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Achieving Greater Project Success & Profitability Through Pre-Construction Planning: A Case-Based Study

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Abstract

Owing to shift in global perspective and socio-economic needs, the construction industry is undertaking risky and complex projects. The complexity of construction projects requires the coordination between designer and contractor in the early stages of the projects. Little research has been performed regarding the pre-construction planning (PCP), which is the integration between contractor and designer in the early stages of a project to ease construction. It is very important for the construction industry stakeholders particularly contractor and designer to acknowledge the significance of PCP. This study analyzed the current utilization of PCP practices, practical benefits from its utilization and barriers faced during its utilization through the study of selected Design-Build residential, commercial infrastructure, transportation, and power plant projects. A questionnaire survey was used for this purpose. The results of this research will provide some solid foundation towards design-construction integration to attain maximum efficiency and success in the construction industry.

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Keywords: Pre-Construction Planning; Design-Build Projects; Construction Industry; Design-Construction Integration

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1. Introduction

A growing challenge for the construction industry stakeholders is to have a successful completion of the project within time and budget. A recent study of Project Management South Africa (PMSA) [1] revealed that out of 300 global megaprojects with budgets of over $1 billion, 65% failed to meet the objectives established at final investment stage. Further, this study also highlighted only 25% of large construction project finished on time within budget. Most of the factors that always affect the project profitability and successful completion of the project can be controlled through pre-construction planning (PCP) effort that usually require 2% to 5% of total installed cost of a project but also depends on type and complexity of the project.

Research studies of [2-4] also documented that project success is greater when effective PCP effort is used. Some outstanding benefits of PCP are the understanding of the project complexity and risk due to the integration between contractor and designer at the early stages of the project. Other related benefits are as follows:

- Enhanced information regarding certainty of cost and schedule
- Increased probability of project success
- Improved performance during construction
- Higher chances of accomplishment of business goals
- Better understanding of risks
- Fewer scope and design changes

Many researchers have already acknowledged the significance of effective PCP practices and integration of designer and contractor in the early stages of construction project life cycle. Findings of Singapore construction industry [5] has also proven that PCP effort can effect in considerable cost and schedule savings. Due to PCP practices ten out of the 12 Singapore firms were able to reduce the project durations approximately up to 15%. Furthermore, in the case of cost savings, 11 out of the 12 companies that were applying PCP which resulted in a reduction of project costs approximately up to 15%, with an average of 6.1%. This is coherence with the recent Construction Industry Institute (CII) best practice report results that indicated that 609 projects cost of $ 37 billion achieved 10% less cost, 7% shorter project duration and 5 % fewer changes due to effective PCP [6]. The research study [7] also supported the fact that constructor's input in the PCP stage had a positive effect on project success and suggested that in the case of a lack of PCP professional, expertise should be hired from external sources at the earliest stages of the project. Also, finding of a recent study [8] proposed the construction input assessment tool for providing construction input during the PCP stage.

PCP practices have also played an important role in affecting the cost performance of green building projects. The research study [9] has emphasized that integration of stakeholders during the PCP stage ensures the project success and cost saving at the early stage of green building projects. Research study [10] also highlights the PCP practices for sustainable infrastructure projects and advocated the significance of developing a tool for PCP of infrastructure projects. Although many of the studies are already emphasized the significance of PCP, but many of the organizations still need to understand the concept of PCP. The CII study [11] describes PCP as "the process of developing sufficient strategic information with which owners can address risk and decide to commit resources to maximize the chance for a successful project".

Several PCP techniques and tools emerged in the last decades to achieve the successful project performance. These techniques include building information modeling (BIM), project control systems, design phase construction planning, and using past projects data to improve performance. However, each of these planning techniques impact differently on project cost and have different effects on the overall project's success [12]. On the other hand, research study [13] highlighted that Project Definition Rating Index (PDRI), Alignment Thermometer, PCP Toolkit, and Shutdown Turnaround Alignment Review (STAR) are the most vital tools which are mostly used by the CII members during the PCP process.

