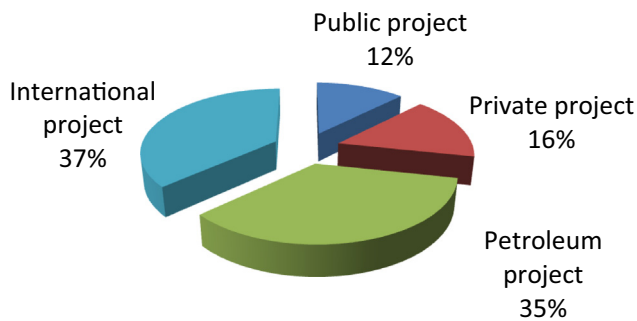**Figure 2** Different companies' classes as per (EFCC).

Figure 3 Ranges of respondents' project nature.

construction projects; a research project was conducted to study the arbitration process for a dispute that was in excess of $31 million, which arose out as a result of the proceeds of a large-scale project with an original contract price of $85 million that was constructed in Cairo, Egypt. Their research project analytically investigated the background of the conflicts, the arbitral proceedings, and the award issued by the arbitral tribunal. Based on such thorough study, it was concluded that arbitration did not provide a timely and cost-effective resolution for the said dispute. It is perceived that his paper would trigger professionals to think of other suitable dispute resolution mechanisms, such as dispute review boards, for settlement of disputes arising from Egyptian large scale construction projects. Furthermore, this study would be valued for contractors and owners who intend to work in the Egyptian construction market. Zakzok [15], developed a framework to assist contractors in calculating lower limits of dispute value. The proposed framework, named Minimum Acceptable Negotiation Amount, is a decision support system which consists of three

modules: duration, certainty and intention. These modules capture the main characteristics of negotiation process including expected dispute duration in case of litigation, certainty of litigation, and contactor's intention to make the litigation. He also described the characteristics of these three modules and their associated factors which have been determined based on interviews with experts and questionnaire surveys. El-Adaway et al. [21], searched for the most suitable dispute-resolution mechanism for large-scale construction projects in Egypt. This dispute-resolution mechanism was attained through a multi step methodology that started with the study of the Arbitration process in relation to an Egyptian construction project with an initial contract price of 85 million; continued with interviews of five senior experts in the field of construction disputes in Egypt about their views pertaining to the most efficient dispute-resolution methodology for Egyptian megaprojects; developed a tailored questionnaire to assess the perceptions of 35 professionals toward the issue of construction disputes and dispute resolution mechanisms, including DRB; finally concluded by carrying out a what-if scenario for the arbitration case of the large-scale construction project using DRB instead of arbitration. On basis of the analysis of the methodology, the authors concluded that despite the wide range of current dispute resolution methodologies, the employment of DRB should mitigate the negative effects of disputes in Egyptian large-scale construction projects. Okharedia [22], showed how South Africa has successfully used ADR (refers to a set of practices and techniques aimed at permitting the resolution of legal disputes outside the courts. The practice and technique of ADR comprises negotiation, mediation, conciliation, arbitration, and a variety of ''hybrid'' processes by which a neutral person facilitates the resolution of legal disputes without formal adjudication.) to settle dispute. How this method used by other countries such as Ghana, Nigeria, Ethiopia, Malawi and other African countries. The main objective is to keep disputes out of the normal court system in an effort to cut down the cost of resolving the dispute among the parties.

The present study is thus an attempt to extend the previous studies by investigating the disputes' definitions, nature, parties, classification and resolutions in construction projects. From the authors' point of view, the studies which were conducted on disputes settlement procedures are too few but rather rare especially on causes of disputes. So this research may be a good starting point for the study by applying a decision support system that helps the contract parties to estimate their performance in dispute management, settle disputes through proposed ADR methodology and provide recommendations in these issues.
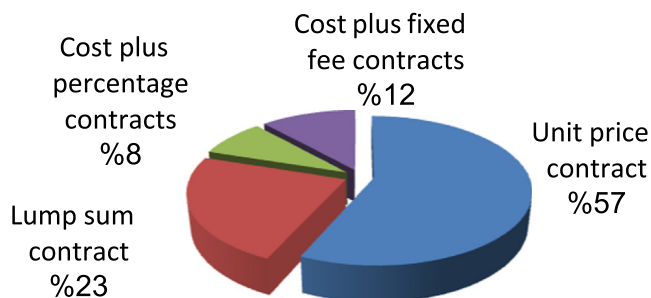

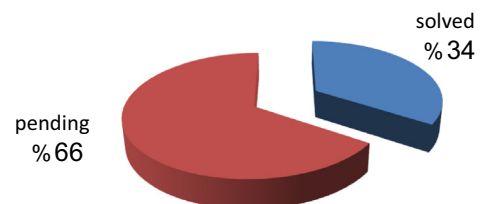**Figure 4** Ranges of respondents' contract types.

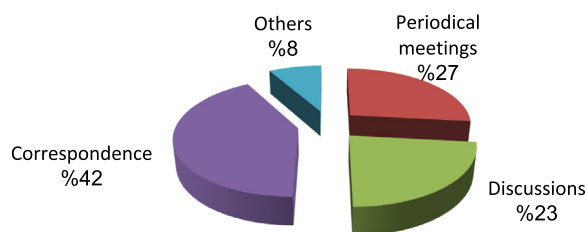**Figure 5** Status of disputes faced by respondents' companies.

