ANALYSIS OF CRITICAL COORDINATION ACTIVITIES OF INDIAN CONSTRUCTION PROJECTS

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The performance of Indian construction projects, when measured in terms of their adherence to schedule or cost have not been always encouraging. Literature review and interaction with professionals in the field reveal that many a time the root cause of failure of a project can be attributed to the poor coordination among project participants. With the arrival of large projects involving multiple participants, the coordination has become all the more important. Yet no adequate emphasis seems to have been given to understand and develop coordination as an important management function. The present study identifies 59 coordination activities. Through a questionnaire survey conducted among Indian construction professionals and subsequent analysis, 33 important coordination activities are selected that has significant contribution in checking cost overruns. Factor analyses of responses on important activities reveal contribution of coordination activities in seven different areas to achieve cost adherence. These areas are planning*; execution; team building; documentation; fulfilment of contractual obligation; resource identification;* and *monitoring of critical path activities*.

Keywords: coordination, cost, project management, project success, statistical analysis.

INTRODUCTION

The construction industry in India is the second largest industry in terms of providing employment to the local population and it accounts for around 40% of the country's annual plan. The schedule and cost compliances are the two most widely used performance criteria of a construction project. However the performance of Indian construction projects in terms of these two criteria have not been encouraging. With the arrival of large projects involving multiple designers, contractors, subcontractors, construction managers, consultants and specialists, the situation has become all the more complex. The existing literature indicates that good and effective coordination among various participants has resulted in the success of many large projects whereas there are instances when projects have failed due to lack of coordination among the participants. Coordination plays an important role in avoiding delays in the construction projects where several agencies are involved and thereby avoiding cost overruns due to delay. Coordination means unifying, harmonizing and integrating different agencies involved in any industry with multiple objectives (Grigg 1993). Coordination is also described as "the all-inclusive management activity." While Higgin & Jessop (1965) recognize coordination as one of the three critical functions in the building process along with "design" and "construction", Sheeran (1976) considers coordination as one of the principal functions of management. Most professionals consider coordination as an integral part of project activities that cannot

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be isolated and viewed separately. Time and effort spent in coordination vary with the activities being handled and prudent professionals realize that time and effort spent in coordination is an investment to achieve project success. Although many researchers have identified the importance of coordination only a few researchers have dealt with the subject in detail. The most recent study on coordination has been by Saram and Ahmed (2001) in which they have identified the important coordination activities in general and time consumed by them in performing these activities in relative terms. It is realized that all the time a project participant may not aim to achieve all the four commonly sought performance criteria, i.e., compliance to schedule, cost, quality and safety. Depending on the situation he may give preference to any one of these criteria. Therefore the present study is undertaken to identify various coordination activities and to analyze their importance with specific reference to achieving or improving target schedule, cost, quality, and safety, which are widely considered to be performance indicators of any construction project. However, due to space constraint, influence of these activities on only one performance evaluator, i.e., 'cost' have been discussed in this paper. The other objective is to explore the latent properties of these coordination activities that could help in formulating guidelines to project participants for their successful use in execution of a project.