There are many factors such as poor area and site investigations, weather conditions and poor safety management system that can cause delays on a regular construction schedule and affect planned cost. But the most important factor that affects project performance is the inadequate scope definition during PCP [14]. The brief explanation of all other aspects of PCP is presented in Table 1. Usually, the general contractor is accountable for meeting all the

requirements of a construction project that affect these factors. However, the planning accountability can rest on another group depending on the type of project and contract delivery system.

Table 1. Explanation of PCP aspects

Sr.#	PCP Aspects	Explanation	Reference(s)
1.	Project Scope (PS)	The process of a project is defined and prepared for fast execution approach.	[15]
2.	Area & Site Investigation (ASI)	The design process of geological investigation & defining political & security issues of the area.	[16]
3.	Team Selection (TS)	Effective communication strategy within the team selection of a contractor.	[17]
4.	Design Review Coordination (DRC)	Reviewing of drawings according to specifications and coordination among designer, consultant, and contractor.	[18]
5.	Constructability (CONS.)	The conceptual planning (regarding performance of schedule, quality, cost, and safety) phase of a project.	[19]
6.	Value Engineering (VE)	Identifying alternative ideas for accomplishing the project function at the lowest cost.	[20]
7.	Risk Analysis (RA)	Chances of delays due to accidents during construction of a project and their respective outcomes.	[21]
8.	Safety in Design (SID)	The initial integration of hazard identification and risk assessment methods into the design process.	[22]
9.	Long Lead Procurement (LLP)	The early procurement of material to accommodate it for long procurement spans.	[23]

The imperative requirement of effective PCP has been stressed and cannot be ignored. However, many organizations are still struggling to apply PCP in construction projects. To comprehend the barriers of PCP, a research [24] was carried out in which the members of the CII from 59 organizations responded that the lack of knowledge or understanding regarding PCP, other existing processes or alternate methods for planning, lack of resources including time or money, lack of trained PCP professional, and lack of management commitment were the main obstacles to effective PCP. Although all these studies, discuss the implementation of PCP, its resulting benefits and barriers faced during the implementation of PCP, these issues have rarely been explored regarding all possible aspects of PCP and in the context of design-construction integration in Pakistani construction industry environment. The main objective of this research is to analyze the level of PCP being used in Pakistan as to take a step towards design-construction integration to attain maximum efficiency and success in the construction industry**.**

2. Objectives and Scope

The scope of this research includes Pakistani construction industry, and the baseline is to study the selected design-build projects of residential, commercial infrastructure, transportation, and power plants and to analyze the level of PCP on the projects. The following objectives were set for this study:

1. To identify the level of involvement, benefits achieved, and barriers faced during the utilization of PCP in Pakistani construction industry.
2. To evaluate the relationship between barriers and involvement in PCP.

3. Research Methodology

After the preliminary study, a detailed literature review was carried out. Based on the gathered knowledge, a detailed survey was conducted to collect the data of PCP through a questionnaire in which all the above aspects of PCP were covered. Only Design-Build recently completed projects were selected, and questionnaires were filled by the contractors who worked on their respective projects during the early stages of the project as a consultant i.e. gave proper recommendations on the basis of their experience in the field. Eleven Design-Build projects were selected, and the questionnaires were delivered to the 11 concerned persons i.e. the consultant contractor on the projects. The following things were considered during the questionnaire survey: 1) the firm must have a registration with Pakistan Engineering Council (PEC), 2) the respondent working in the firm should also have a registration with

PEC, 3) the respondent should have a professional experience of at least five years, 3) the respondent must have the knowledge regarding PCP, 4) the firm must have done a project in Design-Build contract type. 5) the respondent must have participated in the project during its PCP.

3.1. Questionnaire Structure

The questionnaire deals with the role of the contractor as an adviser in the early stages of the project. The introductory part contains questions regarding project information about the selected project, the company details, and respondent's personal information. The next part of the questionnaire consists of main PCP aspects and their respective research variables by which the rate of involvement of contractor in the early stages of the project was determined. Next part of the questionnaire was similar to the involvement of contractor part in which all PCP aspects were covered but the research variables were kept totally different to ascertain the benefits achieved by the organizations through applying PCP, and last part of the questionnaire was about the barriers faced by the organizations during the implementation of PCP stage.