Figure 6 Dispute notification methods considered by respondents' companies.

2. Questionnaire design

2.1. Domain of experts

Interviews and e-mails have been successfully implemented with 120 experts with different scope of experiences in the Egyptian construction industry and different years of field experience for each construction category. They also were selected with suitable period of experience so that their answers can represent valuable information. The studied population was the companies working in the fields of: concrete structures, buildings, steel, roads, water and sewage plants, and electromechanics. The analysis of data shows some interesting findings regarding the selected experts as companies' experience, classes as per (EFCC), project nature, contract type, status of disputes, dispute notification methods and disputes rates during the last five years considered by respondents' companies as shown in Figs. 1–7.

2.2. Method of data analysis

As provided by Odeh and Battaineh [23], the frequency of each type of claims is determined by giving weight for each class of frequency as chosen by the respondent, then calculates its weighted average and importance index is detailed in the following.

A weight in a scale from 1 to 4 was given for each of the four frequencies with a weight of 1 for "Seldom", 2 for "Sometimes", 3 for "Often", and 4 for "Always". No weight was given when no response was provided.

$$\text{Weighted Average} = \sum W_i \times X_i / N \qquad (1)$$

where W_i is the weight assigned to the ith option.

X_i is the number of respondents who selected the ith option; and N is the total number of respondents (140 questionnaires
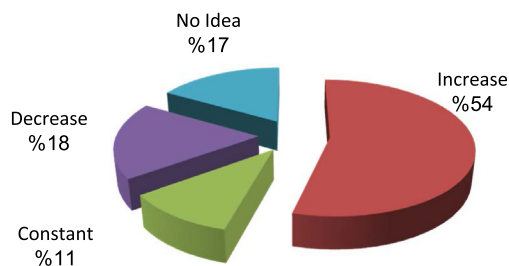
have been distributed, 120 out of 140 filled and completed by the informants in public and private projects in Egypt, and then analyzed).

To better express the importance of the questionnaire responses, an importance index percentage was then calculated:

$$\text{Importance Index } \% = \text{Weighted Average} \times 100/h \qquad (2)$$

where h is the highest scale $= 4$.

2.3. Results and discussions

The results of analyzing main sources of disputes are distributed into five groups as shown in Fig. 8.

Fig. 8 shows a summary of IP.I% of sources of disputes. The first most important source of disputes among the five groups, is the "contract management", then the "contract documents" and the "financial issues" are the third, the "project related issues" is the forth, and finally "other sources" is the fifth, which respectively had Ip.I percentages as 74.04%, 71.49%, 67.8%, 63.92%, and 61.58%.

The results of analyzing modern methodologies to settle disputes in construction projects are categorized into eight methods (Negotiation, Mediation, Conciliation, Fact-Finding, Dispute Adjudication Board (DAB), Mini-trial, Arbitration and Litigation). Five factors have been identified through the literature review and consulting experts who affect choices of each method and these factors as shown in Figs. 9–13.

3. System design and equations

In this section, phases of the development of the knowledge based system for representing alternative resolution technique for construction disputes will be illustrated (the current version of the system will be referred as DRExM). The overall architecture of DRExM will be presented. The detailed structure of each source of disputes phase will be briefed including contract management, contract documents, financial issues, project related issues and others. On the other hand, the procedures of evaluation and the results of the validation process of the proposed DRExM system will be discussed. DRExM is developed for all types of construction projects in Egypt. The system can predict the expected alternative resolution technique of construction disputes for the users depending on user's project information, dispute nature and relation with other project parties.

The expert system depends on the Rule IF Condition and then Action according to the current situation and dispute
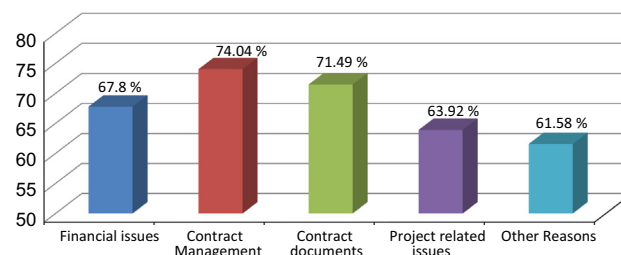

Figure 7 Disputes rates during the last five years considered by respondents' companies.

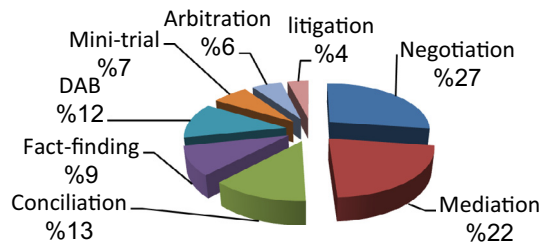**Figure 8** Sources of disputes importance index percentage.

Figure 9 Most useful disputes' resolution methods from Questionnaire Results.

status to choose the suitable procedure for settlement as per the following:

- The first choice is negotiation.
- The second choice is between two procedures (mediation via conciliation).
- The third choice is between four procedures (DAB, fact-finding, mini-trials, and expert system).
- And the fourth and final choice is arbitration.

It can describe every item for every question that is asked to the user. The user of the system has the ability to show all items that affect every construction dispute. Also, the system can save user's project information, user inputs (user's answers), and systems output ADR for disputes. Then, the user can retrieve the saved data and he can update the data and rerun the system to show the new construction disputes.