LITERATURE REVIEW

Saram and Ahmed (2001) point out a lack of systematic study and literature in the area of construction coordination. They identify 64 construction coordination related activities and through questionnaire survey responses these are ranked separately for their order of "importance" and "time consumed" by each of them. Their survey results also prove that the most important activity in construction coordination is identifying strategic activities of the project and their potential delays. Through case study of 7 projects, Wang (2000) discusses effects of involvement of foreign designers on coordination issues in large building projects in China and on the Chinese construction market and local contractors. While he appreciates the innovations and new concepts in engineering designs brought in by the foreign designers to the Chinese industry and breaking the monotony of prevailing Chinese architecture, he is critical about the lack of understanding between the prevailing working patterns or conventions of local Chinese designers and that of the foreign designers. The Chinese designers emphasize on issue of very detailed drawings and correct estimates to the contractors, whereas the foreign designers do not provide detailed drawings and correct estimates. This causes problems right from comprehension of drawings to various stages of execution of work including monitoring the physical and financial progress. Also the long distance causing inability for designers to visit the sites regularly to give decisions, or attend meetings for face to face communication or team building, ineffective communication technique (lack of e-mail, video conferencing, group work tools etc.) and language problems pose another set of coordination problems. All these result in considerable delay and cost overruns in projects. Lammie and Shah (1980) attribute *linking mechanisms* between different levels of project hierarchy for the success of the Atlanta rail transit system project. To manage such a mega project, the entire project is divided into small management groups with specialized task and responsibilities and they are then linked through major integrators viz., owner's general manager, owner's assistant general manager and consultant's project director. The functions of integrators were to ensure that specific decisions, specific actions, and the proper planning perspective were broadcast and coordinated throughout the functional staff. Lam (1991) discusses the success of solving traffic

congestion problem in San Diego where over twelve decision making agencies such as local municipal bodies or state agencies called, the land use and transportation agencies, were involved in the process of planning and execution towards solving traffic congestion problem. The objective is achieved successfully primarily through effective coordination among various agencies. He concludes that often lack of coordination among land use and transportation agencies results in severe traffic congestion in upcoming and developing cities. However, if there is a desire on the part of the policymakers to move forward on a project, and willingness on the part of the strongest entities to take the lead in coordinating policies and implementing strategies, such problems can be tackled. Nam and Tatum (1992) find that a high degree of interaction between the design and production functions is closely linked to successful construction innovation. Through a case study of 10 projects (innovative) they conclude that innovative construction projects have certain types of contractual arrangements that encourage the reconciliation of the project participants' conflicting objectives as well as some contractual clauses that foster the exchange of information among the parties involved.

RESEARCH METHOD

The method adopted to achieve the objectives listed is as given below:

- Literature survey and personal interview with experienced construction professionals to identify construction coordination activities.
- Questionnaire survey approach for data collection.
- Data analysis using SPSS software

IDENTIFICATION OF CONSTRUCTION COORDINATION ACTIVITIES

Work carried out by Saram and Ahmed (2001) on construction coordination activities is found to be extensive and has been quite useful in initially identifying the coordination activities. However all the activities they have listed are not relevant in the Indian context as expressed by the construction professionals during the interview. Absence of sufficient texts and literature on constituents of coordination activities as well as the non-availability of documents showing the responsibilities of a project coordinator made it imperative to go for personal interview with construction professionals followed by a detailed questionnaire survey. A total of 59 coordination activities were identified through literature survey, interaction and brainstorming sessions with experts. The final list of coordination activities are given in the questionnaire, which can be obtained by contacting the authors.

QUESTIONNAIRE RESPONSE AND DATA ANALYSIS

About 400 questionnaires were distributed among professionals that include owners, contractors and consultants having long experience of handling construction projects. A total of 112 responses are obtained. Responses received were given identification number from 01 to 112. All the responses were stored and analysed through Microsoft Excel and Statistical Package for Social Sciences (SPSS). In the questionnaire the respondents were asked to indicate the effects of the coordination activities on all project success evaluation criteria: schedule, cost, quality and no-dispute given alongside these activities. The respondents were asked to choose from 1 to 5 scales in

all these cases with '1' referring to 'Very Large positive contribution', '2' referring to 'Large','3' to 'Small', '4' to 'Very small' and '5' to 'Unnoticeable contribution' on the respective success criteria. The respondents were further advised to strike off those activities, which they felt were not related to coordination and add new activities that they felt to be missing. Mean scores of responses for each activity were calculated separately on each project performance evaluation criterion. These activities were then arranged in the ascending order of the mean score (the lowest mean score indicating the most critical coordination activities having most positive contribution in achieving the given evaluation criterion, the next higher score indicating the next most critical and so on). However in this paper, as indicated earlier, only the analysis of responses for all activities on 'cost' criterion is discussed. Activities having individual mean score less than or equal to 1.5 (≤1.5) may be considered to contribute 'very large' positive effect in minimizing cost, activities with mean score between 1.5 to 2.5 may be considered to contribute 'large' positive effect, between 2.5 and 3.5 'small' positive effect, between 3.5 and 4.5 'very small' positive effect and values greater than 4.5 (≥4.5) to contribute 'unnoticeable' positive effect in minimizing cost. All the coordination activities responsible for minimizing project cost are ranked in the ascending order of mean scores and tabulated. Due to paucity of space the table with rank order of the activities is not given, but the salient interpretations of the results are discussed below.