3.2. Sample Size and Project Information

A total of 11 Design-Build recently completed projects; residential, commercial, transportation and power plant projects were selected from Pakistani construction industry for this purpose, and the questionnaires were filled by the 11 key respondents who worked on their respective projects during PCP stage. All these selected key respondents had, at least, five years professional working experience. All others detail of projects are mentioned in Table 2.

Table 2. Sample Size and Project Information

Project No.	Experience Of Respondent (Years)	Planned Project Cost In Millions of Rupees (PKR)	Planned Duration (Years)	Covered Area (Sq. Ft)
Project 1	5	50-100	Less than 1	More Than 500
Project 2	5	More Than 100	1-3	More Than 500
Project 3	30	10-50	Less than 1	2000 -5000
Project 4	16	10-50	1-3	2000 -5000
Project 5	5	More Than 100	1-3	1000-2000
Project 6	8	More Than 100	More than 5	More Than 5000
Project 7	5	More Than 100	Less than 1	More Than 5000
Project 8	16	More Than 100	Less than 1	More Than 500
Project 9	5	Less Then10	Less than 1	2000 -5000
Project 10	6	More Than 100	3-5	More Than 5000
Project 11	6	More Than 100	Less than 1	More Than 5000

4. Analysis and Discussion

Different tests were carried out on the data to perform statistical analysis. The statistical analysis was divided into descriptive and inferential analysis. In the descriptive analysis, every single project was analyzed through frequency distribution technique. In this part of the analysis, involvement in PCP and achieved benefits were determined through the number of identified research variables of involvement and benefits that were rated by the respondents

according to their level of involvement in the design and the benefits achieved as a result of that involvement. In the inferential analysis, a correlation test was performed using statistical tools such as SPSS and MS EXCEL to analyze the correlations between the contractor involvement in the early stages of project and barriers faced during PCP.

4.1 Descriptive Analyses

4.1.1. Involvement of PCP

Table 3 shows PCP aspects and their respective research variables that were rated by the correspondents on a scale of 1-5 with 1 being "very low" and 5 being "very high" level of involvement of PCP team on their respective projects during the PCP stage. With the help of this data and SPSS software, analysis of all PCP aspects concerning each project was carried out and relative percentages of every single project were determined. These percentages as shown in Table 4 highlight the level of involvement of respondent in that particular project.

Table 3. Research Variables

PCP Aspects	Research Variables
PS	Providing details of estimated cost, providing execution approach, providing procurement strategy, scheduling of master plan, defining project requirements
ASI	Providing surrounding area information, providing geological and geotechnical evaluations, identifying equipment requirements, defining local weather conditions for scheduling, presence of existing underground utilities, identifying availability of essential services, defining political & security issues
TS	Providing effective communication strategy within the team, facilitating the selection of contractor
CONS.	Providing timely input in design to avoid the need for change, preparing control schedules, estimates and budgets, selecting major construction methods and materials, identifying potential major construction problems
DRC.	Reviewing of drawings and specifications, identifying opportunities for cost savings, identifying appropriate construction method & materials
RA	Identifying tight project schedule, identifying inaccurate cost estimate, identifying price inflation of construction materials
VE	Identifying high cost areas, identifying alternative ideas for accomplishing the project function at lowest cost, identifying quality assurance & control procedure
SID	Giving ideas for design changes & to improve construction worker safety, preventing the use of hazardous material, preparing health and safety plan, suggesting work methods and sequences, delivering alternate safer design and planning
LLP	Providing the list of long lead materials &equipment, identifying procurements procedures & plans, estimating cost of long lead material & equipment