3.1. Architecture of the expert system and verification

As the problem of defining the construction disputes is well defined and the knowledge is available in the form of recommendations, the rule based knowledge representation technique (Visual Rule Studio's production Rule System) was selected to implement the expert system.

DRExM uses an integration of computer software such as Visual Basic, Microsoft Access, and Visual Rule Studio. The windows environment involves Visual Basic Environment, Microsoft Access Database, and Visual Rule Studio.

The expert system is designed by using artificial intelligent techniques, and AI is "the branch of computer science concerned with making computers behave like humans". One category of AI is the "Expert System". An expert system is a

"computer application that performs a task that would otherwise be performed by a human expert". Legal expert systems therefore use artificial intelligence techniques to help computers apply the law to any given set of facts.

According to Nilsson [24], AI is concerned with intelligent behavior in artifacts, which involves perception, reasoning, learning, communicating and acting in complex environments. Ultimate goal of AI is generally perceived as the development of machines that can do what humans can, or possibly even better. Another goal of AI can be defined as understanding this kind of behavior whether it occurs in machines or in humans. Thus, AI has both scientific and engineering goals. Coppin
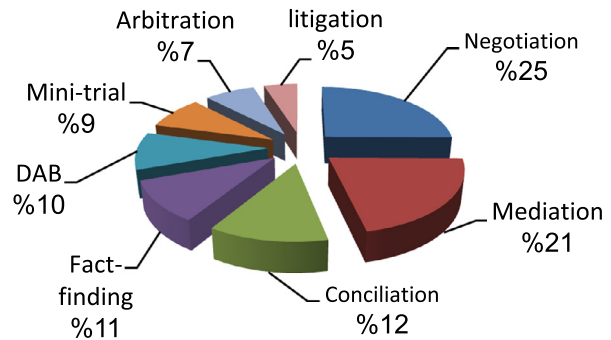

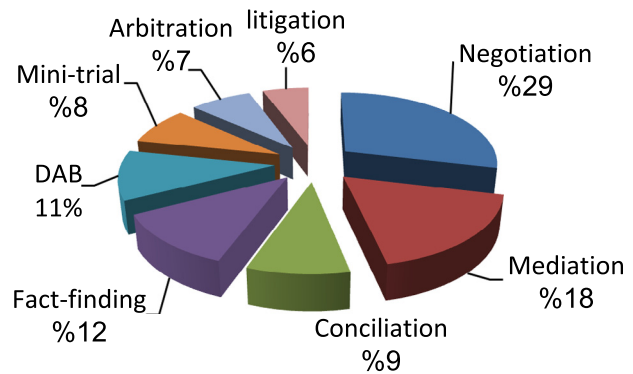**Figure 11** Effect of person in charge in disputes' resolution methods from Questionnaire Results.

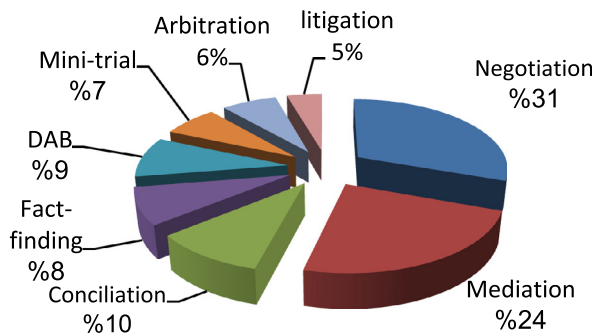**Figure 12** Less cost disputes' resolution methods from Questionnaire Results.

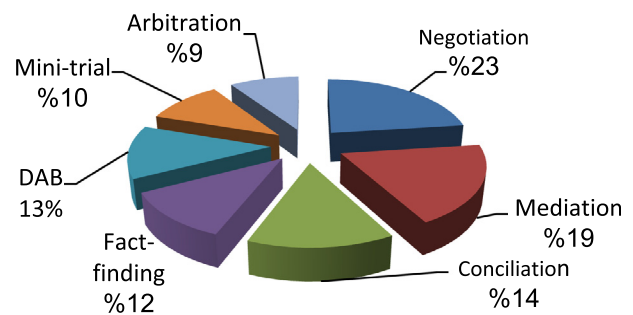**Figure 10** Fastest disputes' resolution methods from Questionnaire Results.

Figure 13 Most acceptable disputes' resolution methods from Questionnaire Results.

[25], defined AI as the study of systems that act in a way to any observer would appear to be intelligent. AI involves using tools based on the intelligent behavior of humans and other animals to solve complex problems. The wide range of applications required further categorizations of AI. The problems of AI have been divided into sub-groups such as deduction, reasoning, problem-solving, knowledge representation, planning, learning, natural language processing, motion and manipulation, perception, social intelligence, creativity and general intelligence.

On the other hand, Approaches to AI have been grouped as cybernetics and brain simulation, cognitive simulation, logical, symbolic, knowledge based AI, sub-symbolic and statistical. However, because of the diversified applications of AI, these sub-groups are still too general.

There are diversified tools used in AI research as well. The most frequently used tools in AI are search and optimization, propositional logic, first-order logic, fuzzy logic, default logics, case-based reasoning, probabilistic methods for uncertain reasoning, classifiers and learning methods, neural networks and genetic algorithms. These tools at the same time constitute the methods used in the applications and determine the approach to the problem at hand.