CRITICAL COORDINATION ACTIVITIES

On scrutiny of mean values of responses on the coordination activities, there emerged 33 activities with mean values less than 2.5 (<2.5), indicating that over 60% of the activities selected in the study were critical and contributed positively in minimizing the cost of a project. As could be guessed, the activity with first rank in the rank order of the activities was 'Monitoring the budget on all activities and taking corrective action'. Rank 1 of this activity in responses of both owner and contractor also indicate that both of them accept unanimously that this is the most important activity having a positive impact on influencing the cost outcome. A close look at the ranking of activities also revealed that high ranked activities generally contained resources related activities viz. estimating, identifying and organizing of appropriate resources (ranks 2, 3 and 4). High rank of an activity indicates relatively high importance of this activity over others, as felt by the respondents, for the success of the project in 'cost' criteria. This may also be interpreted that right resources at right time have a very high cost saving potential. Similarly timely identification and monitoring of critical path activities (ranks 5 and 8) can save the contractor from crashing related cost which can be a cause of concern at times. High ranks of activities such as analyzing the project performance of time, cost and quality and detecting their variances from the budgeted values and coordinating the resources related work (ranks 7, 9,10 and 11) point out their significant influence on cost outcome of a project.

DIFFERENCES IN PERCEPTION ON VARIOUS COORDINATING ACTIVITIES

Subsequently, to test if there exists any difference in perception between two groups of respondents (owner and contractor) on the rank order or contribution of above coordinating activities on achieving the budgeted cost, ANOVA (Analysis of variance) was carried out between the means of responses of owners and contractors. As indicated earlier, consultants' responses are merged with owner's responses.

ANOVA results pointed out differences in perception between owner and contractor in only three (3) activities out of 59 activities. These three activities along with their mean values under two groups, their original ranks, F-statistics and the significance level (α) at which hypothesis of equality of mean values across different groups could be rejected are summarized in Table 1. Subsequent to these analyses, the results were discussed with a few professionals for getting greater insight of the results.

Table 1: Summary of ANOVA results between contractor and owner response

S. No.	Coordination Activities	Contractor response		Owner response		F-value	α
		Mean	Rank	Mean	Rank		
1	Conducting regular meetings and project reviews	2.50	49	2.00	14	3.48	0.06
2	Coordinating hand over of work areas/service areas (such as plant rooms, service routes, etc.) to other parties	2.64	56	2.03	21	5.04	0.02
3	Arranging inputs like drawings, specifications, and technical details on time for execution	1.58	4	2.11	25	4.71	0.03

