Evaluation of key Factors influencing Process Quality during Construction Projects in Pakistan

Abstract

Purpose:
The quality of construction projects is mainly dependent on the process of quality during construction phase than product quality. The key factors that influence process quality of building projects in Pakistan during construction phase of building life cycle were evaluated from literature.

Methodology:
Primary data was utilized and the factors were ranked using the traditional Relative Importance Index (RII) and the Second Synthetic Grey Relational Analysis (SSGRA) method The findings indicate that during construction phase were selection of appropriate contractor is the most important factor. Existence of feedback system and Quality of shop drawings received from subcontractors are also very significant factors, according to the grey relational model.

Findings:
Measures for improvement of process quality in Pakistan are suggested. The results from both methods were not entirely comparable however if one considers uncertainty in data then the second synthetic GRA based ranking should be preferred over RII in decision making.

Originality:
The study is pioneer in the study of key factors influencing Process Quality during Building Construction Projects in Pakistan using a set of traditional and novel methods. The results of this study are significant in improving the process quality during different phases of construction.

Keywords: Project Management; Process Quality; Construction in Pakistan; Second Synthetic Grey Relational Analysis; GRA; Grey System Theory.

1. Introduction

Since the advent of Project management philosophy, it has been applied in numerous industries and fields due to the flexibility, fast speed and superior management of uncertainties, risks and complexities (Javed & Liu, 2018a). Construction industry (CI) plays a vibrant role in development of any country as it has potential to "drive and underpin the economy with its knock-on effect on other sectors" (SI, 2019). According to (Khan, 2008) Actual goal of development and progress of a nation is building, sanctuary, bridges, infrastructure, roads and new resources of employment. Construction action is remarkable to accomplish these objectives as it contains schools, houses, offices, townships, hospitals more over other buildings, roads, railways, airports, agriculture systems and irrigation systems, power systems, ports, highways, telecommunications etc. in the form of infrastructure.

Currently, quality is considered to be important for the construction aspect whose clients increasingly demands the quality (Chung, 2007). Project quality management (PQM) should give importance to both the processes of qualities, i.e. product quality as well as process quality of any project. There is a marginal difference between these two types of qualities. Process quality is the quality and standard procedures adopted while making the product (Nagasaku and Oda, 1965). Unluckily, the construction area is one of the most neglected areas in Pakistan. The implementation of quality management system is competitive advantage to become successful in competitive industrial in Pakistan. According to Temtime (2003), quality management has become an essential part in today's challenging and irrupt business world, moreover due to intense competition all over the word among different companies has made quality management a preconditioned for survival of business. Mostly it

has been observed that the adoption of quality management system is a systematic tool to optimized business processes and improved overall firm performance (Lee, 2002). There are two prospects of quality as far as construction projects is concerned, the process quality and the product quality. The good quality of construction projects may not be possible without following good process quality during all phases of the project. However, in order to follow good process quality, it is mandatory to evaluate and understand those factors which influence process quality of a building project in various phases of its construction.

Supreme quality is a preferable feature for all stakeholders in construction. It is a fact this industry in Pakistan is being faced with severe quality issues for many decades (Khan, 2008). The quality of construction projects is dependent on the process quality during different phases of construction specially construction Phase after approved drawings.

According to Arditi and Gunaydin (1998), there are numerous factors influences the process quality of building construction projects. These factors consist of generic factors for example teamwork, employee training, management commitment, interest of management in promoting importance of quality, cooperation among team etc. and specific factors related to building industry like selection of appropriate firms, previous track of companies, Health and safety, quality of drawings and specifications, adequacy of supervision, etc.

Unfortunately, in Pakistan, all stakeholders, i.e. designers, contractors, clients, and managers, etc. have a very little realization about the factors that influence process quality. It might be due to the fact that in Pakistan, especially as far as quality of construction of building project no major research has been carried out.

Javed (2019) first proposed a second synthetic grey relational degree and stressed the possibility of its deployment as a degree of relative importance. Further, one can find Relative Importance Index (RII) to be an important technique in project management literature (see, e.g., Aziz & Abdel-Hakam, 2016; Batool & Abbas, 2017; Tsiga et al., 2017). Therefore, in the current study, the key factors that influence process quality of building projects in Pakistan during construction phase of building life cycle would be identified from literature followed by prioritizing them using the Relative Importance Index (RII) and the Second Synthetic Grey Relational Analysis (SSGRA) model. The study is both novel and pioneer in addressing the phenomenon.

