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Developing An Expert System for Controlling Cost and Time Overrun (ESCCTO) in Construction Projects

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Abstract
Nowadays Artificial Intelligence especially Expert System is used in the fields of Science, Engineering, Business, Manufacturing, Management, Construction Management and many others. This paper delineates development of an Expert System Frame-Work for controlling time & cost overruns in construction project. The purpose of this paper is to assess the significant level of causative factors of cost and time overrun on project success throughout the lifecycle of construction process. Expert system will be completely attached with the whole project schedule to the approximate outcome of the causative factors, which are not properly controlled. This will be goaled by applying the techniques of artificial intelligence, such as rule based system and case based system. The purpose of system will also be capable for suggesting the mitigation measures for controlling the causative factors. In the last various reports can be made up for controlling the causative factors of cost and time overrun by applying the appropriate mitigation measures.

Keywords
Artificial Intelligence, Expert System, Time Overrun, Cost Overrun, Significant Factors.

1. Introduction

A project can be successful by measuring of different ways of performance such as time, cost, quality etc. Atkinson (1999), expressed that cost, time in addition with quality assists on Iron Triangle to meet a project successful . Time in addition to cost performance will be the most important warning regarding project accomplishment . It shows not only the productivity of an organization but also

firm's profitability throughout any construction project. It can be witnessed and always used to achieve the estimated performance of the project.

However, poor cost and time performance makes a construction project un capable to complete with its estimated time and budget. This persistent issue is increasing to critical condition and it can be observed worldwide. A research work regarding the cost overrun issues was conducted by Flyvbjerg et al. (2003), throughout the world in which they found that 9 out of 10 projects suffer with an average of more than 28% cost escalation . The issue of poor performance of cost and time overrun is frequent issue in both developed and developing countries like USA, UK, Portugal, Malaysia, Pakistan and others. The succeeding section presents literature review of some previous studies related to cost and time overrun.

2. Literature Review

In 1994, a study in usa was conducted. It showed that only 16% of the projects were according to the criteria of cost, time and quality . A case study on four projects on cost performance was conducted by chang (2002), it identified that 12.3% to 51.3% projects were facing cost overrun problem, which is an average of 24.8% of a contract . In contrast, barrick, (1995) studied throughout the uk, that almost a third of the owners' complaints that their own projects usually overrun funds . Even more, Department of Environment, Transport and the Regions (DETR, 2000) stated that 55% of projects experienced a huge amount of cost overrun . An audit report between 1985 and 2002 was published by National Court of Audit Portugal (NACL, 2000) as summarize by (Moura, Teixeira, & Pires, 2007). It included cost effectiveness of 26 motorway and 98 expo projects. The report of these projects showed that 35% of motorway and 41% of expo projects had cost overrun . Construction industry is facing the common issues of cost and time overrun problems . In 2008 Malaysian Auditor General highlighted report which reviewed by other researchers (Khamidi, Khan, & Idrus, 2011). It reported that RM 1.43 billion cost overrun in the completion of double track electrified project between Rawang and Ipoh . A total of 359 projects were analyzed by Endut et al. (2009), in which they found 46.80% projects completed within the estimated budget and remaining projects faced cost overrun . Moreover, a research conducted by Abdullah et al. (2009) in the Majlis Amanah Rakyat (MARA) large construction projects, revealed that more than 90% of MARA large construction projects experiencing delay since 1984 with major effects of time and cost overrun . Like other countries, cost and time overrun are common problem in construction projects of Pakistan. A Research study conducted by Nida Azhar et. el. (2008) mentioned that cost overrun is the major problem in Pakistan. Every construction project exceed 100% of its time and budget . Recently a research study was conducted on time overrun in construction projects by Saiful Haq et al. (2014), which revealed that 99% of construction projects delay due to the time overrun. This indicates that the construction projects are mostly facing the problem of poor time and cost performance and it must be addressed .

3. Factors Affecting Cost and Time Overrun in Construction Projects

Several factors and reasons can cause delays in construction projects or cost overrun issues. Construction performance in terms of time and cost is prone to risk due to several governing factors. Hence, comprehensive literature review on causative risk factors regarding time and cost overrun is carried out to understand these issues. Various researchers have highlighted number of factors which basically become the cause for time and cost overrun. It's quite important to control these factors to limit the cost and time overrun.