From Table 2 it can be seen that activity, 'Conducting regular meetings and project reviews' has received a low rank in the contractor response (rank 49) while it has secured a very high rank (rank 14) in owner responses. Generally in the review meetings owners' overall project objectives are emphasized heavily and the contractors are normally reminded of their shortfalls in different areas making it an unpleasant encounter for the contractor. Contractors feel this is more of an obligation and consider it to be waste of time and probably in the response too they project this activity to be one of the least important one. On the contrary, owners feel that most of the bottleneck of the project can be sorted out and any pending decision can be quickly sought in such meetings. Hence they give high importance to such meetings. So the differences observed in the responses are valid. Similarly, 'Coordinating hand over of work areas/service areas (such as plant rooms, service routes, etc.) to other parties' has received rank 56 and 21 in contractor and owner responses. This also indicates owner's concern to handover the completed portion of work to the next party to enable him to progress with his part of the job. Owner is also concerned that if the particular area is not handed over on time, the other party may claim idling charges adding to the cost of the project. On the other hand, contractor may not be so much interested in handing over particularly when the handing over is not mandatory through the contract provisions, since he would be neither gaining or losing anything from this. Thus the differences observed in responses are valid. Similarly for a contractor 'getting the required inputs like drawings/specifications etc.' (rank 4) are very important for their plan the activities and resources in an optimal way to minimize cost of the project, whereas for an owner this may not be of that priority (rank 25). Though the differences between contractor and owner responses may be observed only in three activities out of 59 activities it cannot be ignored as they actually represent the expected output from other side. As it is generally said that in order to have good coordination between team participants, one must respect the other's expectations and act accordingly.

TAXONOMY OF COORDINATION ACTIVITY

Though the analysis of responses on 59 coordinating activities, as described above gave the relative importance of one activity over the other through their rank order and

ANOVA, results in the this form was very difficult to comprehend by any practicing engineer. Segregation of the top 33 activities having mean score significantly less than 2.5 (<2.5) conveyed only their higher importance over the rest of the activities, but they still remained too broad to comprehend. Therefore the necessity to discuss entire coordination process in a much concise form arose. Accordingly replacing the long list of top 33 activities by a shorter list was considered since it was also observed that these coordinating activities are not independent of each other and there were some overlaps of properties between two or more activities. Due to correlation among set of variables (activities), these can be grouped as small families, each family reflecting some unique latent property. Grouping of various activities in small families by the researchers through their intellectual wisdom may induce some personal bias. Hence factor analysis, which is a widely accepted multivariate statistical tool for data reduction is considered appropriate for present study also. Factor analysis identifies a set of dimensions that are latent (not easily observed) in a large set of variables. Factor analysis of the top 33 activities produced seven factors explaining about 70% of the total variance. These factors were extracted using the principal component method. A summary of the rotated factor loadings matrix is presented in Table 2. Factor loadings <0.4 were suppressed in the analysis and only loading values ≥0.4 are shown in this Table. Further, the communalities of all the variables are found to be much greater than 0.3, hence the factor model is considered reliable. Initially, the extracted factors, which were all orthogonal to each other in nature, were not amenable to interpretation. Therefore an oblique rotation of the reference axes, called varimax rotation, was performed. The seven factors extracted, variances explained by each factor, factor loadings of various variables in each factor and the latent meaning of these factors are summarized in Table 3. The seven extracted factors are described below.

Table 2: Factor structure of coordination activities

Coordination activities	Factor loading	Variance explained
Factor_1: PLANNING		20.41%
Improving/altering/eliminating activities and considering better alternatives that may efficiently meet the project objectives	0.76	
Coordinating with offsite fabricators and their deliveries	0.75	
Preparing coordination drawings for freezing sequence of activities and giving a road map of responsibilities to all involved in the project.	0.70	
Interfacing/integrating the work on different subsystems	0.69	
Establishing and maintaining an effective organizational structure and communication channels	0.64	
Equipping own men and subcontractors with tools, equipment, and resources	0.63	
Coordinating the purchases, delivery, storage and handling of materials	0.62	
Identifying or gathering information on defects, deficiencies, ambiguities, and conflicts in drawings and specifications and having them resolved	0.62	
Agreeing on detailed methods of construction with all the parties involved	0.62	
Arranging inputs like drawings, specifications, and technical details on time for execution	0.59	
Conducting regular meetings and project reviews	0.57	
Identifying /gathering information on requirements of all parties and consolidating for use in planning	0.56	
Coordinating and rescheduling the sequence of onsite work in case of changes in requirement from client side	0.45	
Keeping joint records of all input cost (viz. labour, material, plant etc.) for non-tendered items.	0.53	
Factor_2: EXECUTION		13.67%
Coordinating the purchases, delivery, storage and handling of materials	0.49	