Cheung et al. [26], stated that the use of AI in construction dispute resolution has not attracted too great attention despite the fact that dispute resolution is an important component of project management. Chau [27], also found that AI techniques are not common and are rarely applied in legal field. AI research has become highly specialized and today, applications of AI can be seen in construction dispute resolution as well as many other areas. Although these applications are quite new and regarded as rare by many researchers, AI has already contributed to the field as more efficient use of ADR methods, more systematic approaches to dispute resolution method selection and more analytic appraisal of disputes.

Content validity test was conducted by consulting a group of fifteen experts (ten of them were specialist in construction fields and the other five were academic professors in Faculty of Engineering). That was requested to evaluate and identify whether the program design agreed with the scope of the items and the extent to which these items reflect the concept of the research problem.
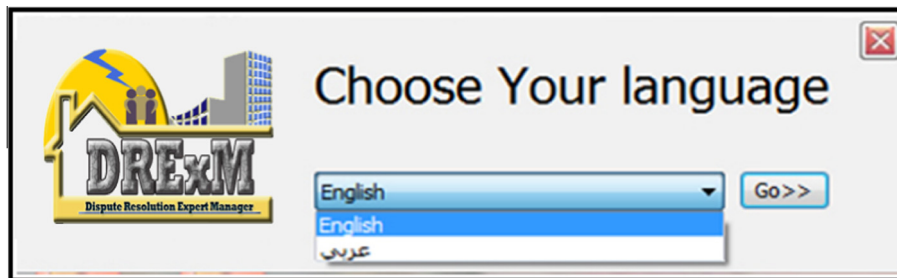

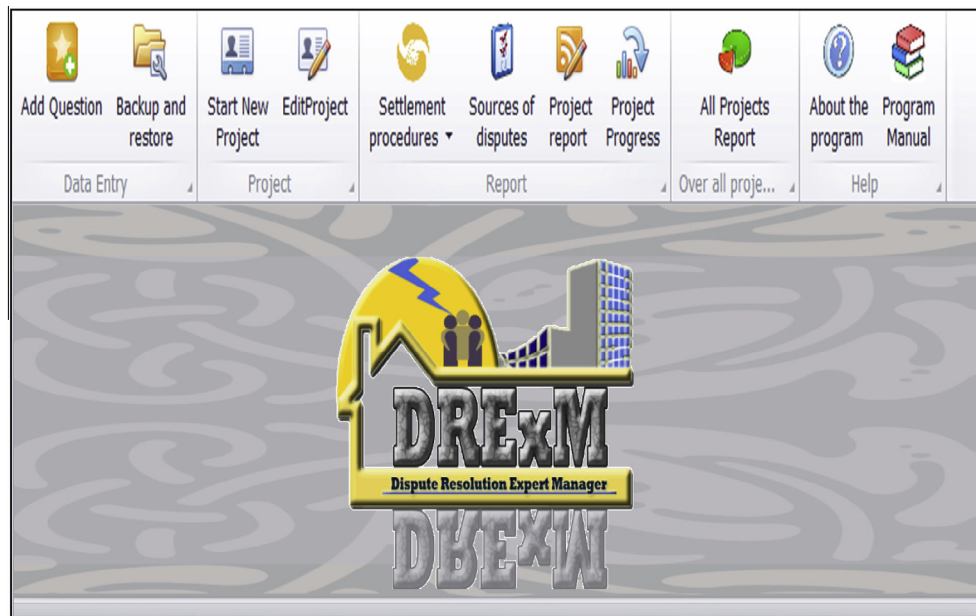**Figure 14** Program language option banner.
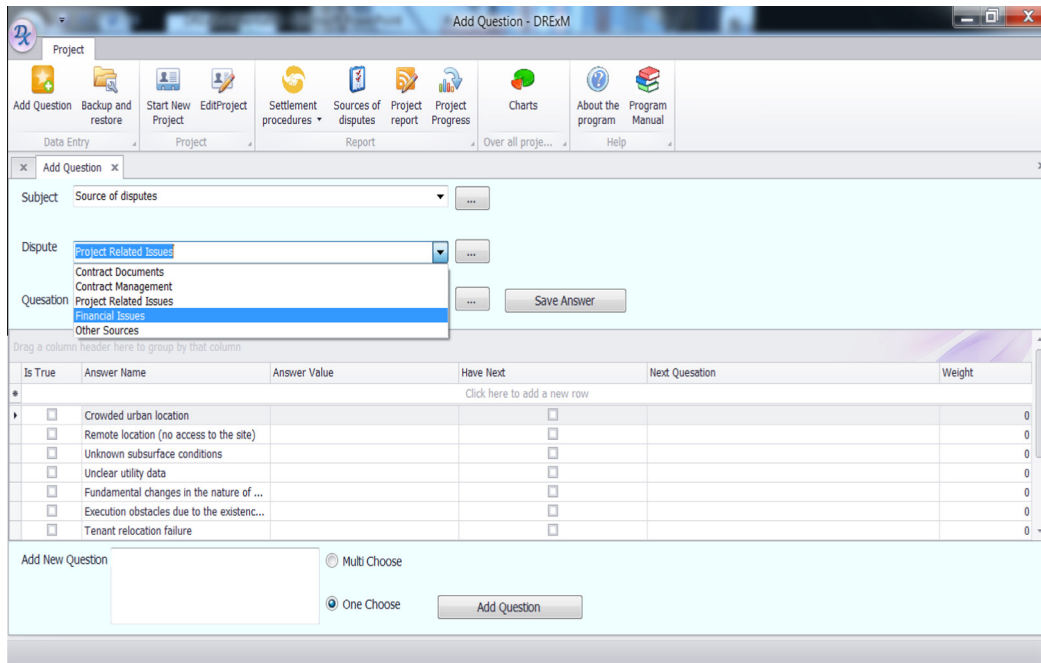

Figure 15 Program interface.