In 2006, Assaf and Al-Hejji studied the reasons for delays in huge construction projects in Saudi Arabia and revealed the utmost important causes of delay, that includes the change orders by owner during construction, delay in progress payments, ineffective planning and scheduling by contractor, poor site management and supervision by contractor, shortage of labors, difficulties in financing by

contractor, changes in government regulations, traffic control and restrictions at site, effect of social and cultural factors and accidents during construction .

A questionnaire survey was conducted by Frimpong et al. (2003). It consisted of 26 factors to study major contributors of cost overrun in groundwater drilling projects in Ghana. Out of 26 factors considered, top 10 factors are monthly payment difficulties, poor contract management, material procurement, inflation, contractor's financial difficulties, escalation of material prices, cash flow during construction, planning and scheduling deficiencies, bad weather and deficiencies in cost estimates prepared . Time overrun issues in construction building projects in Ghana from views of clients, consultants and contractors were focused by Fugar and Agyakwah-Baah (2010), Time overrun factors which influenced much, were delay in honoring certificates, underestimation of the cost of project, underestimation of complexity of project, difficulty in accessing bank credit, poor supervision, underestimation of time for completion of projects by contractors, shortage of materials, poor professional management, fluctuation of prices/rising cost of materials and poor site management .

The causes of construction delay in traditional contracts in Jordan were studied by Odeh and Battaineh (2002). The major causes which were found by the authors includes owner interference, inadequate contractor experience, financing and payments of completed work, labor productivity, site management, slow decision making, construction methods, improper planning and subcontractors . Later, through Sweis et al. (2008), it came to be known that all of the respondents (i.e. clients, contractors, consultants). Too many change orders from owner and poor planning and scheduling are the main critical causes of consultant's part. The shortage of manpower and too many orders from owner were major causes of time overrun in view of contractors. While incompetent technical staff working on the project, poor planning and scheduling done are the most critical factors in view of owners . Le-Hoai et al. (2008) studied the causes of time and cost overrun in large construction project of Vietnam using questionnaire survey. It included 21 causative factors and top 5 common and intense causes of cost overrun were poor site management and supervision, poor project management assistance, financial difficulties of owner, financial difficulties of contractor; design changes .

In UK, Jackson(2002) studied the reasons of budget overrun through questionnaire survey and found that major reasons of overrun were design changes, design development factors, information availability, method of estimation, performance of design team and project management . Another investigation was carried out by Olawale & Sun (2010) for finding time and cost overrun factors through an administered questionnaire and found that cost control inhibiting factors were (in ranking order) design changes, risk and uncertainty associated with projects, inaccurate evaluation of project's time/duration, non-performance of subcontractors and nominated suppliers, complexity of works, conflict between project parties, discrepancies in contract documentation, contract and specification interpretation disagreement, inflation of prices, financing and payment for completed works, lack of proper training and experience of project manager, low skilled manpower, unpredictable weather conditions, dependency on imported materials, lack of appropriate software, unstable interest rate, fluctuation of currency/exchange rate, weak regulation and control, project fraud and corruption, and unstable government policies .

Schedule delay was identified as the major reason of cost overrun; as found in summary of Malaysians Auditor General 2008 report by Khamidi et al. (2011). Ali & Kamaruzzaman, (2010) conducted a study to identify main causes of cost overrun in large building projects in Klang Valley and found that major factors contributing to cost overrun included inaccurate or poor estimation of original cost, inflation of project costs, improper planning, fluctuation in price of raw materials, poor project management, lack of experience, obsolete or unsuitable construction equipments and methods, unforeseen site conditions, mistake in design, insufficient fund, poor contract management, high cost of machineries, and construction cost underestimation . In 2007, Alaghbari et al, the problems of time overrun and were studied and found that the top ten important factors included financial difficulties by owner, financial problems by contractor, supervision too late, slowness in making decisions and slow give instructions by consultant, lack of material by external factor, poor site management, materials shortage, construction mistakes and delay delivery of materials by contractor, slowness making

decision by owner, lack of experience and incomplete documents by consultant . Another study by Sambasivan and Soon (2007) revealed the most important causes of time overrun and those were contractor's improper planning, mistakes during construction stage, inadequate contractor experience, inadequate client's finance and payments for completed work and lack of communication between parties .