2. Literature review

Comprehensive work in the field of process quality has been done internationally. Majority of the studies evaluate the factors that influence quality in general; whereas few studies evaluate the specific factors in different phases of building project which are related to process quality during construction of building life cycle. A broad review of the notable researches is given in the succeeding paragraphs.

Harrington et al. (2012) conducted a study on the United States (US) to investigate the quality problems and improvement opportunities in the US Construction industry. Interviews and surveys were conducted to collect the data. In this research, the authors identified basic elements of quality management comprises employee training and development, managerial leadership toward quality product & services, organizational commitment, improved business processes through econometrics methods, customer complaints and stakeholder involvements in organizational processes. Based on a case study of the Three Gorges Dam in China, Tang et al. (2009) analyzed the key factors of Total Quality Management (TQM) application. The factors were ranked based on their mean values. The ranking showed that leadership in promoting quality, training and teamwork were among the highly rated factors implemented to achieve quality in construction of the Dam. Chan et al. (2006) assessed the factors that influence quality of public housing projects in Hong Kong. Data was collected through questionnaire survey from 54 cases. Factor analysis and multiple regression analysis were used for data analysis. Various factors influencing process quality identified by the authors include leadership of management in encouraging quality, training, and education of employees, the commitment of management to improve quality, clearness of drawings and specifications, control of subcontractor's work, adequacy of supervision and development of standards and availability of feedback systems. In India Jha and Iyer (2006) carried out a

study to evaluate the key factors that influence quality performance in construction projects. By ranking the factors based on the mean score, the authors discovered that top management support, training, feedback systems, and coordination among projects participants are critical success factors for quality improvement whereas lack of education and knowledge adversely influences the process quality in construction projects. Zeng et al. (2005) identified the key factors that influence design quality in China. Data was collected from one hundred design organizations through questionnaire survey, and the factors were ranked according to their Relative Importance Index (RII). The factors included management commitment to quality, education of designer, selection of design firm, coordination skills of designer, allocated budget, and involvement of client. Arditi and Gunaydin (1998) identified the factors that influence process quality in the three different phases of building projects i.e. operation & maintenance phase, construction and design of building life cycle in the US. The factors were ranked according to their degree of importance. The study highlighted some general and industry specific factors during each phase. The general factors comprise management commitment and leadership, a complete building operation manual, teamwork, training, supplier/customer involvement, and statistical methods. The building industry-specific factors were the consistency of drawings and specifications, effective communication practices between the parties, selection of designers and contractors on merit, diligent quality inspection on the building construction site, and an ample budget for building's operation and maintenance. According to a research carried out by Jawaharnesan and Price (1997) in the United Kingdom (UK), the role of owner's representative is essential for the improvement of process quality of construction projects. Another research paper was published by Chase (1993) based on the results of three out of four workshops held at Iowa State University. In this paper, the author outlined the factors that influence process quality during construction of projects. These factors include management involvement, leadership, and commitment, training of employees, teamwork, supplier involvement and determination for continuous quality improvement.

2.1 Construction Industry of Pakistan

In Pakistan, Construction Industry plays a dynamic character in the development of economy and minimize the ratio of unemployment. The CI provides plentiful opportunities for employment as it also has linkages with other industries. The sector through linkages affects about forty (40) building material industries, support investment, and growth climate and helps reduce poverty by generating income opportunities for a poor household. It provided jobs to 2.43 million persons that make about 5.5 per cent of the total employed labor force during 2003-04 (Khan, 2008). Unfortunately, the construction sector is one of the most neglected sectors in Pakistan. It is at nadir, which can be judged from the fact that per capita consumption of cement in Pakistan is one of the lowest among the developing countries i.e. seventy-two (72) kilo grams (Hassan, 2002). In the developing countries like Pakistan, CI has yet to respond to recent technological improvements. Lack of attention towards quality of the process of building construction projects has resulted in poor quality construction works. No significant research has been conducted on process quality and its improvement in Pakistan; therefore, this research will be of great importance for building construction stakeholders as it identifies the critical factors that affect process quality of building projects in various phases of project life cycle. Moreover, appropriate measures have also been suggested which will be helpful for the improvement of quality of building projects in Pakistan. Gardezi et al., (2014) adopted the relative importance index (RII) method to determine the relative importance of the various causes and effects of delays and time extension factors in construction industry of Pakistan. Factors causing cost overrun in the construction projects were ranked on the basis of Relative Importance Index Anwar zeb et (2015). Unfortunately, it was observed from literature that no one had used GRA in construction industry of Pakistan.

