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REVIEW

Heuristic approach for risk assessment modeling: EPCCM application (Engineer Procure Construct Contract Management)

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KEYWORDS

Turnkey projects;
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Abstract Various risk factors influence construction projects cost and schedule performance from project conception to completion. In the context of project management contract assessment helps allocate integrated risks.

The aim of this thesis is to investigate standard conditions of contract, namely *FIDIC*, Turnkey *EPC* (*Engineer*, *Procure*, *Construc*t) conditions of contracts as a standard contract format. Implications of the contract clauses for the risk management strategy to be adopted by contractors are analyzed through pre defined risk assessment plan *RMP*. Relevant conditions will be scrutinized in terms of induced risk events. The basis for defining major risk categories and events are described through *RBS* (*Risk Breakdown Structure*) schemes, as well as, proposed actions and mitigation plans.

Finally, EPCCM; modeling system is created to assist contract administrators, to diminish time, effort, wading back and forth between construction cases and developed projects. The result is a more efficient and proactive contract management environment by providing database for lessons learned in addition to tracking ongoing projects contractual risks, and consequently for issuing relevant decisions and activity plans.

Abbreviation: FIDIC, International Federation of Consulting Engineers; EPC, (Engineer, Procure, Construct) turnkey conditions of contracts, silver book, a standard contract format; RBS, Risk Breakdown Structure; RM, Risk Management; RMP, Risk Management Plan; EPCCM, Engineer, Procure, Construct Contract Management modeling system; PROD, Project Risk Optimized Datum Contract; CCRA, Condition Risk Analysis; RER, Risk Events Report; RRS, Risk Response Summary; RSM, Risk Status Monitoring.

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Contents

1. Introduction

In Project Management Risk is considered to be the cumulative effect of the chances of uncertain occurrences adversely affecting project objectives, identifying the degree of exposure to negative events, and their probable consequences impacting on project objectives, as expressed in terms of scope, quality, time and cost.

Some of these factors are inherent to organizations that are solely responsible for managing them, whereas others are closely related to the political, cultural, economic, and operational environments of the project's location. In practice, project participants tend to be indifferent to risks outside of their control or believe that measures such as forms of contracts and insurance adequately allocate risks between the various parties. Furthermore, many owners and contractors are unaware of the full range of these risks, and few have demonstrated the expertise and knowledge to manage them effectively [32].

While Investigating Contract terms we have to take in consideration that uncertainty, opportunity and risk are closely allied, but *lack of knowledge of future events* constitutes *uncertainty*. In this relationship, the probability of those outcomes which are favorable may be viewed as *opportunity*, while the probability of occurrence of those outcomes which are unfavorable represents risk.

Consequently, risk management is a set of techniques for controlling the uncertainty in a project. Depending on the type of disruption occurring to contractual terms in EPC contracts, that concerns both parties employer and contractor [11].

Project managers will recognize the classic systems methodology outlined in previous applications which consist of input, process, output and feedback loop, a basic model which is so vital to the effective control of any project. Yet risk is

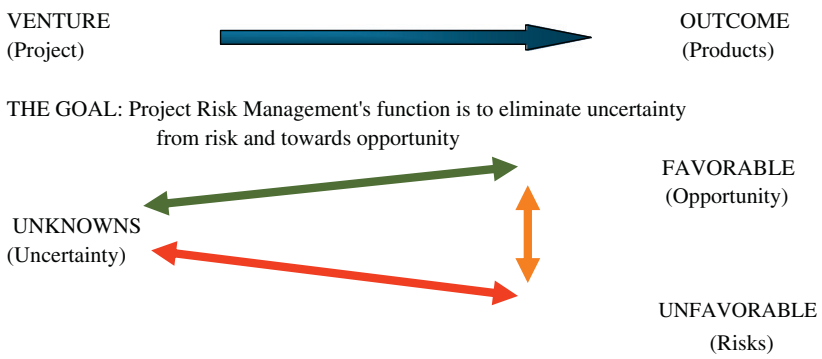

Figure 1 The uncertainty/opportunity/risk relationship [34].

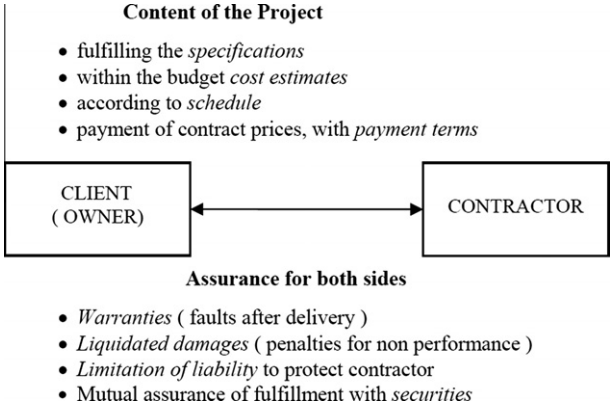

Figure 2 The eight key business levers in contract [3].

somehow different, it has to do with uncertainty, probability or unpredictability, and contingent planning.

However, in construction contract environment there is a gap between the existing risk management techniques and their application and use by contractors and owners. Complexity of the situation and the extensive resource commitment necessary to perform good risk management are among the reasons that have been put forward to explain why this is the case, and no easy-to-use management tool is currently available that can identify and assess the risks specific to construction conditions of contracts. As a result, there is a need to develop such a tool, EPCCM (*Engineer Procure Construct Contract Management*) risk model to help owners and contractors improve the performance of turnkey construction projects.

2. Uncertainty, opportunity and risk

In the context of project management *project risk* is defined as follows:

Project risk is the cumulative effect of the chances of uncertain occurrences adversely affecting project objectives. In other words, it is the degree of exposure to negative events, and their probable consequences impacting on project objectives, as expressed in terms of scope, quality, time and cost. The constant goal of project risk management should be to move uncertainty away from risk and towards opportunity.

Consequently, when assessing overall impacts of uncertainty on a project, it is the net project risk which should be determined, i.e., the cumulative net effect of the chances of both adverse and favorable consequences affecting project objectives [34].

The more we get involved in the project we get to scrutinize effects of expected risks forced by contractual implications, the degree of uncertainty and the consequent associated risk.

While the word "risk" means that uncertainty can be expressed through probability, risk management is a structured process for the management of uncertainty through risk assessment.

Risk and opportunity are mirror opposites of each other. Opportunity emerges from favorable project circumstances and risk emerges from unfavorable events (Fig. 1).

Risks encountered throughout project life cycles and impact severity to parties involved have been demonstrated in previous researches, [10,37], the risk factor in construction business is very high. The size and complexity of construction objects are increasing which adds to the risks. This is in addition to the political, economic, social conditions where the object is to be undertaken, including internal and external risks, [36,17]. The availability and productivity of the resources necessary to construct the project are considered as risks which are proper for the contractor to assume [7].

3. The EPC contract environment

FIDIC [38] edition standard form of condition of contract EPC/Turnkey projects, for works designed by the contractor,

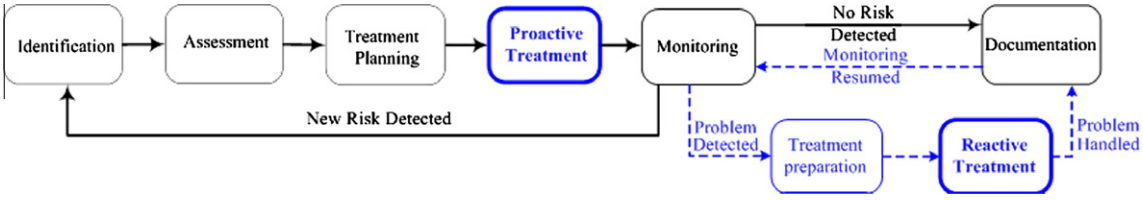

Figure 3 Proactive and reactive treatment cycles within RM process [21].

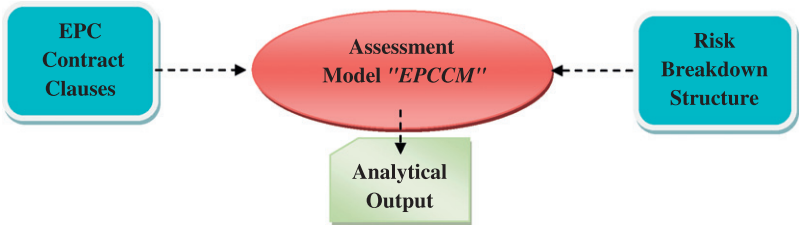

Figure 4 EPCCM main modeling structure, by authors.

the framework consists of two-party arrangement, generally with an Employer's Representative. According to Wang and Chou [33], to make risk management more efficient and effective, all parties must understand risk responsibilities, risk event conditions, risk preference, and risk management capabilities. It can be concluded that the owner has a greater tendency to allocate certain risk to the contractor if the risk is easier to change the probability or effects of its happening. Furthermore, if the probability of a certain risk event condition is uncontrollable, the contractor's tendency of risk handling changes from actively transferring the risk to passively retaining the risk (Fig. 2). On the other hand, if a risk is controllable and certainly allocated to the contractor, the contractor tends to take the initiative to reduce the impact caused by the risk event rather than retain the risk.

Thus, project participants do not have a shared understanding of the risks that threaten a project. Consequently they are unable to implement effective early warning measures and mitigating strategies to adequately deal with project risks [15].

The contract should then go onto consider the obligations and rights of every party. In determining the risk allocation and therefore contract strategy, it is important to apply risk analysis and management techniques to ensure that the worst-case scenario has been anticipated and provision has been made to deal with risk events as and when they occur.