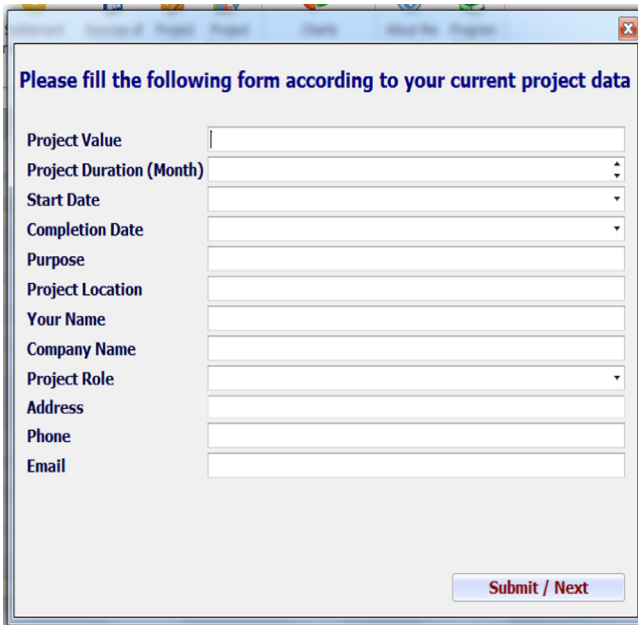**Figure 16** Add questions screen.

Figure 17 Project profile screen.

The group of experts agreed that the program design was valid and suitable enough to measure the concept of interest with some amendments which were then taken into consideration.

3.2. System operation

The proposed system was carefully designed to be easily operated. Such operating environment includes a number of menu screens that work easily in a serial order. To get the proposed system, DRExM, the program screens will appear as follows.
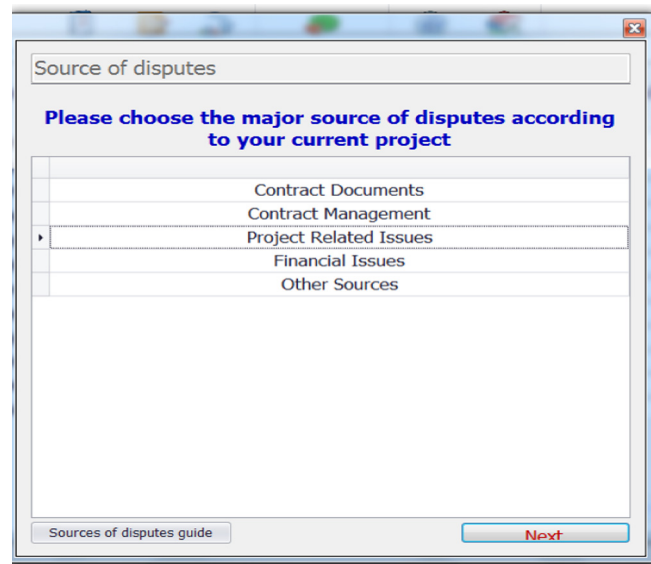

Figure 18 Part I – sources of disputes window.

The program language option banner will be displayed as shown in Fig. 14. It contains two language options English and Arabic, in order to start "DRExM" one of both options should be chosen then click go.

Then, the program interface window will be opened as shown in Fig. 15; the program toolbar at the top of interface window contains the following lists for admin interface and user interface:

- Admin interface (add questions – backup and restore).
- User interface (start new project – edit project).
- Reports (settlement procedures – sources of disputes – project reports – project procedures – charts).
- Help (about the program – manual).

Figure 19 Sources of disputes and its main causes report.

Figure 20 Causes of disputes screen.

Figure 21 Part II – settlement procedures window.

Figure 22 Window of proposed procedure definition.

Figure 23 Window of proposed procedure guide.

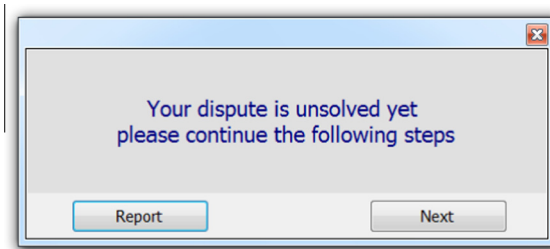

Figure 24 Decision window.

Figure 25 Precaution window for continuing procedure.

3.2.1. Program structure

By selecting Add questions icon, a new window will be opened as shown in Fig. 16; this window is considered the control room of the program where the data entry can control the questions.

The questions could be edited, sorted, or deleted from the database. Once the data have been entered, it will be saved automatically on the program database.

3.2.2. Entering the project profile

The descriptive information specifies the project cost, duration, completion date, work field, project location, project manager name, company name, address, phone, fax, and email as shown in Fig. 17. The user can fill the blank fields of data for his project details and then click on (submit/next) to continue the program.

3.2.3. Assigning the project

After entering the project details and click on submit, the program part I window (sources of disputes) will be opened as shown in Fig. 18.

Figure 26 First checklist window.

Figure 27 Second checklist window.

Figure 28 Last decision window – arbitration stage.

Figure 29 End message window.