Table 2: Factor structure of coordination activities

Coordination activities	Factor loading	Variance explained
Monitoring the budget on all activities and taking corrective action	0.88	
Analysing the project performances on time, cost and quality, detecting variances from the schedule/requirements and dealing with their effects considering time and resource constraints	0.85	
Organizing resources (manpower, plant, and material) for effective utilization.	0.78	
Regular monitoring of critical path activities for adhering to schedule	0.54	
Coordinating and rescheduling the sequence of onsite work in case of changes in requirement from client side	0.51	
Estimating the optimum resource requirements	0.51	
Proper assignment of task to the available human resources for the project	0.50	
Monitoring the overall functioning of each section and department of the project	0.42	
Factor_3: TEAM BUILDING		12.67%
Establishing and maintaining an effective organizational structure and communication channels	0.48	
Proper assignment of task to the available human resources for the project	0.50	
Identifying /gathering information on requirements of all parties and consolidating for use in planning	0.54	
Preparing a project quality plan in line with contract specification	0.72	
Developing a team spirit and receiving constructive input from all participants in the project	0.72	
Motivating project participants	0.61	
Managing the maintenance and safety of plant and machinery	0.58	
Ensuring discipline among all employees	0.57	
Applying good technical practices	0.49	
Factor_4: DOCUMENTATION		9.47%
Keeping joint records of quantities of work done especially of the work that is to get covered up	0.79	
Keeping joint records of price escalations where the contract has escalation clause.	0.76	
Keeping joint records of all input cost (viz. labour, material, plant etc.) for non-tendered items.	0.59	
Proposing remedial work methods and programs for executing in case of defect or damage	0.47	
Ensuring discipline among all employees	0.43	
Factor_5: CONTRACTUAL OBLIGATIONS		5.01%
Implementing all contractual commitments	0.73	
Applying good technical practices	0.64	
Factor_6: RESOURCE IDENTIFICATION		4.90%
Identification of appropriate human resources, materials and equipments for the project	0.62	
Arranging inputs like drawings, specifications, and technical details on time for execution	0.52	
Factor_7: MONITORING		4.65%
Regular monitoring of critical path activities for adhering to schedule	0.82	

PLANNING

A close scrutiny of activities emerging in Factor_1 in Table 3 explains that all the activities are predominantly planning related activities and generally the planning section or planning department staff of the organization carries out these actions. However this section or department will also be headed by the Project Manager who is apparently responsible for overall steering of the project to his liking. This factor alone explains a variance of about 20.41% in the total variance of 70.78% explained by the factor analysis. In the relative term, it can be said that this factor accounts for 29% (=20.41/70.78) among all factors. It means that PLANNING holds the key for minimizing cost and if handled carefully will fetch great amount of success.

EXECUTION

The activities under Factor_2 in Table 3 explain the translation of planned activities in to reality. This could either be said to be execution related activities. 13.67% of variance in absolute scale and 19% in relative scale emphasizes the importance of execution. Unless the planned actions are properly executed, one cannot achieve the progress. In fact both PLANNING and EXECUTION are complementary to each other and success of one set of activities depends on the success of the other. These two factors together account for 48% of the variance.

TEAM BUILDING

The next important factor that emerges is TEAM BUILDING as explained by most activities falling under Factor_3 in Table 3. This factor explains 12.67% of variance and accounts for a relative responsibility of 18%.

DOCUMENTATION

Factor_4 explains necessity of keeping records of quantities of work done, price escalations and input costs for labour, material and plant. These help realize the costs incurred at a later date. This factor through 13% of variance explained on absolute scale asserts that it accounts for 9.47% success.

CONTRACTUAL OBLIGATION

There are only two activities that have emerged in Factor_5 which explain requirement of fulfillment of contractual obligations. The variance explained by this factor is 5.01%, which means a share of 7% in minimizing cost.