Baloi and Price [1] states that the principal guideline in determining whether a risk should be transferred is whether the receiving party has both the competence to fairly assess the risk and the expertise necessary to control or minimize it.

4. Holistic definition of risk management evolving techniques

According to the established risk management standards [40,41], any risk management typically includes a series of the following tasks: (1) identification, (2) assessment, (3) treatment planning, (4) treatment, (5) monitoring, and (6) documentation as per the following Fig. 3.

Risk treatment followed in this work to be consisted of two parts; proactive and reactive treatment, Fig. 1 shows the two cycles of proactive and reactive risk management. Proactive treatment is the traditional known type within risk management in which only anticipated high probability/impact risks, according to the agreed thresholds, are treated by executing the planned treatment strategies [21].

Several researches highlighted RM processes such as [12,22,35].

5. General review of the risk assessment modeling

Although risk assessment is probably the most difficult component of the risk management process, it is potentially the most useful. A critical review of the literature reviews the existing literature on construction risk modeling and assessment has revealed significant results [28].

Architectural and construction risks, as the means of conceptualizing and modeling domain knowledge, architectural and engineering notions are modeled in the form of concept hierarchies, interrelationships between concepts, and rules that specify the definitions of concepts and relations and constraints on their behavior and interpretation[19].

Risk management in construction is a tedious task as the objective functions tend to change during the object life cycle [4]. Tserng et al. [29] presented a study of ontology based risk management framework of construction projects through project life cycle variance – covariance.

Isaac and Navon [14] described models of building projects as a basis for change control.

Risk management processes of construction project describe the work of all project life cycle. The risk assessment problem is analyzed by many authors [27,36,37,26,24].

Other works proposed risk performance index to improve the efficiency of general performance measurement for mega projects by extending the existing cost/schedule based performance of projects [25].

Proper risk allocation in construction contracts has come to assume prominence because risk identification and risk allocation have a clear bearing on risk handling decisions [20].

Hassanein and Afify [13] analyzed risk identification procedure for construction contracts. El-Sayegh [5] presented risk assessment and allocation problem, Han et al. [12] described web-based integrated system, Gao [9] presented strategies with the risk adjustment.

6. EPCCM risk assessment a proactive approach

Different approaches could be adopted to help assess data related to contractual risks. Contract conditions are interpreted by both parties to help enhance project aspects especially quality and time and diminishing pre-expected obstacles to reduce arising difficulties or claims. Choose the terms of contract logically, depending upon the nature of the work, its certainty, its urgency, the motivation of all parties and other factors such as the relationship between conditions implied and manageable events.

Fig. 4 presents EPCCM implemented methodology including risk information assessment in terms of contract conditions and contractual risks confronted to assist in building knowledge based identification within the framework of Turnkey projects.

6.1. Risk as basis for initiating FIDIC contracts

Main objective is to implement solutions for pre-identified risks as well as those occurring within the project execution,

Table 1 EPC contract assessment relational to break down structure of identified risks.

Risk Breakdown Structure (RBS)				
Report Description: EPCCM ECONOMICAL - POLITICAL - CONSTRUCTION - CONTRACTUAL - MANAGEMENT				
E	ENGINEER	Economical Risk	Inflation	Material Labor Equipment
			Energy Shortage	
			Financial Uncertainty	Owner Contractor Designer
			Currency Fluctuation	
P	PROCURE	Political Risk	Environmental	Air Noise Water
			Public Disorder	Demonstration War
			Governmental Acts and Regulations	Tax Changes Permits
C	CONSTRUCT	Construction Risk	Uncertainty in Labor	Availability Skills
			Uncertainty in Equipment	Break Down Availability
			Uncertainty in Material	Storage Availability Protection
			Delayed Site Access	Title Permits
			Quantity Variation	Permits
			Defective Construction	
C	CONTRACT	Contractual Risk	Payment Failure	Owner Contractor
			Delay Disputes	
			Coordination Failure	Owner Contractor
			Change Orders	Delays Design Changes
			Labor Disputes	
M	MANAGEMENT	Management Risk	Productivity	Labor Equipment
			Quality Control	
			Safety	
			Mistakes	
			Management Competence	
			Variation in Quality	

Note: Analysis for potential risks a project is exposed to under FIDIC EPC Contract Conditions.
Reference for project team as a starting point for risk identification and analysis.

putting in consideration FIDIC EPC clauses implication upon parties involved in the contract (employer/contractor).

Risk allocation among events of predefined risk break down structure EPCCM RBS in alliance with clauses implication including responsible cause and actor for response mitigation plans, potential qualitative measurement are then assigned and update according to the confirmed risk management plan.

6.2. Risk allocation by contract clauses

Before the contract is awarded, owners already allocate project risks through contract clauses in projects. Contractors are typically unable to influence the contract conditions and clauses. For this reason, it is indispensable for the contractors to understand which risks they should undertake [6].

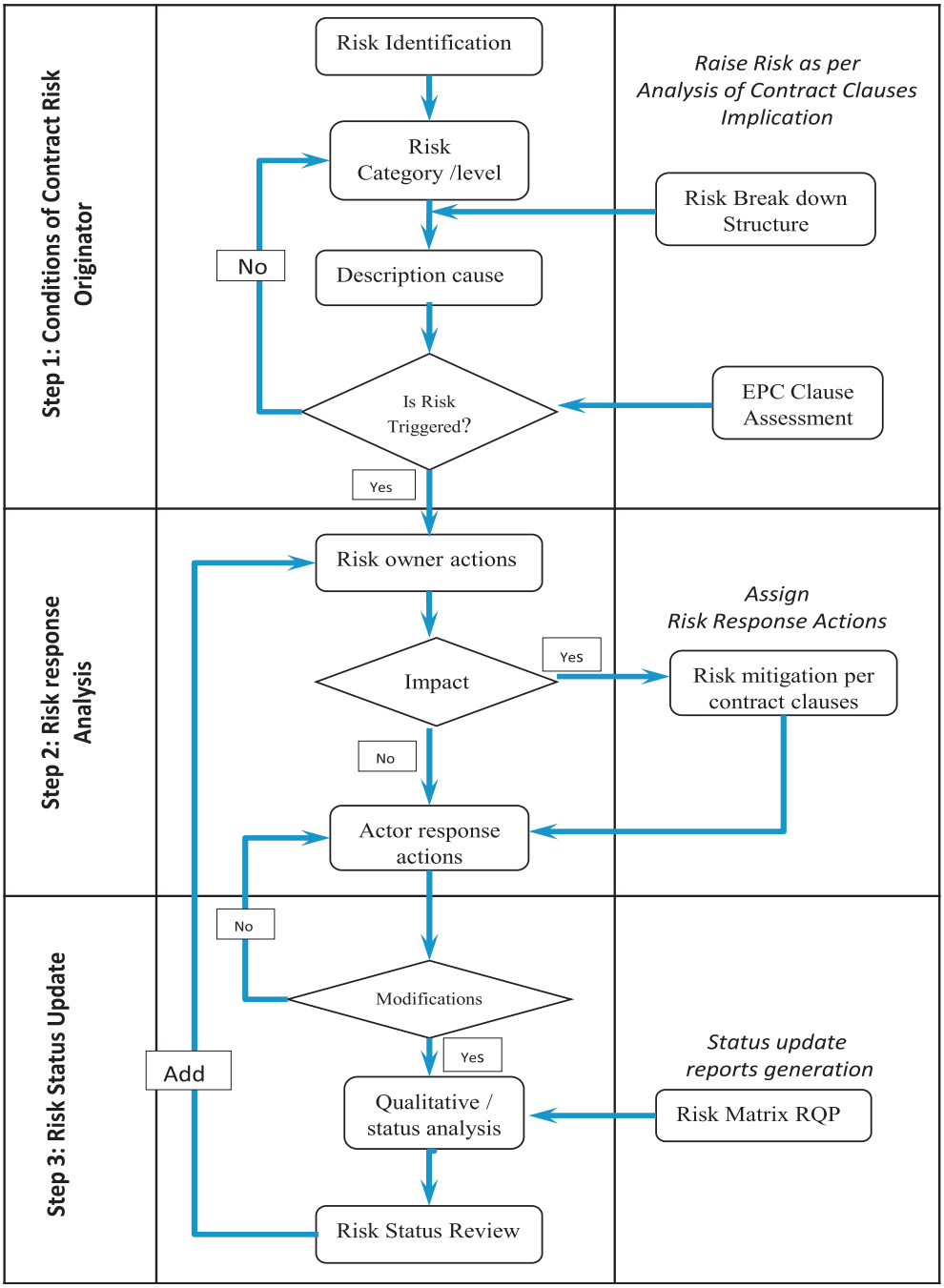

Figure 5 Procedural steps to produce status reports, *by authors*.

In Fig. 4, five major categories are stated to organize the types of risks, to discuss how these risks are managed by the contractors in each risk category and how risk allocation between owner and contractor are handled by contract clauses.

However, there are often different interpretations of risk allocation between owners and contractors. According to Wang and Chou [33], disagreements may result from the absence of related contract clauses, unclear stipulations, or queries about the fairness of risk allocation.