Table 4. Percentage Frequency Distribution Results

Project No.	Very Low (%)	Low (%)	Medium (%)	High (%)	Very High (%)
Project 1	20	12	14	14	40
Project 2	3	21	22	46	8
Project 3	8	23	46	20	3
Project 4	6	31	34	26	3
Project 5	4	41	22	18	15
Project 6	23	11	9	20	37
Project 7	0	3	20	29	48
Project 8	0	0	14	54	32
Project 9	33	3	9	14	12
Project 10	0	0	22	58	3
Project 11	11	22	11	31	25

In Table 4 project 7 has a total of (48%+29%=77%) and project 8 has (54%+32%= 86%) of the points of involvement indicated as "high" and "very high". This shows that the level of involvement during PCP stage on these projects was much better than the others. Project 1, project 2, project 6, project 10, and project 11 also have

good levels of PCP as they have 54%, 54%, 57%, 61%, and 56 % (same calculated as above, i.e., combination of high and very high respective project values) of the points of involvement indicated as “high” or “very high”.

4.1.2. Benefits of PCP

Table 5 shows PCP aspects and their respective perceived benefits that were rated by the correspondents on a scale of 1-5, with 1 being “very low” and 5 being “very high” level of benefits achieved on their respective projects during PCP stage. With the help of this data, analysis of each and every single project was carried out on all aspects of PCP and relative percentages of every project were calculated with the help of SPSS software. This percentage frequency distribution values as shown in Table 6 present the level of benefits achieved due to PCP practices in that particular project.

Table 5. Research Variables

PCP Aspects	Research Variables
PS	Accuracy in the conceptual cost, reduced delays, project completion within budget, improved operational performance
ASI	Ease in developing weather constrained schedule, proper orientation of structure, project completion within time
TS	Improved operational performance, improved coordination
CONS.	Reduced project cost, enhanced project quality, enhanced project safety, reduced project duration, minimized contract change orders and disputes
DRC	Less request for information, improved coordination between contractor as consultant &designer, improved project quality, less design changes
RA	Reduced time delays, risk free project performance, positively impact capital project performance, accuracy in project schedule
VE	Improved project performance, improved quality, reduced unnecessary cost
SID	Reduced site hazards in construction, increased productivity, fewer delays due to accidents during construction
LLP	Reduced time delays, reduced cost

Table 6. Percentage Frequency Distribution Results

Project No.	Very Low (%)	Low (%)	Medium (%)	High (%)	Very High (%)
Project 1	0	0	39	43	18
Project 2	7	14	29	39	11
Project 3	11	8	42	27	12
Project 4	11	8	42	27	12
Project 5	4	50	39	0	7
Project 6	0	3	29	39	29
Project 7	0	0	7	14	79
Project 8	14	14	32	35	5
Project 9	7	52	37	4	0
Project 10	0	0	28	61	11
Project 11	0	13	20	37	30

It is not surprising to see the high and very high percentage values of the respective project. The evaluation of high and very percentage values highlighted the benefits that were achieved due to PCP practices. Such as Project 1 has 61%, Project 2 has 50%, Project 6 has 68%, Project 7 has 93%, Project 10 has 72%, and Project 11 has 67% of the benefits achieved as “high” and “very high”. It is worth noting that these projects had a better level of involvement during PCP. While it is surprising to note the low and very low percentage values in Table 6. Only two projects such as Project 5 has 54%, and project 9 has 59% of the benefits achieved as “low” and “very low”. These were the projects with less involvement of stakeholders during PCP stage. While two projects such as Project 3 has 42%, and project 4 has 57% of the expected benefits as achieved to “medium” level.

4.2 Inferential Analysis

4.2.1 Correlation Analysis between Barriers and Involvement in PCP

Finally, the data was analyzed to correlate barriers faced during PCP stage and involvement of contractor in the PCP stage. SPSS software was used for the completion of this task. With the help of identified top barriers, which were calculated during a survey on the scale of 1= very low, 5= very high and data about the involvement of contractor, a correlation matrix was developed. The extent of correlation can be clearly identified with the development of correlation matrix. Correlation matrix tells that how much the one variable is correlated with the others. In correlation matrix, dependent variables (all PCP aspects) were put in the column while independent variables (barriers) were put in rows. It can be seen in Table 7 that signs of the coefficients are minus (-). A minus sign with the coefficient of correlation means negative correlation, i.e., the increase in the value of one variable will result in a decrease in the value of the other variable.