2.2 Process quality

Process quality refers to attain the quality in the way a project is organized and managed during its life cycle (Arditi and Gunaydin, 1997). It is the quality of the process that causes a product to be either acceptable or not (Nagasaku and Oda, 1965). The desired quality

of a product cannot be achieved without considering quality factors in the process through which the product is obtained. For example, a mixture of good quality cement, aggregates and water is not sufficient to produce good concrete. A good concrete can only be produced if quality of its ingredients is good as well as the quality of the process through which it is prepared is excellent. Similarly, the quality of materials, workmanship, equipment, technology etc. does not guarantee a good quality of building. Quality of building also depends upon how the various activities in its construction are organized and managed, i.e. its process quality.

2.3 Process quality in construction industry (CI) of Pakistan

A study was carried out by Memon et al., (2013) to highlight the importance of TQM for construction industry (CI) of Pakistan. In this study, the authors examined the level of acceptance of TQM and its execution in the manufacture and construction sector of Pakistan. From this research, it was revealed that both the manufacturing and construction companies understand the importance of TQM, but the level of its execution is negligible. Barriers in implementing TQM in Pakistan were also identified in this research. These barriers were lack of lack of training and dedication of internal customers, management commitment and leadership to quality, lack of training and dedication of internal customers, and less expertise in the field of quality management.

Farooqui et al., (2008) analyzed the inclination of construction firms towards TQM implementation in CI of Pakistan. Through questionnaires and direct interviews, it was investigated that attitude of contractors was towards the adoption of TQM. The problems in implementation of TQM were also highlighted in this study. These problems were the lack of knowledge regarding quality, lack of education in CI, uneven nature of CI, and corruption. Contractors consider TQM as an over burden, and therefore they hesitate to adopt TQM practices. It was indicated that management leadership and commitment towards quality and education of employees are very important for quality improvement.

From the above studies, it appears that there is an awareness among the professionals about importance of quality in CI of Pakistan. However, no significant research has been conducted on process quality and its improvement in Pakistan. Therefore, it can be expected that with the times to come, process quality in construction will gain importance and transform from realization to execution. The present study is a step forward in the field of quality management of building construction in Pakistan; and it will evaluate the key elements that influence process quality during these three phases operation & maintenance, construction, operation & maintenance, and design) of building life cycle.

3. Research methodology

A well designed questionnaire was administered to collect the data to empirically investigate the effect of quality indicators on construction of buildings. Questionnaire has been selected from past studies, Arditi and Gunaydin (1998; 1999) and validation, refinement, and improvement of questionnaire according to the environment of CI of Pakistan. Aformentioned, a feasibility survey, full scale survey was conducted from the respondents of 72 contractor firm's registered in Pakistan Engineering council (C-A, C-B, C-1, C-2, C-3 categories) (www.pec.org). Finally, statistical analysis, by using SPSS and MS Excel, was carried out for the collected data to evaluate the key factors. Here one point should be noted that in order to analyze data through statistical means a large sample size is needed but when sample size is Grey System Theory is a recommended approach in literature (Syed et al., 2018). Thus the current study benefits from both traditional and novel approaches.

3.1 Research design

This research was carried out to determine the critical elements that impact on process quality of building projects in construction. The sample size was collected from the contractor firms registered in Pakistan Engineering council (PEC) from CA to C-3 category. Moreover, empirically investigated by Dillman (2000) after calculation including 10% margin

of error and 90% of confidence interval Table 1 shows the details. Since the sample size was small grey system theory approach was considered fit for use.