6.3. Risk allocation by risk events triggered

Furthermore, the previously mentioned RBS, Table 1, is used in the research as typical identified risks a project contract should consider when exposed under FIDIC EPC contract conditions as reference for project team as a starting point for risk identification and analysis. For example, a labor shortage would be a risk issue, with a potential effect or consequence of project delay. Since project delay is an effect that can result from one or more risk issues, it does not appear in

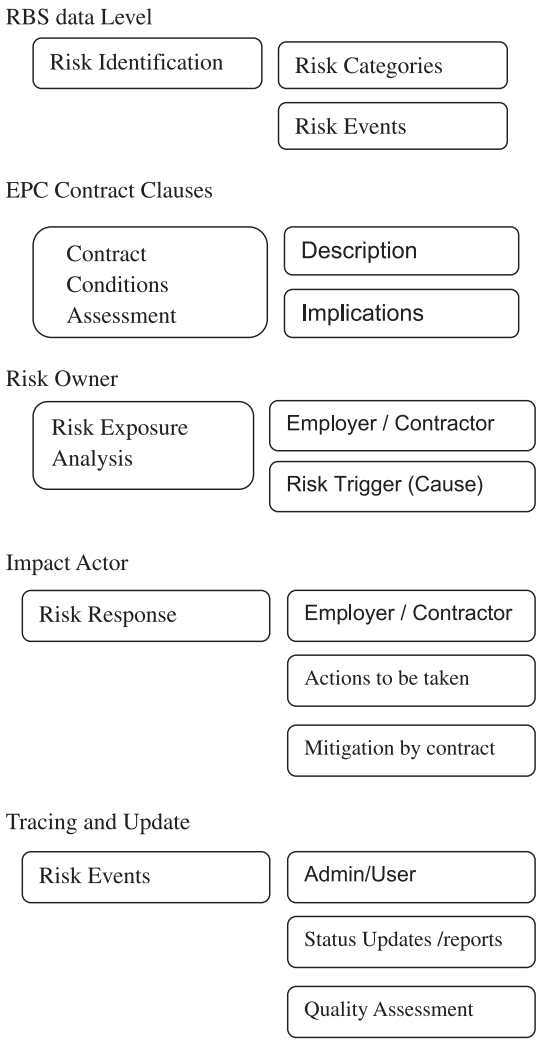

Figure 6 Risk allocation processes, *by authors*.

the risk issue hierarchy. For example, labor shortage is dependent not only on the uniqueness of the project, but on the general economic situation in the region where the project is being built, [23].

6.4. EPCCM risk analytical outputs

Successfully identify, plan, and manage allocated risks within construction projects contracts, involving the value of systematic risk management of project activity providing explicit assessment per contract clause. Abduction points highlighted for application setup introduced for system structure; major benefits derived in analytical outputs considered to be:

- Continuous review and update starting project initiation and contract set-up.
- Tracing for events triggered throughout project life cycle.
- Monitoring for response generated proposed by managerial agents.
- Storing lessons learned per project for post construction handling.
- Flexible manageability for contract terms alterative conditions parameter modification.
- Contract formatting updates enhancing performance and completion criteria.

7. Potential contract risk analytical description

7.1. EPCCM risk break down structure

The user selects factors related to a given project from the list. Each of the general factors is further divided into sub-elements which provide the user with added detail. After identifying the uncertainty factors, the expert system goes onto ask questions about risk policy, and so on.

EPCCM_RBS in Table 1 presents the breakdown structure of an expert system inference net leveled for construction risk management, as previously referred to in Section 6.3.

7.2. EPC Contract Risk Management Plan (EPCCM_RMP)

EPCCM management performance and project success, and normally includes the preparation of a specific project contract – risk management plan. The RMP describes how risk management will be structured and performed on the project Contract clauses. It becomes a subset of the contract management plan. Reference is made for inductive risk assessment methods as previously described in Section 6.4, to determine the appropriate level of detailed risk analysis to be performed on the project. The research provides a complete assessment for expected risks to be management within the EPCCM risk registers RMP *Risk Management Plan* a format of which is reproduced through modeling project risks; (Table 2). The RMP comprises four main sections of risk assessment: (1) risk identification; (2) risk response strategy; (3) risk analysis (qualitative); and (4) risk monitoring and control.

7.2.1. Risk identification

It determines which risk might affect the project and documents their characteristics, as an iterative process because new risks may become known as the project progresses thought its life [16]. The frequency of iterations and who participates in each cycle will vary from case to case. The project team is involved in this process to develop and maintain a sense of ownership of, and responsibility for, risks and associated risk response strategy.

7.2.2. Risk response strategy

It is a process that allows for developing options and determining actions to be taken to enhance opportunities and reduce threats to the projects objectives. Planned risk responses must be appropriate to the significance of the risk, cost effective, timely, and realistic within the project context, agreed upon by all parties involved, and owned by a responsible person. The project manager and team agree upon the appropriate actions implemented for each risk. It also involves: Choosing alternative response strategies, implementing a contingency plan, taking corrective actions, re-planning the project.

7.2.3. Risk analysis

Qualitative risk analysis is performed implying risk actual status and relevant degree of severity impact on project events Insert any comments that would be helpful for risk tracking and

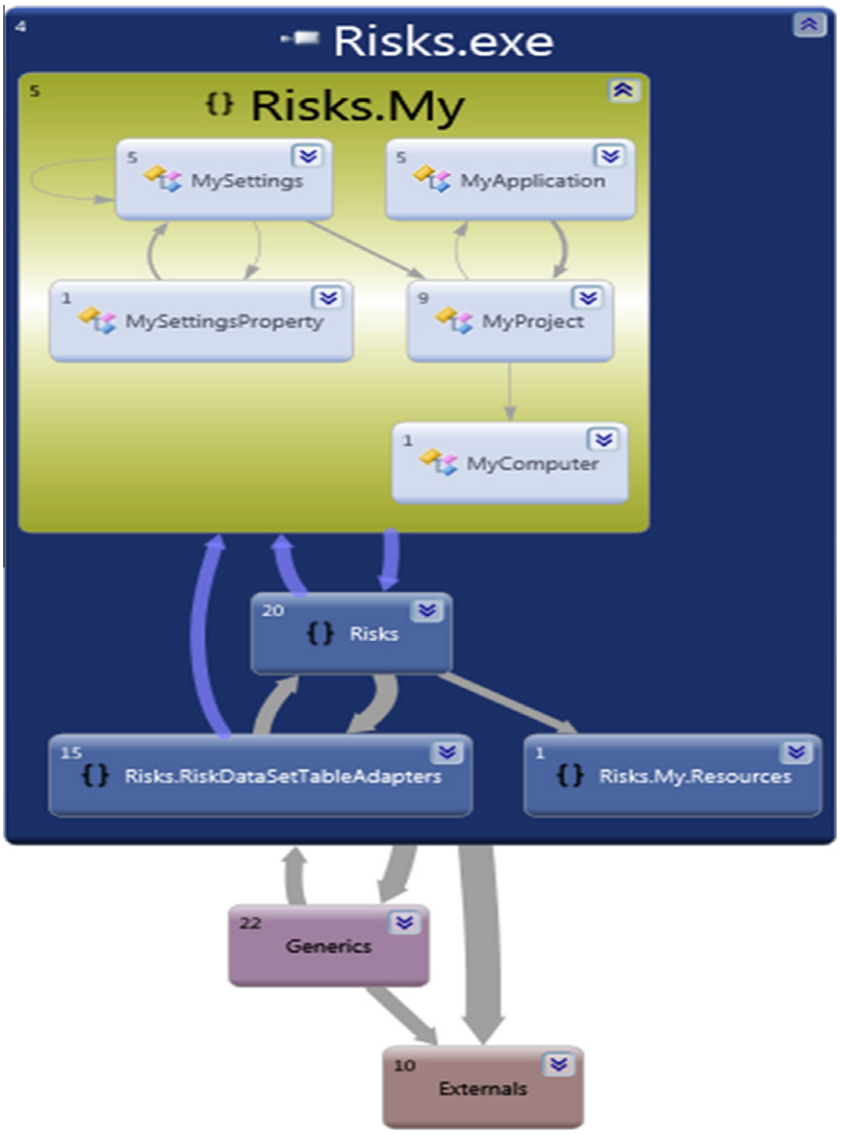

Figure 7 EPCCM model graph dependencies (*Research Model*).

control. If an unanticipated risk emerges, or a risk's impact is greater than expected, the planned response strategy and actions may not be adequate. The project manager and the project team must perform additional response strategies and actions to control the risk.

7.2.4. Risk monitoring and control
User is enabled in the process to track identified risks, to monitor residual risks, and to identify new risks, ensuring the execution of risk plans, and evaluating their effectiveness in reducing risk. Risk monitoring and control is an ongoing process for the life of the project.

8. EPCCM model description

The EPCCM_RMP serves as a contract risk measurement tool where the nominated user assigned to each risk reports periodically to the project manager on the effectiveness of the plan, any unanticipated effects, and any mid-course correction that the project team must take to mitigate the risk. This helps monitoring and updating status for residual risks relevant to different projects phases.

8.1. Modeling and quality advantage

One of the benefits of using computer modeling techniques is that it enhances quality of management because it enhances communication between project parties as well as efficiency of data storage and retrieval; this becomes more obvious because modeling raises abstraction to a level where only the core essentials matter. The resultant advantage is twofold: easier understanding of the reality that exists and efficient creation of a new reality [30].

The advantage of modeling in understanding complexity is derived from the fact that models distill reality. Elements that are not significant in understanding the reality are dropped. This holds true for modeling in many industries such as construction projects [2].