Table 7. Correlation between Barriers and Involvement

Barriers	PCP Aspects									
	PS	ASI	TS	CONS.	DRC	RA	VE	SID	LLP	Overall PCP value
Lack of time for PCP	-0.25	-0.17	0	-0.41	-0.37	-0.87	-0.8	-0.19	0	-0.3634
You were not involved at the right time	-0.09	-.017	-0.63	-0.21	-0.36	-0.21	0	-0.21	-0.42	-0.2456
Not getting key stakeholder involve at early stages	-0.26	-0.19	-0.43	-0.09	-0.29	-0.26	-0.35	-0.24	0	-0.2665
Insufficient expertise of professionals	-0.12	-0.09	-0.49	-0.34	-0.19	0	0	-0.13	0	-0.1505
Incorrect perception of professionals	-0.09	-0.14	-0.42	-0.34	-0.13	0	0	-0.13	0	-0.1395
Minimal resource allocation for task execution	-0.03	-0.08	-0.25	-0.02	0	-0.03	0	-0.14	0	-0.053
Ineffective collaboration between designer and contractor	-0.02	-0.15	0	-0.13	-0.07	-0.02	-0.05	-0.19	0	-0.707
Unclear definitions of roles and responsibilities	0	0	-0.37	-0.11	-0.24	-0.04	-0.83	-0.17	0	-0.1958
Limited resources availability	-0.16	-0.13	-0.14	-0.206	-0.13	-0.05	0	-0.24	0	-0.1177

Finally, with the help of individual PCP aspects coefficient values, the overall average value of all PCP aspects was calculated to show the correlation between barriers and overall PCP involvement on the selected projects. In Table 7 the barrier “Lack of time for PCP” produced the highest effect on the involvement in PCP. It means that on the selected projects, very less time was available for the PCP, and it was an obstruction to a great extent. The second highest barrier that affects the involvement was “Not getting key stakeholder involve at early stages”. The third and the fourth highest were “Wrong time of involvement” and “Unclear definitions of roles and responsibilities” respectively. While “Limited resources availability” and “Insufficient expertise of professionals” were the effect the involvement at a medium level and “Minimal resource allocation for task execution” and “Ineffective collaboration between designer and contractor” affect the involvement at very low level.

5. Conclusions

This study aimed to investigate the impact of PCP on project performance to move towards design-construction integration in the Pakistani construction industry and to encourage more industry professionals to practice it. The analysis demonstrated that PCP could significantly improve project performance if implemented consistently and decorously. It is revealed that lack of time for PCP and not getting the key stakeholder involve at early stages are top two barriers that produced the highest effect on the implementing of PCP practices in Pakistan construction industry.

6. Recommendations

Special consideration should be given to PCP to make the project successful and for the efficient and effective completion of the project. Special time should be allocated for the implementation of PCP. Also, key stakeholders should be present to play their roles at early stages of the project. Furthermore, expert professionals should be hired for the effective utilization of PCP and roles, and responsibilities of professionals should define clearly. Most of the construction management professionals are unaware of the significance of PCP, and it's extremely important to change the mindset of professional by organizing different seminars, workshops, and short courses in universities so that the professionals can be familiar regarding PCP and its advantages.