Table 1: Sample Sizes

Phase	Population Size	Sample Size
Construction Phase	2300	66

Based on objectives a questionnaire has been selected. The pilot survey has been done to verify the reliability and validity of the questionnaires. The selection of questionnaire also includes essential elements of measurement scale, measurement attitude and categorical response ranges were taken into consideration. In this research Likert scale approach is used to collect the observation of all the respondents. The questionnaire was divided in two parts. Part I consisted of the respondent's general information. Part II was the main body of all the contained eighteen (18) factors.

3.2 Data Collection

Various modes as given by Johnson and Owens (2003) were adopted for data collection for this research. As the research instrument is classic which has already been adopted by Arditi and Gunaydin (1998) in the USA, pilot survey was carried out to test the questionnaires' items as well as the whole questionnaires. A sample of ten (10) professionals was selected. Five (5) of them had ample design experience and five (5) had plenty of knowledge and experience of the field. The questionnaires were delivered by hand to ensure maximum feedback. The responses provided by the respondents were helpful in refining and improving the questionnaires according to the CI of Pakistan. A detailed survey questionnaire was conducted afterwards. Different modes of communication were adopted to achieve maximum response rate from the industry. As three coauthors are working in the industry so high response rate was accepted. The modes include personal (face to face), telephone, mail, web or combination of all methods. Lists of valid constructor firms were obtained from the website of PEC (2014). These lists contained the mailing addresses, email addresses and phone numbers of all the firms. Majority of the respondents were accessed through telephone and questionnaires were delivered to them through email. Many questionnaires were also delivered personally to those respondents who were accessible to the researcher. Bell (2010) argued that delivering questionnaires to respondents by hand have distinct advantages. Respondents can get a better understanding of the research purpose, questionnaires can be filled through face to face communication, any difficulty in the questionnaires can be sorted out easily, and high response rate can be obtained. Therefore, stakeholders working in Islamabad, Rawalpindi, Peshawar and Multan region were visited personally and questionnaires were delivered to them. In addition, few questionnaires were also delivered to the respondents through postal mail. Lastly, social media was also used to gather as much data as possible from the suitable respondents.

3.3 Response rate

One of the important factors of survey research methodology is response rate. Response rate can be increased by paying attention to some variables. The research includes following variables for the response rate.

3.3.1 Advance notice

Response rate can be increased by advance notice. An advance notice indicates the willingness of respondent to take part in the research survey. In this research telephone calls were made as advance notices.

3.3.2 Follow-ups

During the collection of data follow ups were made through e-mails and phone calls after asking a question in the distribution phase because some respondent may not like the follow up calls. Facebook, linkedin and WhatsApp messages on different engineering groups were also sent as a reminder.

Beside the above mentioned strategies, author is working in a prestigious client of Pakistan and having a lot of professional connection and strong linkages in every domain of construction industries all over of Pakistan. So the response rates for the research is exceptionally high. A good response rate is around 30% in the construction enterprises (Black et al., 2000). Therefore, these response rates were acceptable for this research study. Table 2 shows the rates of response for this research.

Table 2: Response Rate

Respondents	Phase	Questionnaires Sent	Questionnaires Received	Response Rate	Invalid Response
72 Registered firms with PEC (CA-C3)	Construction Phase	100	73	73.00 %	1

4. Results and Analysis

4.1 Data analysis

MS Excel and IBM SPSS used for detailed data analysis. As mentioned earlier, this empirical research was carried out to investigate the effect of quality indicators on quality of building projects in Pakistan during the construction of building life cycle. Therefore, the opinion of professionals of CI from, constructor firms were obtained by means of questionnaires. Data were analyzed and developed based on summary of respondents, reliability analysis, ranking of factors based on the calculations of RII, mean and standard deviation, and the list of top five (5) key factors that influence process quality. There were total 72 construction firms selected. Qualification of most of the respondents (61%) to this survey was Bachelors in Civil Engineering. It was interesting to observe that few of the respondents (6%) were not qualified at all. These respondents were owners of the firms. It shows that the ownership of a constructor firm is not subjected to have the qualification in Pakistan's CI. A detailed breakup of respondents' qualification is given in table 3. Beside qualification of respondents, their management level, their area, company capacity, and their province was also asked and tabulated. Sample size was calculated by Dillman (2000), that was 66. Approximately 100 questionnaires were sent and divided into four groups; each coauthor has given 250 questionnaires to distribute and strongly followed up. Due to strong follow up 73 received, 1 respondent has just returned back the questionnaire without filling part-2 do that was considered as invalid.

