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Identification of Significant Factors Influencing Performance of Road Construction Industry Using Factor Analysis

S. B. Wijekoon

Department of Engineering Management, Faculty of Engineering, University of Peradeniya, Peradeniya, Sri Lanka
E-Mail: sbwijekoon@hotmail.com, TP: +940777802855

Abstract: This study is aimed at identifying the significant factors affecting the performance of road construction projects in Sri Lanka using factor analysis. Data collected using a questionnaire distributed among thirty engineers working in the road construction industry in Sri Lanka who represent the engineer and the contractor organizations. A list of 130 factors influencing performance of road construction industry have been identified & included in the questionnaire and all thirty engineers responded and returned the questionnaire. Participants were requested to allocate marks from 1-5 (1-very poor influence; 2-poor influence; 3-average influence; 4-high influence; 5-very high influence) to each factor according to their knowledge.

Factors influencing performance of the road construction contracts have been ranked based on average score initially. Significant factors influencing the performance have been identified using factor analysis and they were: conducting progress review meetings and site inspections at appropriate intervals; previous experience of the construction team working on similar project; effective monitoring and feedback by the construction manager; availability of skilled construction labour; engineer's ability to analyze contractor's claims fair and reasonable manner; making payment for Interim Payment Certificates within reasonable time (2 weeks); quick response by the contractor to employers and engineer's requests and instructions; certification of the Interim Payment Certificates by the engineer within a reasonable time (2 weeks) and timely submission of the Interim Payment Certificates by the contractor.

Keywords: Construction, Factor Analysis, Industry, Performance, Roads.

1. Introduction

Road Development is an important component of the economic development in Sri Lanka. Although respective Governments have recognized the importance of improving the road network in the country aiming rapid economic growth which is the top priority of the Government. Accordingly, number of road improvements projects have been planned and some of them are in progress. However, it is learned that the majority of these road projects do not perform as expected especially within time, cost and quality standards due to various factors. This study is aimed at identifying the significant factors influencing the performance of road projects using factor analysis.

2. Literature review

Industry related factors influenced performance of road construction industry were: Uniqueness of construction projects; varied locations; adverse weather and seasonality; dependence on the economy; size of the firm; research and development programs; construction codes, regulations & laws and labour related factors were: high percentage of labour cost; supply - demand characteristics; learning; risk of accidents; work rules and worker motivation [1]. Four management related factors influence construction productivity identified were: planning; resource utilization; information system; and selection of human resources [2].

Non-availability of material and tools, equipment breakdown, repeat work, changing craftsmen, interference, absenteeism, supervision delays, overcrowding, changing foreman, and working overtime have been identified as factors influencing construction productivity in different countries [3], [4], [5].

Construction equipment, materials, tools and consumables, engineering drawings management, direction and coordination, project management, training, craft worker qualifications, superintendent competency and foreman competency are affecting construction labour productivity. Communicating with the supervisors, pay and monetary bonus, training on skills, safety and health influence performance of the construction works [6].

Another important factor influencing the construction productivity and performance is subcontracting. It has become a standard practice implemented by the contractors for project execution. Sub -contracting allows the contractor to have less number of permanent staff and it allows the contractor to downsize the organization. Thereby ensure better handling of the unstable market conditions. When sub - contracting is introduced, there can be an institutional gap between the contractor's staff and sub - contractor's staff and this will lead to disturb the teamwork at sites [7].

It is observed that the fleet of machinery currently deployed in the Sri Lankan construction industry is fairly old and susceptible to frequent breakdowns, and also belongs to various makes and models. As a result, their preventive maintenance and repairs have become complicated. Also the contractors are reluctant to invest on new machinery due to the high cost of capital and also due to the risk of continuity of construction works. Due to these reasons, the contractors are preferred to hire machinery [8].

Some difficulties and constraints faced by the contractors during construction identified were: shortcomings in the market and business environment in which they operate; shortcomings of the clients and consultants and personal shortcomings of the contractor. The other two important factors for effective training for improved performance were: skill upgrading of workmen and upgrading of management skills of contractors [9].

Unanticipated conditions on a construction project result in a significant loss of productivity. Some of the factors that may affect are: adverse weather; scheduled overtime and material shortages [10].