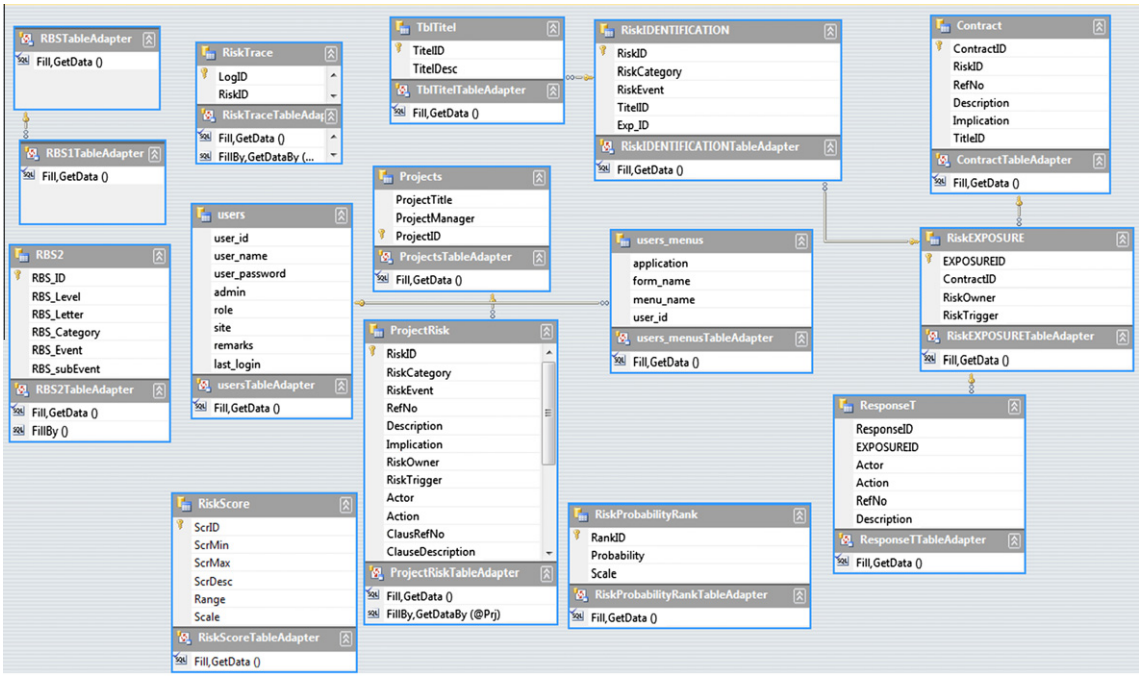

Figure 8a EPCCM schematic activity processes relational diagram (*Research Model*).

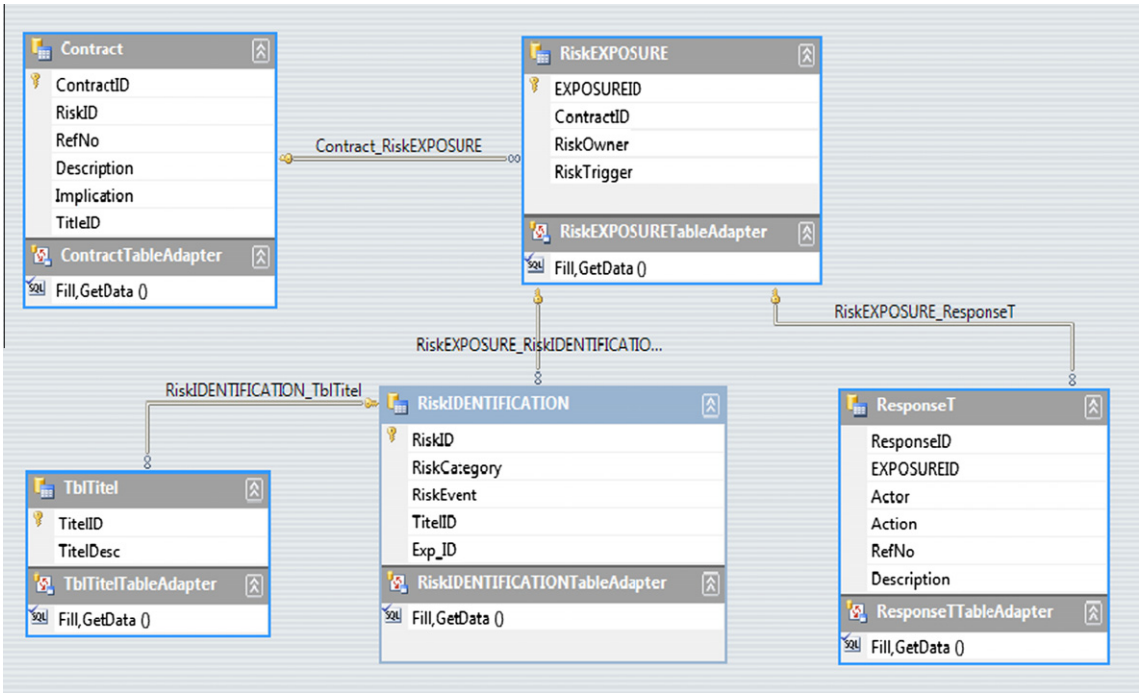

Figure 8b Communication between contract clauses/risk identification modules (Research Model).

8.2. EPCCM standard tools

Application is created under the environment of Microsoft windows XP, Vista, 7 or higher, by the use of the following tools:

a. Basic tool consistent on data base management tool created using Microsoft SQL server 2008 or higher in addition to Dot Net frame work version 3.0 or higher.
b. Crystal report runtime 2008, for the purpose of generating editable data reports and updates.
c. In addition to the above types of projects, UML is being used providing integration between application modules

The great value of data retrieval and updates as well as their complexity justify the effort towards the automation of utilizing logical induction and set theory approaches for the

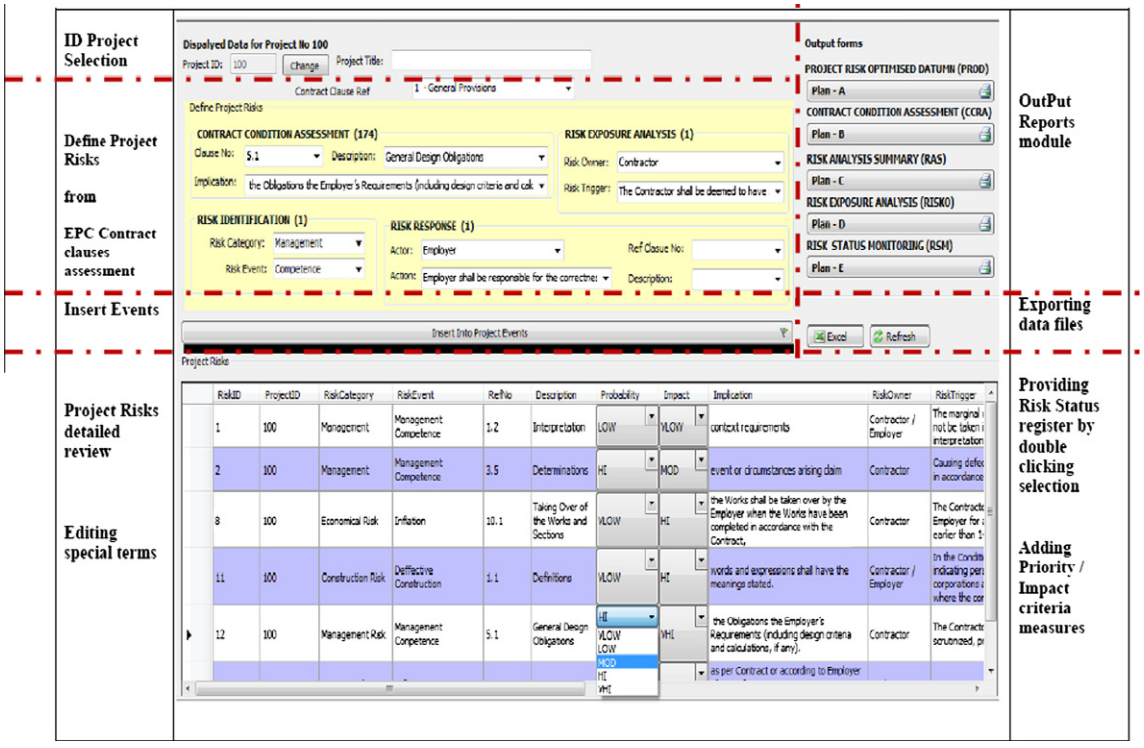

Figure 9 EPCCM main console description added for modules handling (*Research Model*).