Table 3: Qualification of respondents from constructor firms

Qualification	Number of Respondents	Percentage	Cumulative Percentage
Matriculation and Under	4	6	6
DAE	13	18	24
Bachelors	44	61	85
Masters	8	11	96
PhD	3	4	100
Total	**72**	**100**	**100**

4.2 Summary of responses

In case of *Selection of appropriate contract forms* manual ranking received from all the respondents were separately entered on an Excel sheet. After that it was calculated and found none of individual ranked the factor 1 Not important at all, 8 Individuals thinks factor 1 is somewhat important, 24 individuals decided this factor is Important, 24 ranked this factor 1 as 4 (very important), and 16 respondent's thoughts factor 1 is Extremely important. Total 72 respondents were actually responsible for getting this Factor 1. Table 4 shows the summary of responses from the professionals of constructor firms.

Table 4: Responses from constructor firms

Sr. No	Factor	Rating				
		(1) Not at all Important	(2) Somewhat Important	(3) Important	(4) Very Important	(5) Extremely Important
1	Selection of appropriate contract forms	0	8	24	24	16
2	Appropriateness of technology used in the construction process	0	5	12	34	21
3	Quality of shop drawings received from subcontractors	0	4	21	29	18
4	Adequacy of supervision/inspection by owner representative	0	4	11	16	41
5	Adequacy of supervision / inspection by contractor	0	0	14	34	24
6	Level of supplier involvement in the construction process	1	11	36	19	5
7	Use of statistical methods	2	12	32	14	12
8	Existence of feedback system	0	10	21	26	15
9	Application of construction management techniques	0	0	19	24	29
10	Budget allocated by owner for construction	0	0	12	36	24
11	Personalities of the participants	4	11	27	11	19
12	Selection of appropriate contractor	0	4	6	19	43
13	Extent of employee training by all parties	0	8	20	37	7
14	Level of management leadership in promoting quality	0	0	15	25	32
15	Level of management commitment to continuous quality improvement	0	2	18	33	19
16	Level of coordination of the contractor's personnel	0	4	9	34	25
17	Extent of teamwork of parties participating in the construction phase	0	4	6	34	28
18	Quality of drawings and specifications received from designer	0	4	9	29	30

4.3 Reliability analysis

The data was processed in the SPSS software ir order to check the reliability of the factors that influence process quality of building projects during construction phase. Cronbach's alpha was estimated for reliability analysis of the factors. The reliability of each item was noted over 0.70 the instrument was likely reliable. The result shows that the research

instrument was reliable. Firstly, the RII of each factor was calculated and secondly, the mean and standard deviation of each factor were analyzed based on the ranking criteria.

4.4 Relative Importance Index (RII)

Relative Importance Index is one of the common techniques widely used for ranking of factors. Pervious studies indicate that RII has been used widely in construction industry, e.g., Rajgor et al., (2016) used RII to evaluate the relative importance of numerous causes and effects of delays. They used this technique within different groups (i.e. site supervisor project engineers, owner and contractors). A four-point scale which ranges from 1-4 was used from (very little degree affect) to (very high degree affect). The purpose of study was to identify the delay factors in construction projects, as delays causes immense problems in the construction industry. Kazaz et al. (2008) also used RII in construction industry and evaluated 37 factors influencing productivity of construction worker; they distribute all the factors into 4 main groups then ranked the factors through RII. Relative importance Index is used to rank the variables between the available data. RII is the mean for any factor which gives it value within representation of respondents. The factor with the highest value has RII = 1, while the next factor with lower value has RII = 2, and so on till RII= 5 in our case. The relative importance index for all the factors were calculated using the equation below. Factors were ranked from all the input data received from the respondents.