Construction performance can be improved by scheduling construction activities realistically, planning them proactively, motivating workers, and establishing effective project coordination communication mechanisms [11].

Change orders and timing of change orders have adverse effects on the labour productivity in construction [12]. Competitive environment has a great influence on the contractor's performance [13].

3. Data Collection and analysis

A well-designed questionnaire including 130 factors influencing the performance of the road construction industry has been prepared using the factors identified in the previous studies and they were distributed among selected 40 engineers representing engineer and contractor organizations. Thirty engineers have responded and returned the questionnaire with comments. The participants were requested to allocate scores from 1-5 (1-very poor influence; 2-poor influence; 3-average influence; 4-high influence; 5-very high influence) to each factor according to their knowledge. Thirty six factors obtained average score of 4.00 and above are listed Table 1.0 [14].

Average score of the responses are varying from 4.57 to 2.77. Factors obtained average score of 4.00 and above (80% of the maximum score) have been selected for the factor analysis initially and there are 36 such factors. IDM SPSS (Statistical Package for Social Studies) Software Version 22 was used for factor analysis and initial run was conducted with the 36 factors. Factor analysis result of this run indicated that the matrix is not positive definite. In order to make the matrix positive definite the number of factors selected should be less than the number of responses. Therefore 27 factors up to the average score of 4.07 were selected and the second factor analysis run was conducted and the result indicated that this run was satisfactory.

As a first step to perform factor analysis, the adequacy of the survey data was examined by conducting the Kaiser-Meyer-Oklin (KMO) test and Bartlett's test of specificity [15]. The KMO statistics very between 0-1 and recommended bare minimum value of KMO for a satisfactory factor analysis is greater than 0.50 [16]. In this analysis KMO value obtained for the selected 27 factors is 0.577, which is more than 0.5 and hence, considered acceptable. The Bartlett's test of sphericity was 737.907 with an associated probability of 0.000 (less than 0.001), suggested that the population correlation matrix is not an identity matrix. The results of these tests show that the sample data appropriate for factor analysis. During the factor analysis seven principle components with eigenvalues greater than 1 are extracted. Component matrix after varimax rotation using factor analysis and the rotation sums of squared loadings carried out for the questionnaire survey of the Sri Lankan industry are given in Table 2.0 and Table 3.0 respectively.

Table 1.0 - Factors Scored more than 4.0

Number After Ranking	Original No. Allocated	Description of the Factor
1	28	Making the payment for IPCs within a reasonable time (2 weeks)
2	12	Certification of the IPCs by the engineer within a reasonable time (2 weeks)
3	38	Timely issue of instructions by the engineer
4	80	Good working relationship with the employer, engineer & the contractor
5	49	Construction manager's ability to manage people at work
6	85	Timely submission of IPCs by the contractor
7	45	Contractor's ability to prepare timely, accurate and complete IPC
8	117	Availability of skill construction labour
9	2	Employer's ability to provide agreed / required resources (funds, land, etc.) throughout the project duration
10	113	Availability of the required number of plant & equipment
11	116	Technical ability & construction knowledge of contractor's staff
12	11	Discuss with the employer, the engineer & the contractor on construction issues and constraints at a regular intervals
13	112	Condition/reliability of the construction plant & equipment
14	14	Leadership qualities of the engineer
15	15	Authority to take day-to-day decisions by the engineer or his assistants
16	22	Effective monitoring and feedback by the construction manager
17	51	Having very good contract administration knowledge and experience by the engineer
18	72	Previous experience of the construction team working on similar project
19	17	Engineer's technical ability
20	5	Selection of a construction manager with proven track record at the start of the construction work
21	37	Conducting progress review meetings and site inspections at appropriate intervals
22	128	Head office support to site staff during construction
23	36	Engineer's qualifications and experience
24	6	Providing effective assistance to the construction team to take decisions as required on time
25	9	Allowing the engineer to take decisions and supporting such decisions by the employer
26	50	Engineer's ability to analyse contractor's claims fair and reasonable manner
27	105	Quick response by the contractor to employer's / engineer's requests / instructions
28	63	Adequacy and accuracy in contractor's planning on operations, resources & funds
29	109	Contractor's commitment to complete the project within the original or agreed time period
30	110	Availability of specified construction materials
31	21	Understanding of the responsibilities by various members of the construction team
32	25	Academic and professional qualifications of the engineer
33	77	Effective monitoring of plant & equipment utilization
34	119	Knowledge & skill of the construction supervisors
35	126	Contractor's knowledge on construction methods