To read more about the major sources of disputes and its causes (sources of disputes guide) button could be pressed, or from sources of disputes icon at the program interface toolbar, then a report window will be opened as shown in Fig. 19.

Then the program goes to the next window to specify the main cause led to dispute according to the previous source chosen from the previous window as shown in Fig. 20.

Then the program goes to part II to propose a proper ADR solution for current dispute according to dispute status and current situation as shown in Fig. 21.

The program always suggests to follow negotiation stage as the first and best choice to settle dispute with a brief definition of the negotiation stage as shown in Fig. 22.

The users have the ability to read more details about the procedure, feature of the negotiator, stage cost, and its duration on different kinds of contracts (long and short term) by click on the button "Go to procedure" or escape this detail if so desired.

To read more about the proposed procedure as shown in Fig. 23 (go to procedure) button could be pressed, or from settlement procedure icon at the program interface toolbar.

The program gives an opportunity to try following this procedure, then returning back to the program to check feedback as shown in Fig. 24.

After applying the negotiation procedure, if it is found that this procedure is not appropriate for the situation the next stage should be moved as shown in Fig. 25.
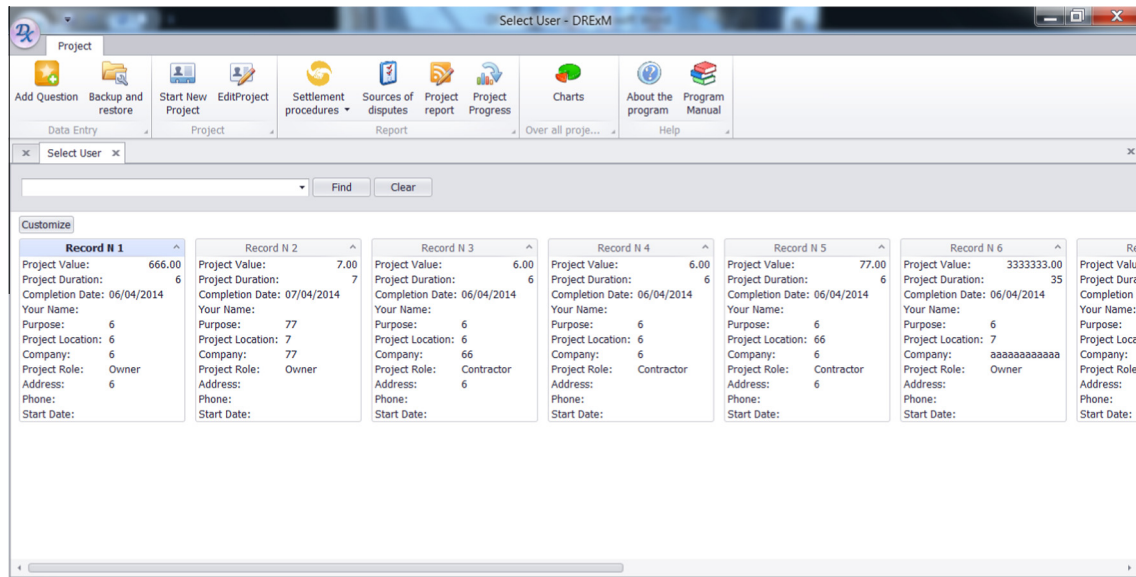
Figure 30 Edit project profile window.

Table 1 Results of all case studies disputes summary.

Case no.	Type of contract	Sources of disputes	Actual procedure\status	DRExM proposed procedure\status
(1)	FIDIC Contract [28]	Contract management & financial issues	Negotiation (solved)	Negotiation (solved)
(2)	Petroleum Contract	Contract Management & financial issues & other sources	Mediation (solved)	Mediation (solved)
(3)	Private Contract	Contract management	Arbitration (solved)	Conciliation
(4)	Public Contract	Financial issues & other sources	Litigation (unsolved)	Mediation
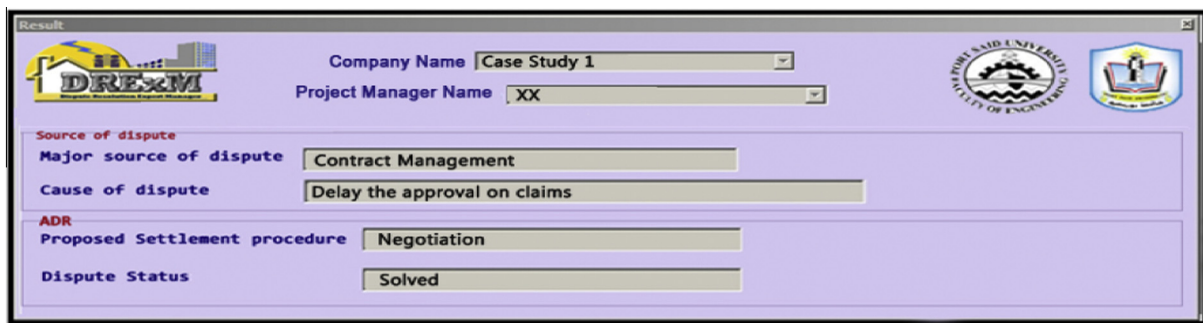
Figure 31 "DRExM" result – case study No. (1).

Now the program gives choice of two options (mediation via conciliation) stage according to the current situation, dispute status and the answers to the next checklist as shown in Fig. 26. Then as mentioned previously the program gives options to read more about the procedure and try applying the proposed procedure then returning back to the program to check feedback.