In 2008, Nida Azhar et al, conducted a research concerning the Pakistan's construction industry to identify the major causes of cost overrun and determined major factors of contributing the cost overrun including the fluctuation in prices of raw materials, unstable cost of manufactured, management/ poor cost control, delays between design and procurement phases, incorrect/ inappropriate methods of cost estimation, additional work, improper planning, and unsupportive government policies, materials, high cost of machineries, lowest bidding procurement procedures, poor project (site) .

Later Naeem Ejaz et al. (2013) studied that these are the main causes of time and cost overrun in Pakistan construction projects. The authors identified escalation of material prices, inadequate control procedure, shortage of technical persons, delays in work approval and shortage of materials, plant/equipment are most critical factor of time and cost overrun . These factors of time and cost overrun throughout the world in construction projects are the part of the whole literature review. On the basis of this comprehensive literature review 27 common factors of time and cost overrun are identified, which are shown in table 1.

Table 1: Mapping Factors Affecting Cost and Time Overrun

No.	Factors Affecting Time and Cost Overrun	Origin
1	Change orders by owner during construction	Fugar and Agyakwah - Baah (2010), Sweis et al. (2008), Le-Hoai et al. (2008).
2	Delay in progress payments	Assaf and Al-Hejji (2006), Frimpong et al. (2003), Odeh and Battaineh (2002).
3	Ineffective planning and scheduling by contractor	Assaf and Al-Hejji (2006), Sweis et al. (2008).
4	Poor site management and supervision	Frimpong et al. (2003), Assaf and Al-Hejji (2006), Fugar and Agyakwah - Baah (2010), Le-Hoai et al. (2008).
5	Shortage of labors	Assaf and Al-Hejji (2006), Odeh and Battaineh (2002), Naeem Ejaz et al. (2013).
6	Difficulties in financing by contractor	Assaf and Al-Hejji (2006), Frimpong et al. (2003), Fugar and Agyakwah - Baah (2010), Odeh and Battaineh (2002), Le-Hoai et al. (2008).
7	Changes in government regulations	Assaf and Al-Hejji (2006), Olawale & Sun (2010).
9	Material procurement	Frimpong et al. (2003), Assaf and Al-Hejji (2006).
10	Escalation of material prices	Frimpong et al. (2003), Fugar and Agyakwah - Baah (2010), Olawale & Sun (2010), Khamidi, Khan, & Idrus, (2011).
11	Unpredictable weather	Frimpong et al. (2003), Olawale & Sun (2010),
12	Shortage of material	Assaf and Al-Hejji (2006), Fugar and Agyakwah - Baah (2010), Olawale & Sun (2010).

13	Inadequate contract experience	Odeh and Battaineh (2002), Sweis et al. (2008), Sambasivan and Soon (2007).
14	Improper planning and subcontractor	Odeh and Battaineh (2002), Olawale & Sun (2010), Khamidi, Khan, & Idrus, (2011), Sambasivan and Soon (2007), Nida Azhar et. el. (2008).
15	Incompetent technical staff	Sweis et al. (2008), Olawale & Sun (2010), Alaghbari et al. (2007).
16	Design Changes	Le-Hoai et al. (2008), Jackson (2002), Olawale & Sun (2010), Khamidi, Khan, & Idrus, (2011).
17	Conflicts between project parties	Olawale & Sun (2010), Khamidi, Khan, & Idrus, (2011).
18	Lack of appropriate software	Olawale & Sun (2010), Alaghbari et al. (2007).
19	Lack of experience	Khamidi, Khan, & Idrus, (2011), Alaghbari et al. (2007).
20	Mistakes in design during construction	Khamidi, Khan, & Idrus, (2011), Alaghbari et al. (2007), Sambasivan and Soon (2007).
21	Lack of communication between parties	Sambasivan and Soon (2007), Olawale & Sun (2010).
22	Delays between design and procurement phases	Olawale & Sun (2010), Nida Azhar et. el. (2008).
23	Inappropriate cost estimation methods	Olawale & Sun (2010), Nida Azhar et. el. (2008).
24	Unsupportive government policies	Olawale & Sun (2010), Nida Azhar et. el. (2008), Sambasivan and Soon (2007).
25	High cost of machineries	Nida Azhar et. el. (2008), Sambasivan and Soon (2007).
26	Inadequate control procedure	Nida Azhar et. el. (2008), Naeem Ejaz et al. (2013).
27	Delays in approval of documentation	Olawale & Sun (2010), Alaghbari et al. (2007).