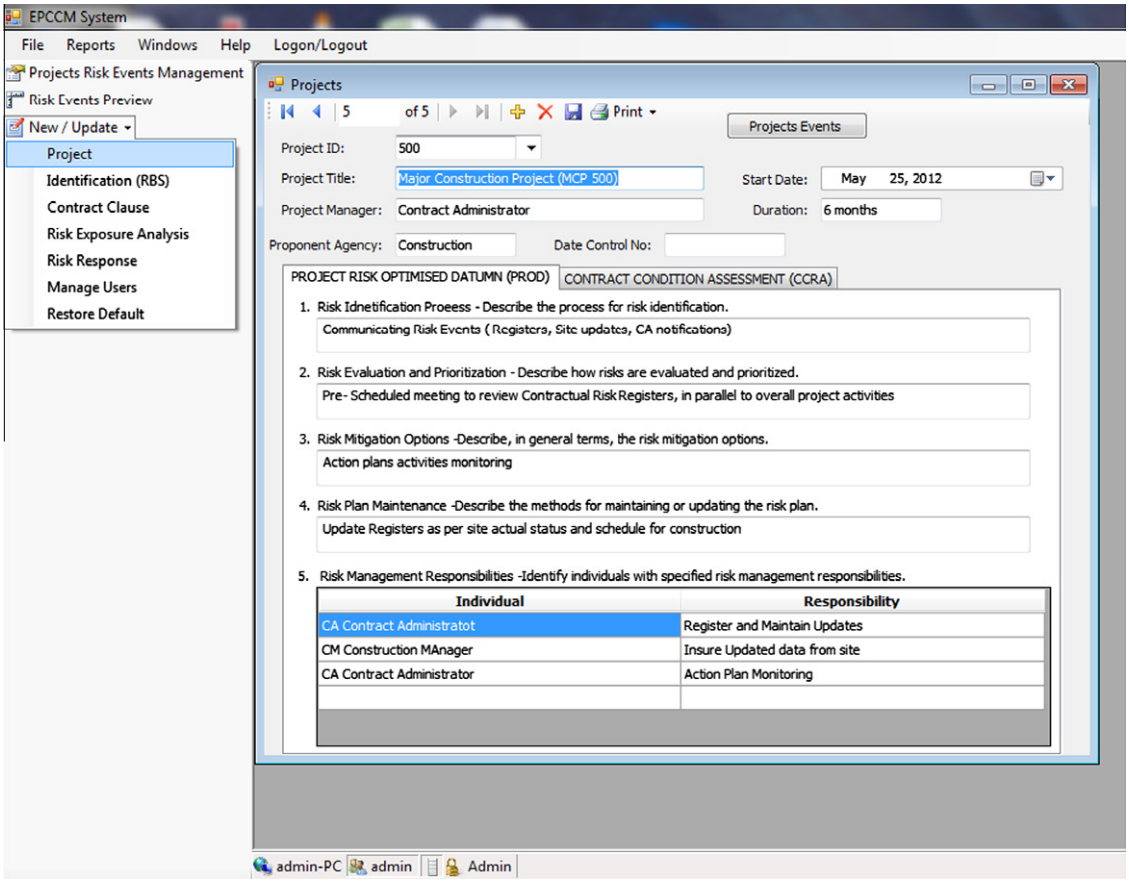

Figure 10 Creating new project related ID, name and datum further imported to report A (Research Model).

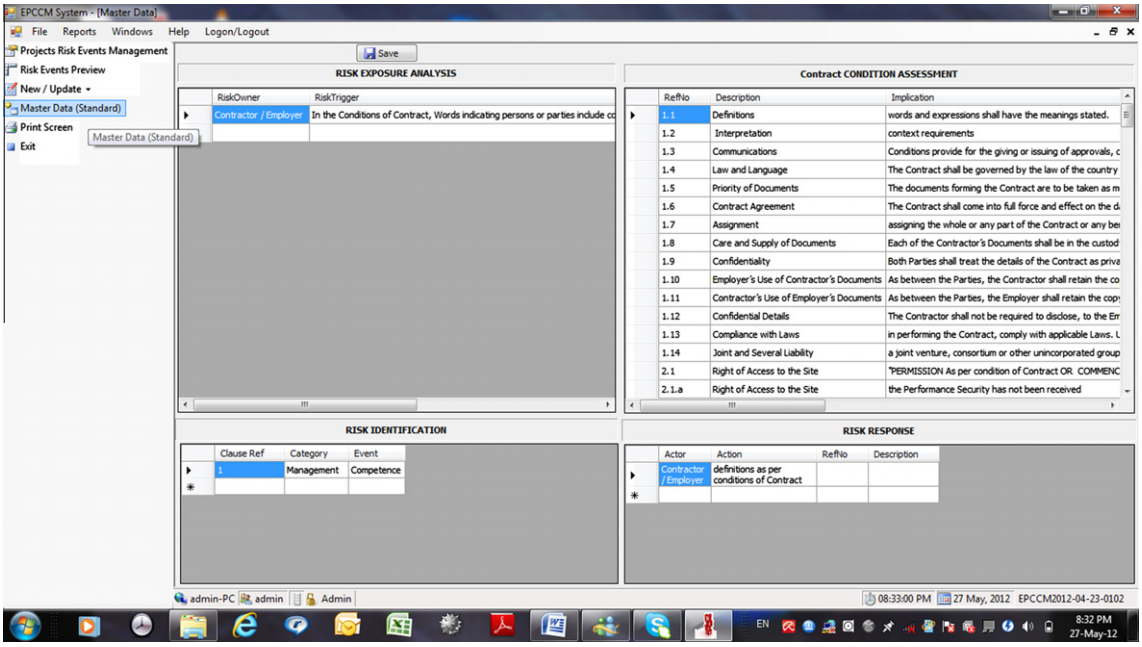

Figure 11 Interface for assessing contract clauses in term of analyzing risk: exposure, identification and response (*Research Model*).

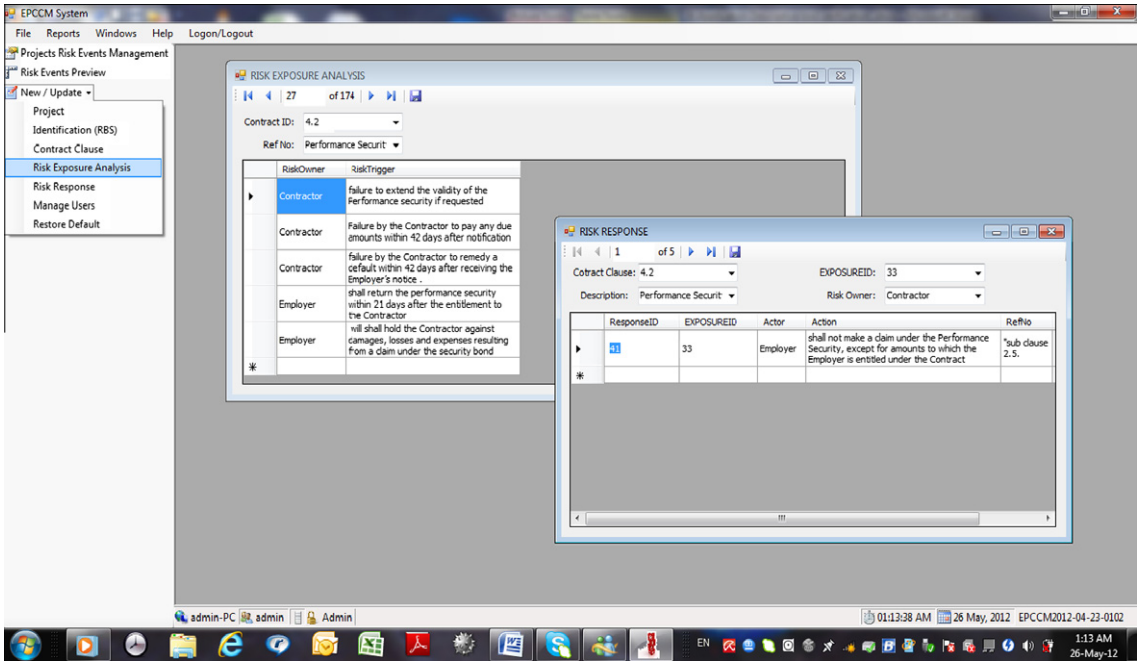

Figure 12 Risk exposure analysis, risk response (*Research Model*).

generation of risk mitigation plans per event triggered at any stage of project life cycle.

8.3. Analogy for EPCCM model guidance

EPCCM model for risk management application constructed in order to evaluate and assess risks emerging throughout Turnkey projects life cycle. Inductive logical procedures, as shown in Fig. 5, the three main steps utilized for utilizing logical induction support system in assessing contractual risk.

8.4. Master data modules

Contract risk assessment guides the project team in reviewing the project work plan (and any other project plan elements) to determine the probability and impact of potential adverse events on project.

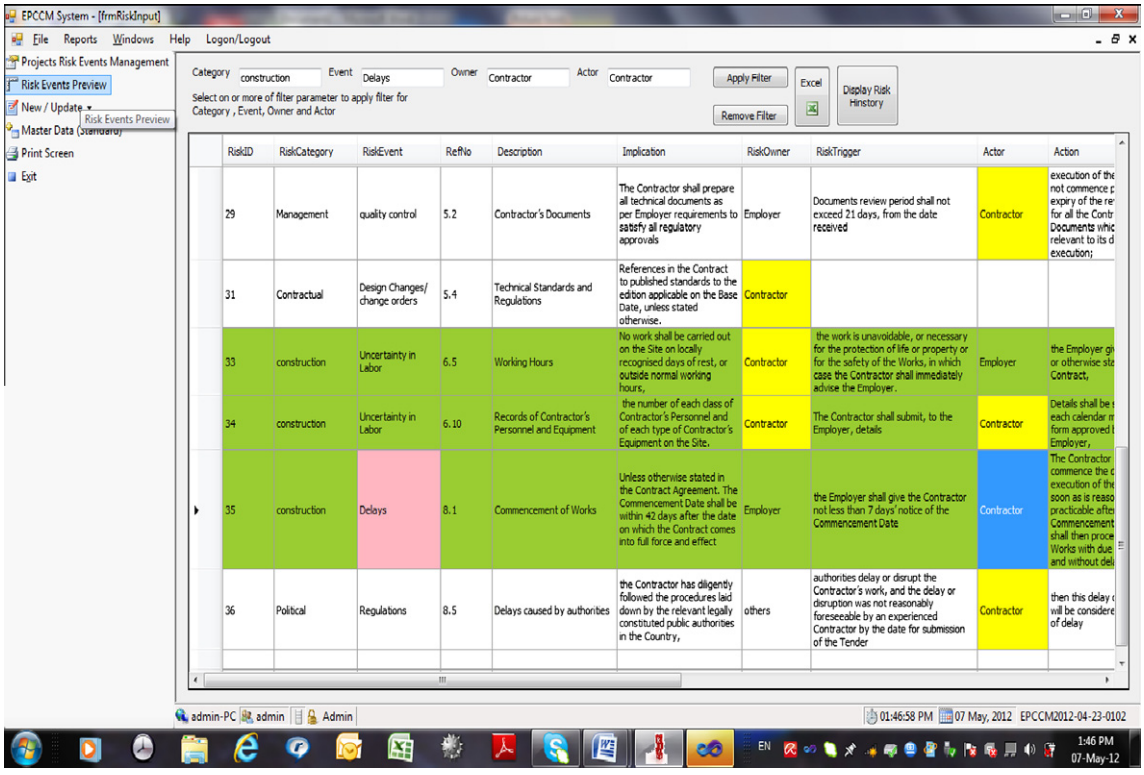

Figure 13 Filtration and tracing for detailed risks triggered and actions response as part of mitigation plan (*Research Model*).