Again if one found this procedure not appropriate for situation one should move to the next stage. The program gives the choice of four procedures (DAB, fact-finding, mini-trials, and expert system) according to current situation and dispute status and respondent' answers to the following checklist as shown in Fig. 27.

As mentioned previously the program gives options to read more about the procedure and try applying it and making the decision about it.

Finally, if all the previous proposed procedures are not appropriate for the situation the program suppose try to follow arbitration procedure as the last choice one may have to settle the dispute amicably as shown in Fig. 28.
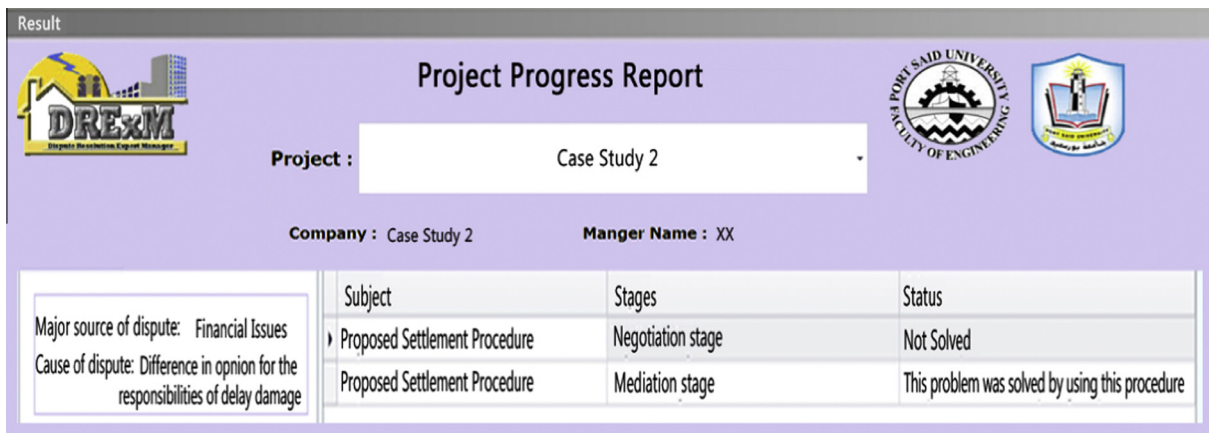
Figure 32   "DRExM" result – case study No. (2).
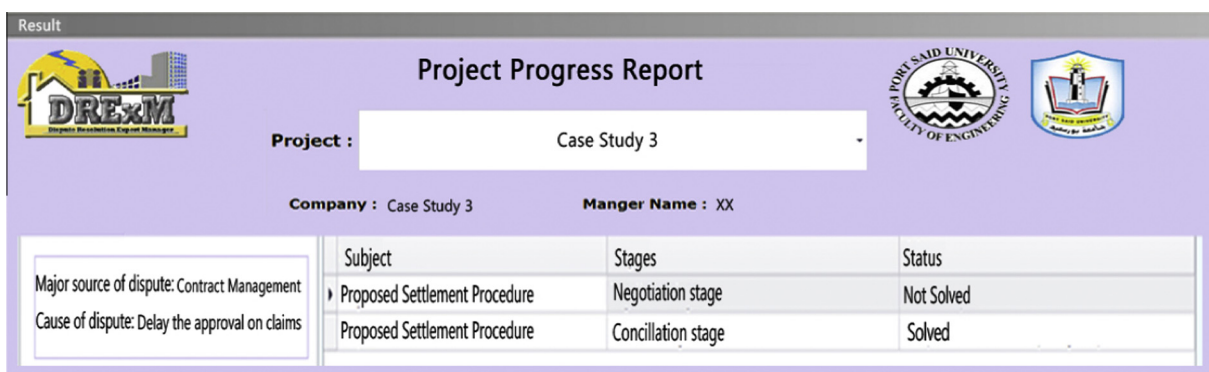
Figure 33   "DRExM" result – case study No. (3).
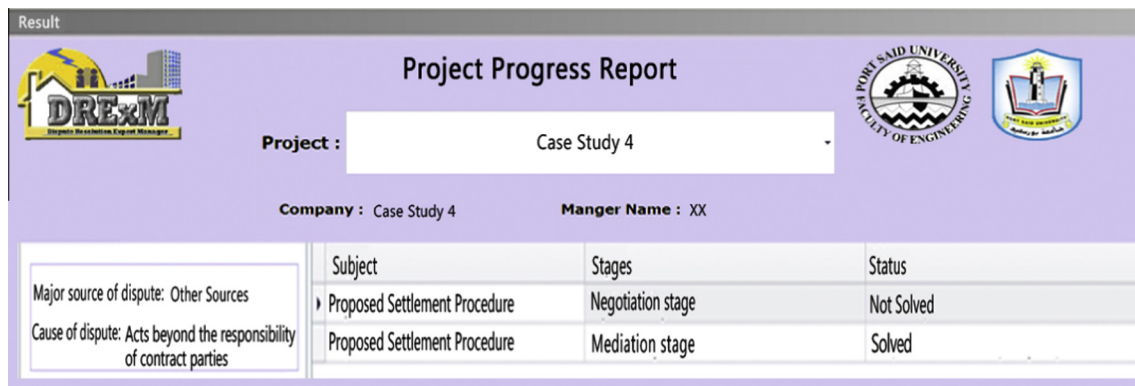
Figure 34   "DRExM" result – case study No. (4).