Resource identification

The two activities under this factor emphasize the importance of identifying the right kind of resources for the project and arranging the different inputs at the right time. This definitely helps in achieving the cost objective. The variance explained by this factor is 4.9%.

Monitoring

Factor_7 with single activity ‘Regular monitoring of critical path activities for adhering to schedule’ factor (Factor_7) that explains 4.65% variance establishes the importance of this particular activity. Monitoring alone hold key of 7% chance of success. If the activities on the critical path are always kept in check it avoids the situation of crashing activities thereby avoiding any additional cost.

It can be inferred from the factor extraction and variances explained that the project coordination is not an isolated and independent activity, but is a typical management function having its inherent role of varying degrees in all the major management activities that are broadly represented by the above seven factors, i.e., Planning, Execution, Team building, Documentation, Fulfillment of contractual obligation, Resource identification and Monitoring. Variance explained by different factors can be said to represent the extent of coordination’s role in different major activities. While all factors are important and cannot be ignored, Factor_1, Factor_2, Factor_3, and Factor_4 (Planning, execution, team building, and documentation) together hold key for a variance of about 80% on a relative scale and definitely require greater

attention. The practitioners are advised to take special precaution in performing these groups of activities.

FUTURE RESEARCH DIRECTIONS

Having identified the components of coordination activities the next logical step is to develop a framework for evaluating the coordination indices for a construction project and measure its relationship with project success. These coordination indices shall be used to compare and forecast the outcome of projects from coordination point of view. The results of the study will provide suggestions to improve the coordination indices of any project and thereby address project ailments of cost and schedule overruns etc. The authors are currently working on it.

SUMMARY AND CONCLUSION

Coordination has been identified as a very important function for the success of a project. The extent of coordination involved in various activities and its importance has not been assessed so far. Through this study, 59 coordination related activities are identified and questionnaire survey is conducted to know importance of coordination related activities in achieving schedule, cost, quality and dispute prevention. However in this paper importance of coordination related activities for minimizing cost is only discussed. Based on the mean values of responses these activities are ranked and 33 activities having high ranks are found to be highly important contributing positively to achieve the project goal with minimum cost. These important activities are then subjected to factor analysis, which yield seven dimensions to the coordination activities. They are *planning; execution; team building; documentation; fulfillment of contractual obligation; resource identification;* and *monitoring of critical path activities*. If coordination is considered as sole element for project success, the study points out that coordination activities in planning, execution, team building and documentation account for 80% credit of all coordination activities. While all the seven dimensions are important, the relative importance of one set of activities over the set can be gauged from the relative contribution imparted by different sets.

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REFERENCES

Grigg, N S (1993) New paradigm for coordination in water industry. *Journal of Water Resources Planning and Management,* ASCE, **119** (5), 572-587.

Higgin, G and Jessop, N (1965) *Communications in the building industry: The report of a pilot study*, Tavistock Publications: London.

Lam, E L (1991) Hardwiring Coordination among Land use and Transportation Agencies. *Journal of Urban Planning and Development,* ASCE **117**(4) 168-180

Lammie, J L and Shah, D P (1980) Project Management- Pulling it all together. *Journal of Transportation Engineering Division, ASCE,* **116** (TE4), 437-451.

Nam, C H and Tatum, C B (1992) Non contractual methods of integration on construction projects. *Journal of Construction Engineering and Management,* ASCE **118**(2) 385-398.

Rad, P F (1979) Delays in construction of nuclear power plant. *Journal of the Energy Division*, Proc of ASCE, **105** (EY/1), 33-46.

Saram, D D D and Ahmed, S M (2001) Construction coordination activities: What is important and what consumes time? *Journal of Management in Engineering, ASCE* **17**(4), 202-213.

Sheeran, F B (1976) *Management essentials for public works administrators*. American Public Works Association, Chicago, III.

Wang, Y (2000) Coordination issues in Chinese large building projects. *Journal of Management in Engineering, ASCE* **16**(6), 54-61.