This modeling system provide the user in reference to his integrity (owner/contractor) a detailed risk assessment for contractual clauses throughout project life cycle regarding considered event impact and equivalent mitigation responses as well as a qualitative overview updated status, Fig. 6.

9. Model graph dependencies

While advances have been made in defining the information that should be contained within a risk register, and in implementing a register as a computer tool, the development of a richer set of attributes that can be modeled in the risk data adapters, and the incorporation of search and navigation technologies and reporting mechanisms that can make the contents of the register more accessible can also be considered as desirable improvements (Fig. 7).

9.2. EPCCM internal dependencies

As the project progresses the project team would update the register with response measures that were adopted, the risks that were realized during the project and their impact on project performance measures, additional risks that might have been identified and so forth. At the end of the project, the information in the register would serve as a means to augment the organization's risk issue library knowledge base.

9.3. EPCCM external dependencies

The project risk reports for implemented contract risk plans prove to be the most tangible part of the system, where actual data is extracted from previously analyzed events. Output for the risk assessment function, providing information on risks, their time windows, methods of incorporating risks into the further analysis, and appropriate response measures including details for crystal reports engine integrated within the application modules and allowing for producing updated reports.

10. Quality of EPCCM activity diagrams

Activity diagrams have their origins in the state chart diagrams, consequently in UML as per the following scheme Data view 2.0 they are considered quite independent of their origins [8].

As seen in the procedural activity diagram in Fig. 8a, showing the flow of activities, making them ideal to EPCCM Schematic Modeling processes.

Projects: Module contains classes to allow for multi projects storing initial data such as title and duration datum for closure date as well as other required data to be stored and reported in report A.

Project assessment: contains data retrieved per each event triggered to be stored as per ProjectassessmentID class level identified to provide further integration to events captured and required actions to be monitored and updated.

ProjectRisk: Include classes for assigned data per each triggered event such as RiskID related to triggered risk categories and events, data required to allow for assigning action response filtered in event tracing module.

Sample module design is described in the next graph (Fig. 8b) is presented the communication level established between contract class stored master data selection for assessed terms conditions and the relevant RiskExposure event derived from RBS tables Stacked including classes for differentiating between different levels for rbs_Category, rbs_Event.

Table 3 EPCCM generated output reports.

Report A	Project Risk Optimized Datum	PROD	Datum for project initiation and risk management strategy
Report B	Contract Condition Risk Analysis	CCRA	Risk management plan and responsible actors
Report C	Risk Events Report	RER	Cumulative analysis for risk categories/events
Report D	Risk Response Summary	RRS	Trace required response action as part of mitigation plan
Report E	Risk Status Monitoring	RSM	Qualitative-risk analysis for probability and impact

(*Research Model*).

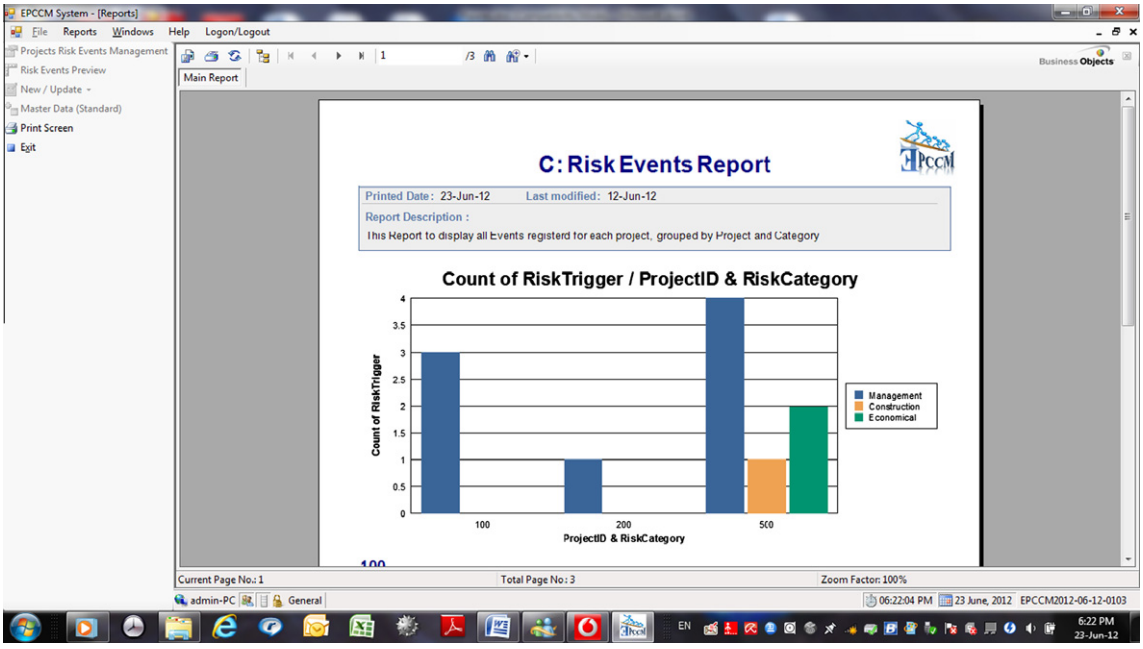

Figure 14 Report C, derived analysis for risks categories occurrence and severity impact (*Research Model*).

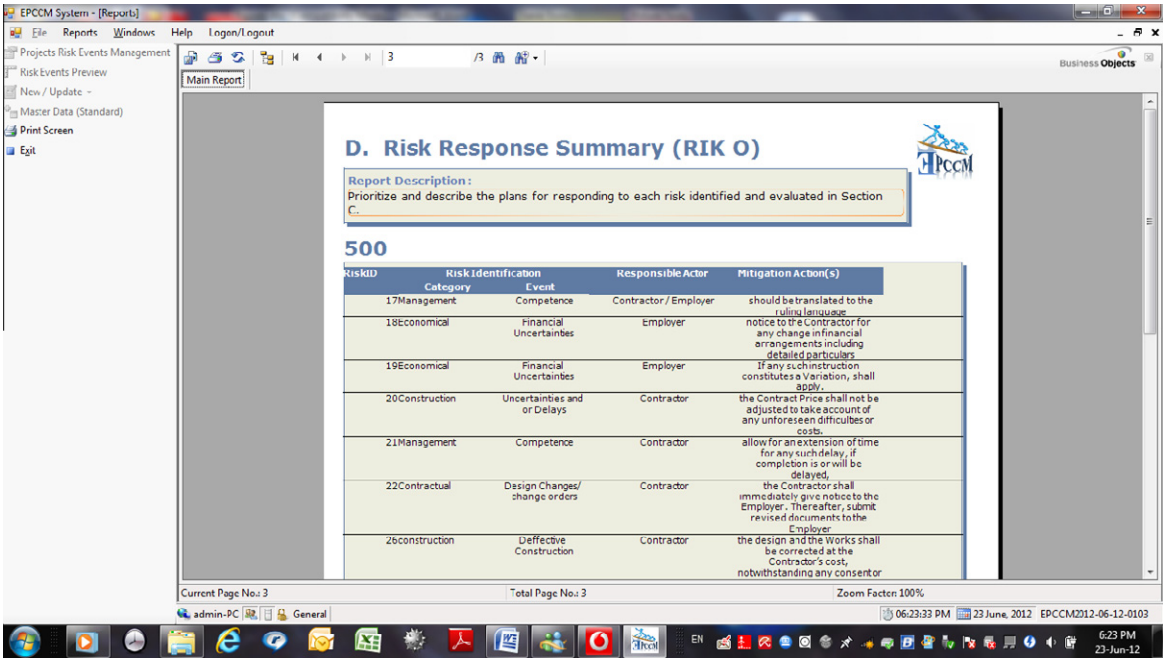

Figure 15 Report D details for risk events identified with relation action response required (*Research Model*).

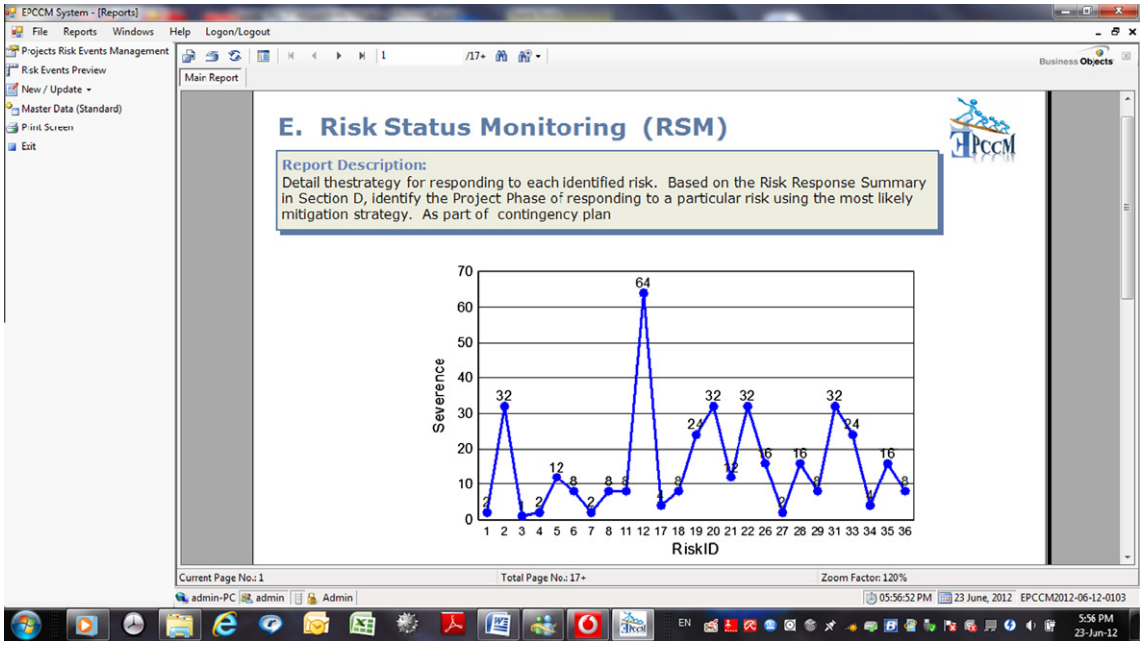

Figure 16a Qualitative risk analysis defining severity and occurrence impact per risk ID (*Research Model*).