The formula of Calculation of RII of each factor, adopted from Fagbenle *et al.* (2004), is presented below.

$$RII = \frac{\Sigma(P_i * U_i)}{N * n}$$

Where,
RII = Relative Importance Index
P_i = Respondent's rating
U_i = Number of respondents with identical rating
N = Sample size
n = Highest value on Likert scale

Inserting values into Fagbenle *et al.* (2004) equation, RII of Factor 1 is found 0.733. In this equation, 1,2,3,4,5 are the ranks from lower to higher and 0,8,24,24,16 were the values which were calculated from the excel sheeting after entering each respondent input data

$$RII = \frac{\sum((1*0)+(2*8)+(3*24)+(4*24)+(5*16))}{72*5} = 0.733$$

The ranking of each factor along with its RII is shown in Table 5. The ranking shows that *appropriate contractor selection*, *Adequacy of supervision/inspection by owner representative and Level of management leadership in promoting quality* are most important factors.

Table 5: RII based ranking of construction phase factors

Factors No.	Factor	RII	Ranking
Factor 1	Selection of appropriate contract forms	0.733	13
Factor 2	Appropriateness of technology used in the construction process	0.797	10
Factor 3	Quality of shop drawings received from subcontractors	0.769	12
Factor 4	Adequacy of supervision / inspection by owner representative	0.861	**2**

Factor 5	Adequacy of supervision / inspection by contractor	0.828	7
Factor 6	Level of supplier involvement in the construction process	0.644	18
Factor 7	Use of statistical methods	0.661	17
Factor 8	Existence of feedback system	0.728	14
Factor 9	Application of construction management techniques	0.828	7
Factor 10	Budget allocated by owner for construction	0.833	6
Factor 11	Personalities of the participants	0.683	16
Factor 12	Selection of appropriate contractor	0.881	**1**
Factor 13	Extent of employee training by all parties	0.719	15
Factor 14	Level of management leadership in promoting quality	0.847	**3**
Factor 15	Level of management commitment to continuous quality improvement	0.792	11
Factor 16	Level of coordination of the contractor's personnel	0.822	9
Factor 17	Extent of teamwork of parties participating in the construction phase	0.839	4
Factor 18	Quality of drawings and specifications received from designer	0.836	**5**

4.5 Ranking by Grey Relational Analysis

Grey relational model is one of the key models of Grey System Theory. Grey system theory was proposed by Professor Julong Deng in 1982 (Liu, Forrest & Yang, 2016). If we take one system data which is known into white and other system data which is unknown into black then the combination of data will be Grey. In Grey System Theory, they are commonly known as grey systems (Deng, 1989; Mahmoudi et al., 2019). From much strength, a unique strength of the grey system theory and its models is their predictions and decision making using small samples and incomplete information (Javed & Liu, 2018b; Ikram et al., 2019). There are many models of GRA however the models proposed by Deng is the most popular one (Liu et al., 2016) and has been widely used in both engineering and social sciences (Mahmoudi et al., 2018; Javed, Mahmoudi & Khan, 2018; Javed & Liu, 2018a). In 2018, scholars proposed a novel Second Synthetic Grey Relational Analysis (SSGRA) model, building upon Deng's GRA (DGRA) model and Liu's Absolute GRA (AGRA) model (Javed & Liu, 2018b; Javed, Liu, Mahmoudi & Nawaz, 2018). The model has been effectively used to solve various problems containing uncertainty. In the following section the second synthetic grey relational analysis as defined in Javed and Liu (2018b) has been conducted. This analysis is superior to traditional statistical methods especially when data contains uncertainty or data is small. We cannot rule out the possibility of uncertainty in data during data collection process; therefore we deployed grey rationality analysis. Further, GRA method are not only novel they have been successfully applied in project environment in past as well (see, e.g., Javed & Liu, 2017; Javed & Liu, 2018b). Therefore, considering the suitability of GRA methods for our study, we considered it appropriate to us it. Table 6 shows the grey relational analysis of the factors of process quality during construction phase of building projects in Pakistan. SSGRA model was executed according to the steps mentioned in Javed and Liu (2018a) and Javed et al. (2018).