Table 2.0 Component Matrix after Varimax Rotation (Questionnaire Survey Sri Lankan Industry)

Factors		Factor loading 1	2	3	4	5	6	7	Variance explained (%)
Group 01:									41.405
72	Previous experience of the construction team working on similar project	0.826							
105	Quick response by the contractor to employer's / engineer's requests / instructions	0.782							
85	Timely submission of IPCs by the contractor	0.759							
45	Contractor's ability to prepare timely, accurate and complete IPC	0.696							
22	Effective monitoring and feedback by the construction manager	0.682							
80	Good working relationship with the employer, engineer & the contractor	0.439							
Group 02:									8.588
28	Making the payment for IPCs within a reasonable time (2 weeks)		0.792						
12	Certification of the IPCs by the engineer within a reasonable time (2 weeks)		0.779						
5	Selection of a construction manager with proven track record at the start of the construction work		0.680						
2	Employer's ability to provide agreed / required resources (funds, land, etc.) throughout the project duration		0.661						
49	Construction manager's ability to manage people at work		0.527						
112	Condition/reliability of the construction plant & equipment		0.498						
Group 03:									5.753
15	Authority to take day-to-day decisions by the engineer or his assistants			0.744					
9	Allowing the engineer to take decisions and supporting such decisions by the employer			0.601					
6	Providing effective assistance to the construction team to take decisions as required on time			0.573					
128	Head office support to site staff during construction			0.535					
Group 04:									5.493
117	Availability of skill construction labour				0.812				
113	Availability of the required number of plant & equipment				0.694				
11	Discuss with the employer, the engineer & the contractor on construction issues and constraints at a regular intervals				0.598				
116	Technical ability & construction knowledge of contractor's staff				0.446				
Group 05:									5.041
14	Leadership qualities of the engineer					0.701			
51	Having very good contract administration knowledge and experience by the engineer					0.711			
36	Engineer's qualifications and experience					0.645			
Group 06:									4.556
17	Effective monitoring and feedback by the construction manager						0.817		
50	Engineer's ability to analyse contractor's claims fair and reasonable manner						0.812		
Group 07:									3.766
37	Conducting progress review meetings and site inspections at appropriate intervals							0.830	
38	Timely issue of instructions by the engineer							0.585	
								Total variance explained (%)	**80.602**

Table 3.0 – Rotation Sums of Squared Loadings

Component	Eigenvalues	% of Variance	Cumulative %
1	12.799	47.405	47.405
2	2.319	8.588	55.993
3	1.553	5.753	61.746
4	1.483	5.493	67.239
5	1.361	5.041	72.28
6	1.23	4.556	76.836
7	1.017	3.766	80.602

4. Conclusion

According to the results in Table 2.0, seven components extracted account for 80.602% of the variance and Group 1 accounts for 41.405% of the total variance with six factors. Group 2 accounts for 8.588% of the total variance with six factors. Group 3, Group 4, Group 5, Group 6 and Group 7 accounts for total variances of 5.753%, 5.493%, 5.041%, 4.556% and 3.766% respectively. Factors which have earned loading more than 0.75 were considered as significant factors and they are listed below with the loading each factor received:

1. Conducting progress review meetings and site inspections at appropriate intervals (0.830)
2. Previous experience of the construction team working on similar projects (0.826)
3. Effective monitoring and feedback by the construction manager (0.817)
4. Availability of skilled construction labour (0.812)
5. Engineer’s ability to analyse contractor’s claims fair and reasonable manner (0.812)
6. Making payment for IPCs within reasonable time (2 weeks) (0.792)
7. Quick response by the contractor to employer’s and engineer’s requests and instructions (0.782)
8. Certification of the IPCs by the engineer within a reasonable time (2 weeks) (0.779)
9. Timely submission of the IPCs by the contractor (0.759)

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