11. EPCCM package graphical user interface

Application tool developed to support risk assessment for EPC contracts, consists of a multi console Graphical User Interface GUI, to support the pre-described model and cover different aspects of the processes involved. GUI is integrated with data base system and allowing for a back and forth interaction in order to display multi project data presentations.

System admin is allowed seamlessly to access all master data modules as well as editing parameters and criteria introducing flexibility to model design, and customizing data per each project under study.

Main application modules accessed by admin as follows:

The administrator for EPCCM package has the authority to either start new project or proceed with update, review and edit previously available projects, used for EPPCM Users to review available projects and related reports as per stated in reporting and analysis section, access permission is denied to other main data files for model parameters and stored projects data files.

11.1. Risk event manager interface

This interface showed in Fig. 9, provides the integral view of different modules of EPCCM allowing interaction and swift access for other modules related to *Master Data Standard Review* in Fig. 10, each module interface is allowed to be viewed, edited, and printed separately through file drop down menu for any new updated fields.

11.2. Case study

Through the EPCCM administrative interface for creating new project "Major Construction Project_MCP 500" a set of triggered events and respectively action plans to fulfill required actions on timely manner, in order to mitigate impact on project delayed start, as per site conditions and required documentation.

Filtration for required risk categories to be tracked, as per Fig. 10, is used to clarify any required response to be initiated by the contractor CM Construction Manager, or considered from CA Contract Administrator, point of view to be fulfilled by owner, the other active contract party.

11.2.1. Demonstration

Thus, the aim of this research is to examine how risk factors are shared between different parties in EPC conditions contract, investigate how the risk management strategy of contractor change with respect to different contract conditions.

Finally, throughout the project and during project closure, EPCCM Application risk-related lessons are reviewed in order to contribute to organizational learning and support continuous improvement of project contract risk management practice.

Minimize project site condition risk exposure, assure project completion with no delays, secure project budget.

11.2.2. Tracking and monitoring

With respect to entries on the project risk register side, related exposure to contractor risks managed by Construction Manager CM, considered as user to keep close eye on ACTUAL Project risks.

Contract Administrator CA, Considered as system administrator in research case; additional data will be provided by project team.

Step 1. Project creation.

Save project data DATUM for risk management protocol, corresponding to specific project.

Step 2. Risk events criteria.

In research case study most influencing risk events have been selected to check and validate system modules where integrity of each caused event will have direct influence on

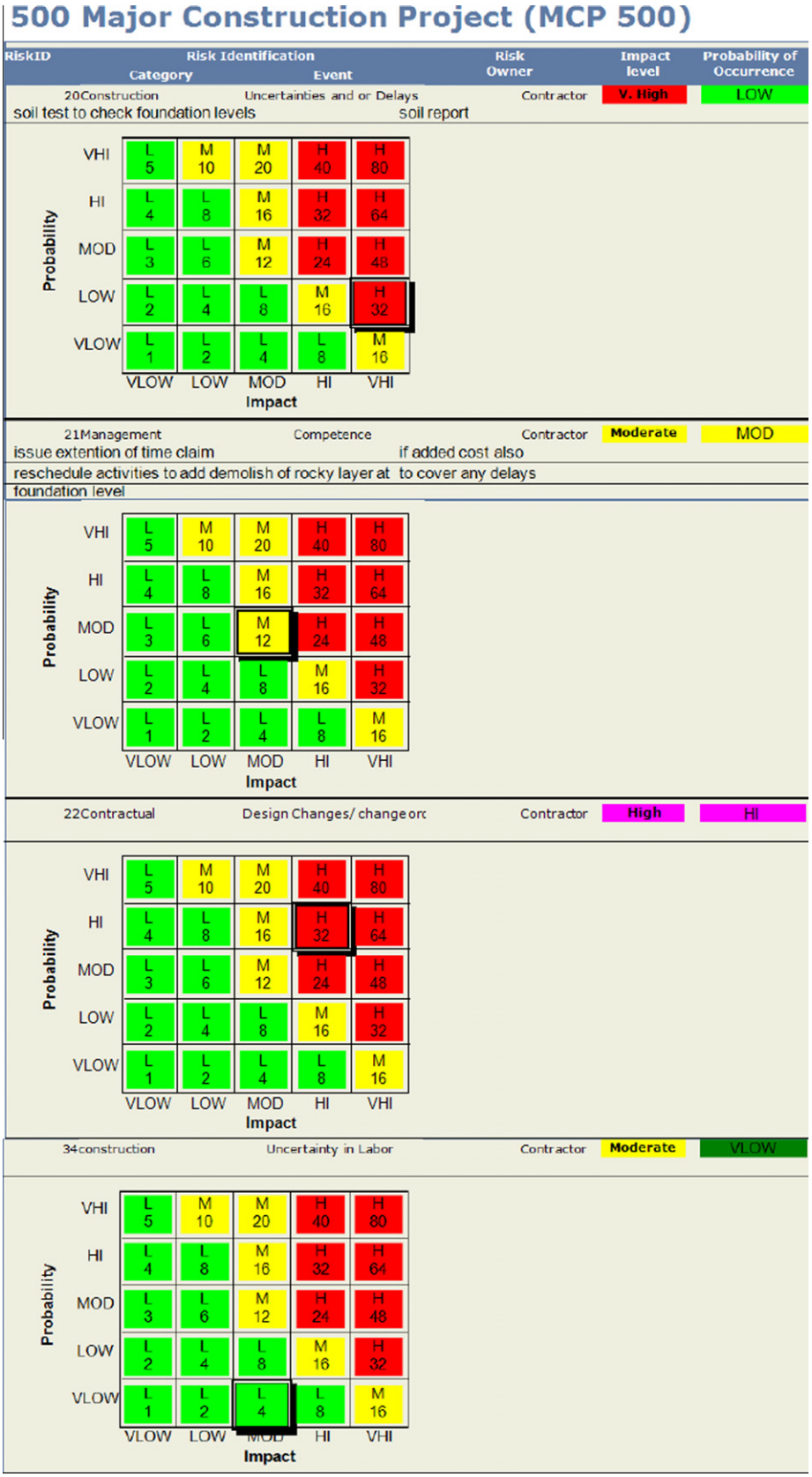

Figure 16b Detailed qualitative risk analysis defining project event analysis in addition to mitigation responsive actions (*Research Model*).

Table 2 Extracted data exported to excel format (*Research Model*).