Table 6: Grey Relational Evaluation of the Factors of process quality during construction phase of building projects

Factors No.	Factor	AGRA (ε)	DGRA (γ)	SSGRA (ρ)	Rank
Factor 1	Selection of appropriate contract forms	0.874	0.873	0.874	10
Factor 2	Appropriateness of technology used in the construction process	0.906	0.960	0.933	5
Factor 3	Quality of shop drawings received from subcontractors	0.992	0.877	0.935	3

Factor 4	Adequacy of supervision / inspection by owner representative	0.692	0.872	0.782	17
Factor 5	Adequacy of supervision / inspection by contractor	0.769	0.943	0.856	12
Factor 6	Level of supplier involvement in the construction process	0.922	0.948	0.935	4
Factor 7	Use of statistical methods	0.879	0.975	0.927	6
Factor 8	Existence of feedback system	0.967	0.925	0.946	2
Factor 9	Application of construction management techniques	0.765	0.847	0.806	15
Factor 10	Budget allocated by owner for construction	0.771	0.954	0.863	11
Factor 11	Personalities of the participants	0.765	0.768	0.767	18
Factor 12	Selection of appropriate contractor	0.958	0.937	0.948	1
Factor 13	Extent of employee training by all parties	0.943	0.885	0.914	7
Factor 14	Level of management leadership in promoting quality	0.853	0.925	0.889	9
Factor 15	Level of management commitment to continuous quality improvement	0.987	0.822	0.905	8
Factor 16	Level of coordination of the contractor's personnel	0.936	0.753	0.845	13
Factor 17	Extent of teamwork of parties participating in the construction phase	0.771	0.822	0.797	16
Factor 18	Quality of drawings and specifications received from designer	0.921	0.754	0.838	14

According to Grey Relational Analysis, Selection of appropriate contractor and Effective customer complaints system are key factors influencing process Quality during Building Construction Projects in Pakistan. Owner/representative scheduled supervision and inspection and Personalities of the participants turned out to be least important factors. In the following table, the comparative analyses of the two ranking, obtained through RII and the Second Synthetic GRA, have been presented. One can see, in top five factors in both rankings, three factors are similar, which depict the soundness of both methods in the given scenario. However, the difference between the two rankings is because of the consideration (by SSGRA) and non-consideration (by RII) of uncertainty in data by the two methods. It is suggested that when the decision maker is uncertainty conscious, then the decision should be driven by grey ranking otherwise traditional approach is using RII. However, knowing the fact that uncertainty and risk are common phenomenon in project management the current study recommends the deployment of grey system theory based methods in project management for better decision making. Table 7 shows the comparative analysis of the two rankings. One can see a significant difference between the rankings produced by the second synthetic GRA and RII. The reason can be owing to difference in methodologies. RII is a simple method that does not incorporate any kind of uncertainty in its algorithm however GRA models are comprehensive models that incorporates uncertainty better than other traditional methodologies. Hence, the difference can be due to difference in methodologies.

Table 7: Ranking comparison of RII and SSGRA

Factor No.	Factor Title	Ranking by RII	Ranking by

			SSGRA
1	Selection of appropriate contract forms	13	10
2	Appropriateness of technology used in the construction process	10	5
3	Quality of shop drawings received from subcontractors	12	3
4	Adequacy of supervision/inspection by owner representative	2	17
5	Adequacy of supervision / inspection by contractor	7	12
6	Level of supplier involvement in the construction process	18	4
7	Use of statistical methods	17	6
8	Existence of feedback system	14	2
9	Application of construction management techniques	7	15
10	Budget allocated by owner for construction	6	11
11	Personalities of the participants	16	18
12	Selection of appropriate contractor	1	1
13	Extent of employee training by all parties	15	7
14	Level of management leadership in promoting quality	3	9
15	Level of management commitment to continuous quality improvement	11	8
16	Level of coordination of the contractor's personnel	9	13
17	Extent of teamwork of parties participating in the construction phase	4	16
18	Quality of drawings and specifications received from designer	5	14

The top five influential factors identified by the second synthetic grey relational analysis are discussed in following paragraphs.

a) Selection of contractor

Selection of appropriate contractor was found to be most important factor (ranked 1st) of construction phase in Pakistan. Here it is worth noting that it was also one of the most important factors (ranked 5th) in the US constructy industry, as reported by Arditi and Gunaydin, (1998). Usually, a large amount of different contractors bid for a project. It is very important to select a suitable contractor for that project to achieve a high quality performance. The contractor's expertise, financial situation, technical staff, equipment ownership, reputation, and workload may straight away affect the project quality. Therefore, a contractor must be selected carefully after a prequalification analysis.