At the end of each proposed procedure if dispute solved, one would have the following message as shown in Fig. 29 and navigate to the project report.

3.2.4. Edit the project profile

This information can be edited by using project details edit command from Edit project icon. Once this information is added it will be automatically saved. This information will be included on all printed reports generated by "DRExM".

If the user had an account on the program, he has the ability to reassign his profile and answers, and his report will be corrected automatically, as shown in Fig. 30.

3.3. System validation

The objective of this section is to check the validity of the expert system. Validation can be defined as the process of making sure that the system operates as desired. Nosair [16], Stated that validation is the process of making sure that the system
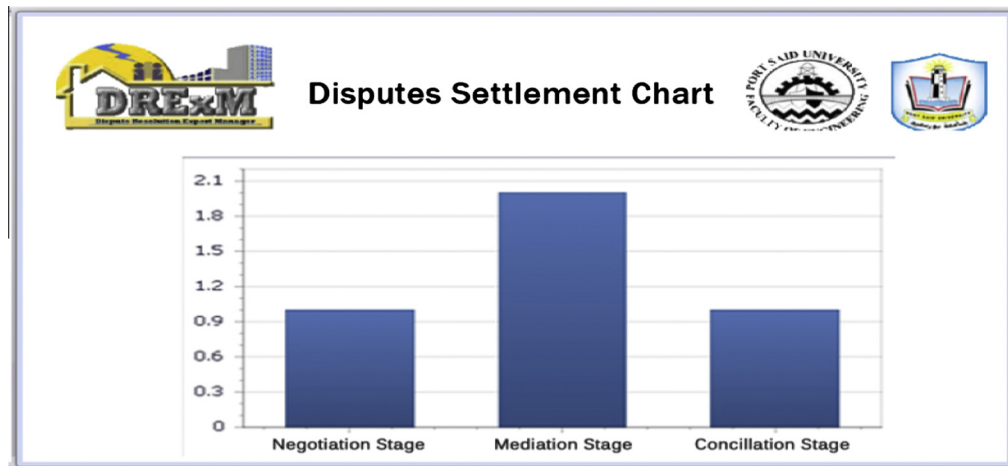
Figure 35 "DRExM" All case studies disputes settlement chart.

has a proper level of reality. Four construction projects were selected for the proposed system. After providing some general data regarding the four case studies such as project type, nature, contract period and price, the main inputs are added. These are concerned with the sources of disputes that have been identified as contract management, contract documents, financial issues, project issues, and others.

The results of the four case study applications are shown in Table 1. The table shows a comparison between the predicted resolution method from the system application of disputes and the actual resolution of disputes occurs during the project construction. This can give clear picture regarding the validity of the proposed system.

Table 1 summarizes the results of the four case study applications. The table also shows the actual resolution of disputes and those resolution predicted by the proposed system. For instance, the first and second case study has been respectively solved during construction by negotiation and mediation and the same methods were predicted to be solved by the expert system. This shows us that DRExM gives results identical to the actual situation in sites with simplified presentation of results as shown in Figs. 31 and 32. This may be considered as a good indicator for the system validation.

For the third case study the dispute has been solved during construction by arbitration after negotiation has been failed. On the other hand by using the expert system and depending on parties' relationship and dispute nature, the parties can use conciliation instead of arbitration to solve the dispute. This confirms that "DRExM" gives results better than the actual resolution method that indicates the benefits of using "DRExM" to go to conciliation instead of arbitration that saves time and cost with simplified presentation of results and minimum durations as shown in Fig. 33.

As shown in the forth case study, the dispute has not been solved yet after using negotiation and failed, then the parties go to litigation without using other amicable settlement stages. On the other hand, the expert system gives results better than the method actually occurred on site that indicate the benefits of using "DRExM" to go to mediation instead of litigation that saves time and cost with simplified presentation of results and minimum durations as shown in Fig. 34. The system also

illustrates the settlement stages for the four case studies as shown in Fig. 35.

Finally, it is fair to say that the system can describe the real situation of the construction disputes in Egypt at an appropriate end level of confidence.

4. Conclusions

- The research illustrates that the most used dispute resolution methods are negotiation, mediation and arbitration respectively.
- The study proposes a reliable and accurate method to quantify and analyze sources of construction disputes. The most important source of disputes was "contract management (74.04%)", the second was "contract documents (71.49%)", the third was financial issues (67.80%), the fourth was "project related issues (63.92%)", and the lowest one was "other sources" such as force majeure, and loose of construction laws, (61.58%).
- The study indicates that the contract management can be considered the main factor that can affect the existence of disputes due to many reasons such as the issues related to the owner and the contractor, their management of the contract, time schedule prepared by the contractor and required update.
- The proposed program "DRExM" is capable of presenting ADR techniques. The program results matched with actual ones of the case studies with simplified presentation of results.
- The ADR for disputes by using "DRExM" saves time and cost with simplified presentation of results and minimum durations.
- The benefits of the "DRExM" program confirmed that the companies should have program to facilitate the dispute Management and to assess the current status of the dispute then propose the alternative settlement procedure instead of going direct to arbitration or litigation.
- The architecture of the program is designed to be open, flexible and upgradable, allowing it to be customized for individuals and corporations with relative ease.

• This study would be of added value for contractors and owners who intend to work in the Egyptian construction market and face difficulties to deal with disputes.

Acknowledgments

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