EPCCM Risk EventsRegister

Project title MCP 500 | Filtered Actions (if exist) | Date of Issuance

Major Construction Project

Risk ID	Project ID	Risk Category	RiskEvent	Ref No	Description	Probability	Impact	Implication	RiskOwner	RiskTrigger	Actor	Action	ClausRefNo	Clause Description	Title Clause	Closed	Closed Date	ClosedBy
17	500	Management	Competence	1.4	Law and Language	2	2	The Contract shall be governed by the law of the country (or other jurisdiction) stated in the Particular Conditions.	Contractor / Employer	If any part of the Contract has been written in one language a	Contractor / Employer	should be translated to the ruling language			1 - General Provisions			
18	500	Economical	Financial Uncertainties	2.4	Employer's Financial Arrangements	1	4	evidence / payments for price due at that date reply within 28 days by the Employer	Contractor	the Contractor request submittal for payments	Employer	notice to the Contractor for any change in financial arrangements including detailed particulars	clause14	[Contract Price and Payment]	2 - The Employer	FALSE		
19	500	Economical	Financial Uncertainties	3.4	Instructions	3	4	The Employer may issue to the Contractor instructions necessary to perform obligations	Employer	Each instruction shall be given in writing and shall state the obligations specified	Employer	If any such instruction constitutes a Variation, shall apply.	Clause 13	[Variations and Adjustments]	3 - The Employer 's Administration			
20	500	Construction	Uncertainties and or Delays	4.12	Unforeseeable Difficulties	2	5	as per Contract he Contractor shall be deemed to have obtained all necessary information as to risks, contingencies and other circumstances which may influence or affect the Works	Contractor	the Contractor accepts total responsibility for having foreseen all difficulties and costs of successfully completing the Works; and	Contractor	the Contract Price shall not be adjusted to take account of any unforeseen difficulties or costs.			4 - The Contractor			
21	500	Management	Competence	4.24	Fossils	3	3	All fossils, coins, articles of value or antiquity, and structures and other remains or items of geological or archaeological interest found on the Site shall be placed under the care and authority of the Employer.	Contractor	If the Contractor suffers delay and/or incurs Cost from complying with the instructions,	Contractor	allow for an extension of time for any such delay, if completion is or will be delayed,	Sub-Clause 8.4	[Extension of Time for Completion]	4 - The Contractor			
22	500	Contractual	Design Changes/ change orders	5.2	Contractor's Documents	4	4	The Contractor shall prepare all technical documents as per Employer requirements to satisfy all regulatory approvals	Contractor	If the Contractor wishes to modify any design or document which has previously been submitted for review	Contractor	the Contractor shall immediately give notice to the Employer. Thereafter, submit revised documents to the Employer			5 -Design			
26	500	construction	Deffective Construction	5.8	Design Error	2	4	If errors, omissions, ambiguities, inconsistencies, inadequacies or other defects are found in the Contractor's Documents	Employer	Review of all works	Contractor	the design and the Works shall be corrected at the Contractor's cost, notwithstanding any consent or approval, under this Clause.			5 -Design			
27	500	Management	Competence	5.1	General Design Obligations	2	1	the Obligations the Employer's Requirements (including design criteria and calculations, if any).	Contractor	The Contractor shall be deemed to have scrutinized, prior to the Base Date,	Employer	Employer shall be responsible for the correctness of the portions of the Employer's Requirements and of the data and information provided by (or on behalf of) the Employer			5 -Design			
28	500	construction	Deffective Construction	5.1.a	General Design Obligations	2	4	except as otherwise stated in the Contract.	Employer	is responsible for all data and information which cannot be verified by the Contractor, including criteria for the testing and performance of the completed Works, and	Contractor	The Contractor shall be responsible for the design of the Works and for the accuracy of such Employer's Requirements (including design criteria and calculations), except as stated below.			5 -Design			
29	500	Management	quality control	5.2	Contractor's Documents	2	3	The Contractor shall prepare all technical documents as per Employer requirements to satisfy all regulatory approvals	Employer	Documents review period shall not exceed 21 days, from the date received	Contractor	execution of the Works shall not commence prior to the expiry of the review periods for all the Contractor's Documents which are relevant to its design and execution;	Sub-Clause 5.7	[Operation and Maintenance Manuals].	5 -Design			
31	500	Contractual	Design Changes/ change orders	5.4	Technical Standards and Regulations	2	5	References in the Contract to published standards to the edition applicable on the Base Date, unless stated otherwise.	Contractor						5 -Design	TRUE		
33	500	construction	Uncertainty in Labor	6.5	Working Hours	3	4	No work shall be carried out on the Site on locally recognised days of rest, or outside normal working hours,	Contractor	the work is unavoidable, or necessary for the protection of life or property or for the safety of the Works, in which case the Contractor shall immediately advise the Employer.	Employer	the Employer gives consent, or otherwise stated in the Contract,			6 - Staff and Labor			
34	500	construction	Uncertainty in Labor	6.10	Records of Contractor's Personnel and Equipment	1	3	the number of each class of Contractor's Personnel and of each type of Contractor's Equipment on the Site.	Contractor	The Contractor shall submit, to the Employer, details	Contractor	Details shall be submitted each calendar month, in a form approved by the Employer,			6 - Staff and Labo			
35	500	construction	Delays	8.1	Commencement of Works	2	4	Unless otherwise stated in the Contract Agreement. The Commencement Date shall be within 42 days after the date on which the Contract comes into full force and effect	Employer	the Employer shall give the Contractor not less than 7 days' notice of the Commencement Date	Contractor	The Contractor shall commence the design and execution of the Works as soon as is reasonably practicable after the Commencement Date, and, shall then proceed with the Works with due expedition and without delay.	Sub-Clause 1.6	[Contract Agreement].	8 - Commencement, Delays and Suspensions			
36	500	Political	Regulations	8.5	Delays caused by authorities	2	3	the Contractor has diligently followed the procedures laid down by the relevant legally constituted public authorities in the Country,	others	authorities delay or disrupt the Contractor's work, and the delay or disruption was not reasonably foreseeable by an experienced Contractor by the date for submission of the Tender	Contractor	then this delay or disruption will be considered as a cause of delay	Sub-Clause 8.4 (b)	[Extension of Time for Completion].	8 - Commencement, Delays and Suspensions			

total project completion and quality for execution, further reports and contingency plans of actions could be considered. At start of project, mainly concerning contractual arrangements, site access, advance payments and performance security, start adding risk events relevant to contract conditions, displayed from

- Master data review clauses/risk events in accordance with the coordinated assessment respectively.
- Risk identification: risk category/risk events; in relevance with EPCCM risk breakdown structure analysis.
- Contract condition assessment; reference is made to clauses/description/implication/included in master plan.
- Risk exposure analysis: risk owner (employer/contractor/or both)/Risk events triggered per clauses interpretation.
- Risk response: action/actor (employer/contractor/or both) tracing relevant in risk event.

Shifting between projects IDs allow to add new risk events or update existing risk parameters such as actual status, probability of occurrence, degree of severity impact, in order to allow for Updating and/or reviewing existing project data assessment (see Fig. 11).

11.2.3. Proactive data handling

Step 1. Analyzed implications related to project terms of contract are prescribed in order to extract respective responsibilities between contract parties (employer/owner), accordingly the cause for risk event triggered is highlighted through a definite risk exposure versus response actions to eliminate, mitigate impacts (Fig. 12).
Step 2. Risk events preview

Another induced data assessment presentation is allowed through the event preview screen.

Data is filtered by selecting field and relevant events category to be analyzed, this filter application allows for tracking preventive actions and checking for suitable mitigation clauses.

By double click on four columns we can find filter tool to apply by one or more of these four fields (category–event–owner–actor); resulting events triggered are displayed by the *Risk Event Preview* interface allowing for further analysis by selecting filtered data according to parameters selected by risk owner or response actors in relation to category of risk events allocated, racing details for actions required as response mitigation plan is permissible by selecting event in Fig. 13.

Extracted data exported to excel format as per the following risk register addresses various aspects of contract risk assessment such as:

- Contract clause reference and description.
- Related triggered events.
- Required response actions.
- Impact levels, in terms of probability of occurrence and severity degree.
- Responsible actors and date of update.

RMP project contractual risk register, the continuous monitoring and updates permits the visibility of contractual terms as well as responsive actions taken under mitigation purposes.

11.3. Reports module

Project participants most suited to manage the risk identifies the party or parties who are best able to control the risk. For our soil investigation example, one could take the position that no party is able to control the risk, and it simply has to be passed onto the owner, fully documented. Finally, the opportunity exists to include previous experience that has been particularly effective in identifying, and judging and managing the risk issue. EPCCM generates, reports cited in Table 3.

11.3.1. Examples for reports

Mostly used figure representing report C demonstrating summary for events occurring, allowing for tracing and updating confronted risks in contractual project environment changes fundamentally the basis of managing in addition to lessons learned impact this could have upon the future development of the organization works.

It is important then to reassess the project and relatively study its allocation of risk defined under EPC standard forms of contract, decisions will be taken in reference to stored data and updated reports for risk management as per referenced reports in Figs. 14 and 15.

11.4. Qualitative risk analysis

Conducting a combined qualitative-risk analysis to determine if the allocated risks to the project start.

EPCCM includes methods for prioritizing the identified risks for further action, such as quantitative risk analysis or risk response planning. Qualitative risk analysis assesses the priority of risks by using their probability of occurrence, corresponding impact on project objectives if the risks do occur, as well as other factors such as the time frame and risk tolerance of the project constraints of scope, schedule, budget, and quality, result presented in Figs. 16a and b.

11.5. EPCCM system validation and verification

In order to allow for system verification a project prototype is created to demonstrate different modules efficiency and relational outputs. Steps are described in parallel to analysis for selected events under study.

In performing risk analysis of a project, we are interested in predicting the consequences of a risk issue on project performance, and where it is significant, on developing risk mitigation measures.

Risk mitigation deals with how best to manage a risk using strategies such as redesign, alternative processes (procurement, construction, etc.), insurance, contingency allowances, contractual language, and so forth. By linking risk issues through to project performance measures, including consideration of the project context, it is possible to assess the importance of a risk issue, and judge the efficacy of various risk mitigation measures.

12. Conclusion

Major Risk issues related to contract administration environment is explained as well as the risks allocated to contracting parties through contract conditions. Necessary steps to success-

fully manage the contractual elements of a construction contract. Types of contracts and relationships between contracting parties are explored, a brief application is produced with general information about the FIDIC and Egyptian design and build contracts are given, followed by risk allocation schemes in contracts are explored so that risks can be managed successfully.

Hypothesis 1. Standardized set of the risk events specified within EPCCM RBS Risk Breakdown Structure assessed through contract clauses. Developed risk categories will reflect issues that occur across the entire project life cycle.

Accordingly it is implemented within the proposed model, ECPCM risk model is presented with registers enhancing contract parties responsibilities and suggestions for mitigation of uprising events as well as contract terms conditions implications on contract parties.

Hypothesis 2. A Risk Management tool is created that will allow for these risks to be identified and assessed in a proactive manner. Presentation of the EPCCM application including system verification, findings and recommendations regarding the ECPCM risk management model will be presented.

Hypothesis 3. The risk issues that become part of the management tool can be evaluated in terms of potential quality factors describing their impact and probability of occurrence As a result, their relative importance to one another can be determined.

Finally conclusion and discussion points are highlighted description of risk management standard, indicating various tools and techniques applied widely for assessing risks, hence justification for system selected EPCCM, In terms of achieving an explicit approach for contract risk management, the presented research allows project participants to prioritize their response and develop mitigation strategies that will enhance overall project performance. In short, projects that use the structured risk assessment process will have a better chance of meeting financial, schedule, and other stakeholder expectations.

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