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References

1. Murray, M., *CII best practices front end planning and alignment*. 2015, Obtained online January 2016 from http://www.projectmanagement.org.za/?page=KnowSer.
2. Griffith, A. and G. Gibson Jr, *Alignment during preproject planning*. Journal of Management in Engineering, 2001. **17**(2): p. 69-76.
3. George, R., L.C. Bell, and W.E. Back, *Critical activities in the front-end planning process*. Journal of Management in Engineering, 2008.
4. Waly, A.F. and W.Y. Thabet, *A virtual construction environment for preconstruction planning*. Automation in construction, 2003. **12**(2): p. 139-154.
5. Hwang, B.-G. and J.W. Ho, *Front-end planning implementation in Singapore: Status, importance, and impact*. Journal of Construction Engineering and Management, 2012. **138**(4): p. 567-573.
6. Construction Industry Institute (CII), *CII Best Practices Guide: Improving Project Performance*. Implementation Resource 166-3. Vol. Version 4.0. 2012: University of Texas at Austin.
7. Mollaoglu-Korkmaz, S., L. Swarup, and D. Riley, *Delivering sustainable, high-performance buildings: Influence of project delivery methods on integration and project outcomes*. Journal of Management in Engineering, 2013. **29**(1): p. 71-78.
8. Oh, E.H., et al., *Integration of the Construction Knowledge and Expertise in Front-End Planning*. Journal of Construction Engineering and Management, 2015. **142**(2): p. 04015067.
9. Son, H., S. Lee, and C. Kim, *An Empirical Investigation of Key Pre-project Planning Practices Affecting the Cost Performance of Green Building Projects*. Procedia Engineering, 2015. **118**: p. 37-41.
10. Gibson, G.E., E. Bingham, and C. Stonger. *Front end planning for infrastructure projects*. in *Proc., Construction Research Congress*. 2010.
11. Construction Industry Institute (CII), *Pre- Project Planning Handbook*. 1995, Austin, TX: Univ. of Texas at Austin.
12. Alshanbari, H., *Impact of Pre-Construction Project Planning on Cost Savings*. 2010, University of Florida.
13. Bosfield, R.P., *Front End Planning In The Modern Construction Industry*. 2012, Arizona State University.
14. Wang, Y.-R. and G.E. Gibson Jr. *Pre-project planning and its practice in industry*. in *International Symposium on Automation and Robotics in Construction 2006*. 2006.
15. Wang, Y.-R. and G.E. Gibson, *A study of preproject planning and project success using ANNs and regression models*. Automation in Construction, 2010. **19**(3): p. 341-346.
16. Zolfagharian, S. and J. Irizarry. *Current trends in construction site layout planning*. in *Construction Research Congress*. 2014.
17. El Asmar, M., et al., *Quantitative methods for design-build team selection*. Journal of Construction Engineering and Management, 2010. **136**(8): p. 904-912.
18. Riley, D. and M. Horman. *Effects of design coordination on project uncertainty*. in *Proceedings of the 9th Annual Conference of the International Group for Lean Construction (IGLC-9), Singapore*. 2001. Citeseer.
19. Raviv, G., A. Shapira, and R. Sacks. *Relationships between Methods for Constructability Analysis during Design and Constructability Failures in Projects*. in *Construction Research Congress 2012@ sConstruction Challenges in a Flat World*. 2012. ASCE.
20. Chen, T., T. Kuo, and C. Lin. *Value engineering applied at the construction planning stage*. in *Industrial Engineering and Engineering Management (IE&EM), 2011 IEEE 18Th International Conference on*. 2011. IEEE.
21. Mohamed, F.D. *Integrating Risk Assessment in Planning for Sustainable Infrastructure Projects*. in *ICSDEC 2012@ sDeveloping the Frontier of Sustainable Design, Engineering, and Construction*. 2012. ASCE.
22. Sacks, R., et al., *Safety by design: dialogues between designers and builders using virtual reality*. Construction Management and Economics, 2015. **33**(1): p. 55-72.
23. Ramsey, D., M. El Asmar, and G.E. GIBSON Jr. *Assessing the Performance of Two-Step Design-Build Procurement*. in *Construction Research Congress 2014@ sConstruction in a Global Network*. 2014. ASCE.
24. G Edward GIBSON and R. BOSFIELD, *Common Barriers to Effective Front-End Planning of Capital Projects*. Construction Research Congress, ASCE, 2012: p. 2459-2468.