b) *Supervision by owner representative*

Supervision by owner representative was found to be very important (ranked 2nd) in Pakistan, whereas this factor was not considered that important (ranked 15th) in US as compared to Pakistan (Arditi and Gunaydin, 1998). This might be due to the fact that prime contractors are bound by rules and law to ensure process quality to avoid heavy penalties and reworks in US. Whereas in Pakistan, in absence of proper rules and their enforcement, the owners themselves have to ensure good process quality of construction projects through their representatives.

c) *Management leadership*

The level of management leadership of constructor firms in promoting quality is found critical in Pakistan as well as in US (ranked 3rd). The top management of constructor firms must understand the importance of quality and must promote the measures conducive to high quality.

d) *Teamwork in construction firms*

Teamwork in construction firms was found critical in Pakistan (ranked 4th) and also a highly important factor in US (ranked 6th). Teamwork is very important to avoid the conflicts in the construction phase. In construction, allocation of resources is based on team structure. It is the task of management to improve the efficiency and coordination between these teams. Use of information technology can enhance the level of coordination between contractor's personnel. Conflicts such as material shortage, overlapping activities, inefficient resource allocation, etc. may arise due to poor coordination.

e) Drawing and specifications

Quality of drawings and specifications received from designers is found very important factor in Pakistan (ranked 5th) and also in US (ranked 7th). Drawings and specifications given to the constructor provide technical information on performance of the constructed facility, materials, and quality requirements. Drawings and specifications often contradict each other. Therefore, it is critical that drawings and specifications should be uniform, concise, and clear. Findings of this study point out that the quality of drawings and specifications received from designer affect the quality in the design and construction phases and subsequently the quality of the building. Therefore, it can be argued that the findings of the current study are not irrational.

5. Conclusions & recommendations

5.1 Conclusions

By middle of 20th century, Project Management is relatively new field of study that emerged from within management and have larger vistas (Sajid et al., 2015) hence there are numerous novel issues in project management which need to be addressed and investigated using both conventional and novel methodologies. The objectives of this research study were to evaluate the influencing factors with in process quality during construction phase of building life cycle in Pakistan, and to suggest measures for its improvement. Based on extensive literature review, questionnaires were selected for construction phase of building life cycle and the study objectives were achieved through analysis of the responses collected through survey questionnaire. For construction phase, those respondents were selected who were registered constructor firms of PEC above category C-4. Data was analyzed through MS Excel and SPSS. The factors for each phase were ranked according to their RII, mean and standard deviation. Hence, the top five key factors which influence the process quality in construction phase of building projects in Pakistan have been established. The top most factor in the rankings, obtained by RII and Second Synthetic GRA models, were same i.e., the selection of appropriate contractor, however there was variation in other factors. This variation can be attributed to the difference in the intrinsic properties of the two methods e.g., RII took data values as it is however the grey model considered the uncertainty in the data as well (Syed et al., 2018). Further, in future the scholars can replace the absolute degree in the SSGRA model by the recently released bidirectional absolute degree given by Javed and Liu (2019) when the relationship between different factors is not same or uncertain. The future researchers can explore the phenomenon in detail and also, the study can be replicated in different countries before the results could be generalized.

5.2 Recommendations

There is a need to develop codes/standards in Pakistan that should be compatible with the local conditions. Universities can help in this regard by carrying out research works in this field which might be helpful in the development and improvement of comprehensive national building codes and standards. The teamwork between participants of construction phase is very crucial to achieve good quality work. In this regard, a proper structure should be developed for better cooperation and coordination between all tiers of management. Selection of contractor should be done carefully after pre-qualification analysis. In this regards, Experience of contractor for the same project, financial status, Staff having technical relevant experiments, contractors owned equipment, reputation of contractor, and workload should be

considered as criteria for pre-qualification. Vigilant supervision and regular inspection by the owner's representative is very important to minimize the chances of mistakes and reworks during construction and to achieve quality. Depending upon the process quality of construction phases, an adequate amount of budget must be allocated by owners for the operation and maintenance of buildings. Management leadership of all the firms must actively participate in promoting high process quality while practically applying the quality management systems and measures. Management must show committed-ness to continual improvement regarding quality modules and quality enhancements protocols. This study is the first study in the area of process quality during construction phase of building constructions in Pakistan. It will definitely guide upcoming researchers to create a detailed process quality framework for building projects of Pakistan.

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