4. Expert System for Controlling Cost and Time Overrun (ESCCTO)

The purpose of "ESCCTO" is to provide a user interface friendly system for determining the various causative factors of time and cost overrun performance; it will also be able to suggest the possible mitigation measures for controlling the time and cost overrun factors. Following tasks are involved in developing the ESCCTO.

1. Determining the causative factor of time and cost overrun in each phase of construction project life cycle.
2. Determining the significant level of causative factor through (SPSS) Statistical Package for Social Science.
3. Incorporating expert system in proposing mitigation measures for controlling causative factors of time and cost overrun.

This research will use quantitative and qualitative approach in determining the causative factors of time and cost overrun in each phase of construction project life cycle. The data will be analyzed by using SPSS. The key fulfillment of this research is incorporating the expert system with experience

based mitigation measure for controlling the identified/ expected causative factor of time and cost overrun.

4.1 Conceptual Frame-Work of ESCCTO

For determining the various causative factors of time and cost overrun, ESCCTO will provide a user interface friendly system and this system will also support the users in suggesting the mitigation measures of the causative factors. The figure 1: is shows the conceptual Frame-Work of ESCCTO system.

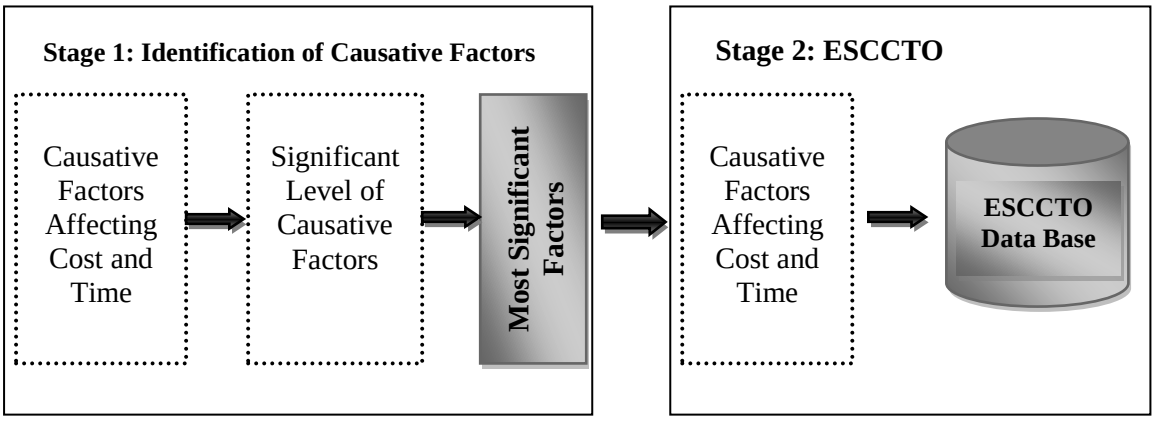

Figure 1: Conceptual Frame-Work of ESCCTO

The conceptual frame-work of ESCCTO is divided in two stages as explained bellow;

Stage 1: Give the clear image of the determining the causative factors of time and cost overrun. This will be completed through quantitative approach technique using questionnaire survey and interviews with the experts involved in construction projects. From that stage users will be capable to find out the significant factors of cost and time overrun for exploring the mitigation measures.

Stage 2: A data base of mitigation measures will be developed on the basis of the causative factors. The expert system will help in selecting the most appropriate measure from the data base to control the causative factors of cost and time overrun.

5. Conclusion

This research study is presenting a conceptual frame work of software development for controlling the problem of time and cost overrun is faced by construction industry since decades. As mentioned most of the construction projects throughout the world are concerned with time and cost overrun. These overruns are the outcome of various causative factors which are the main barriers to project completion. ESCCTO – frame work will be able in determining the various causative factors in affecting the project time and cost. On the basis of determined factors the proposed system will be capable to suggest the mitigation measure for controlling the causative factors of time and cost overrun and consequently improve the project performance.

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