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Application of Performance Based Specification in Building Projects

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Abstract— *A performance-based contract sets the performance expected from the final product (project), instead of directing the contractor by the methods to achieve the final project. The building's performance as a whole, and the more specific performance objectives of its items, originate from relevant user requirements. The requirements of a user can easily be expressed in colloquial terms but not in technical terms. The purpose of the project is to explicitly bridge the gap between technical quality and customer satisfaction by proposing performance-based specifications. In the research project, Performance-based specifications are framed for the works to be carried out under the items of Plastering/Rendering and Painting, of building construction. Literature is reviewed to identify the commonly observed defects in these items in constructed buildings. Draft statements of performance criteria are developed to avoid such defects. A questionnaire survey is carried out to find out the level of importance of each of the criteria included in the draft specifications. The survey was based on an ordinal, 5-point Likert scale which helped to determine relative importance of the criteria included in draft statements. The performance-based specifications are then articulated by relating these performance criteria to specific quality characteristic for that building item.*

Keywords- Performance based contract, Performance based specifications, Performance concept, Questioner survey, Likert scale.

I. INTRODUCTION

A performance-based contract (PBC) is by nature performance based; it sets the performance expected from the final product (project), instead of directing the contractor by the methods to achieve the final project; it means a PBC focuses on the desired outcome, not the process to achieve the outcome (A. Gajurel, 2014). In PBC, the client specifies minimum performance measures to be met or exceeded within the contract period. PBC is a type of contract in which payment is explicitly linked to the contractor successfully meeting or exceeding certain clearly defined minimum performance indicators. This research aims at identifying the user requirements and building structure requirements by framing Performance-based Specifications for specific building construction items of Plastering/Rendering and Painting, to address these requirements.

1.1 Research Objective

The purpose of this research is to test whether the Performance-based Contracts that are being widely used in the road infrastructure can also be used in the building infrastructure.

1.2 Scope

The performance based concept is being applied worldwide since years in the road infrastructure. Thus, a lot of research work has been done on the application of Performance based specifications in the management and maintenance Performance-based contracts of road projects. The Performance-based contracts are also being tried out in other infrastructure projects like Water Infrastructure, Railway Infrastructure and Building Infrastructure. As the concept is new for the Indian contracting industry, the scope of this research is limited to the application of Performance-based specifications of a PBC in building projects.

This research focuses on the study and formulation of Performance Specifications that satisfy the user requirements and building structure requirements. The specifications may help in forming the conditions of a Performance based contract for construction works of residential buildings.

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1.3 Need Of The Study

The concept of PBCs in management and maintenance of roads is widely used in the USA and is fast spreading to other countries and being adopted. Enough research has been carried out on the use of PBCs in road infrastructure. Now, the concept is being tried in other infrastructures as well. Natural wear and tear, lack of maintenance, poor design and/or construction quality are few of the causes for distresses in a building. The user requirements and distresses in the building form the basis for a building's performance requirements. The user needs include needs for serviceability, accessibility, safety, security, health, comfort, and ease of maintenance. Users are also largely concerned with durability, as deterioration may affect all other aspects mentioned above (p. 358 in [3]). As there is a need to address the concerns of the building users, the performance requirements need to be focused on.The performance requirements of a building can be fulfilled by formulating qualitative and/or quantitative measures to define them. Thus performance-based specifications are to be established, which are capable enough to address the performance requirements of a building and also eventually the user requirements, which can then be incorporated in the conditions of a Performance-based contract.

II. LITERATURE REVIEW

2.1 Performance based contract

A performance-based contract is by nature performance based; it sets the performance expected from the final product (project) over a pre-defined time period, instead of directing the contractor by the methods to achieve the final project; it means a PBC specifies the desired outcome, not the process to achieve the outcome. The performance standards of the output to be delivered are clearly defined in the project instead of the material to be used or the procedure to be followed. The performance specification differs however from the prescriptive specification as the prescriptive specification mentions the means by which the objectives are to be achieved (A. Gajurel, 2014).

Though the specifications of a method-based contract are straightforward and easy for the builders, developers and contractors to follow and also easy for in-house or third party checking, it also carries some drawbacks with it, due to which a need for developing the concept of Performance-based contract arose.

2.2 PBC in management and maintenance of Roads

The concept of Performance-based contracting for the management and maintenance of road networks is to increase the efficiency and effectiveness of road maintenance operations. It ensures that the physical condition of the roads under contract is adequate for the need of road users, over the entire period of the contract which is normally several years. This type of contract significantly expands the role of the private sector, from the simple execution of works to the management and conservation of road assets.

Suitable performance indicators are selected to define the performance measures. As the contract is designed from a user's perspective, the performance indicators should satisfy user's expectations.

Typical performance indicators for road performances are .

1. The International Rough Index (IRI) to measure the roughness of the road surface; roughness of the road is related to vehicle operating costs.
2. The absence of potholes and the control of cracks and rutting that are related to the safety aspect and pavement performance.
3. The amount of friction between tires and the road surface that is required for safety reasons.
4. The maximum amount of siltation or other obstruction in the drainage system to avoid destruction of the road.
5. The retro reflexivity of road signs and marking for safety.

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Table 2.2
Example of performance indicator applied in different performance contracts in Latin America

Asset class	Component	Performance indicator
Pavement	Potholes Roughness (asphalt) Roughness (bituminous) Rutting treatment Cracks	No potholes IRI < 2.0 (Argentina), IRI < 2.8 (Uruguay) IRI < 2.9 (Argentina), IRI < 3.4 (Uruguay) <12 mm (Argentina), 10 mm (Uruguay, Chile) Sealed
Gravel surfaces	Potholes Roughness Thickness of gravel layer	No potholes IRI < 6 (Uruguay), IRI < 11 (Chile) 10 cm (Chile, Uruguay)
Shoulders	Potholes Cracks Joints with pavement	No potholes Sealed Vertical alignment <1 cm (Chile, Uruguay), sealed (Peru)
Drainage system	Obstructions Structures	No obstructions. Should allow for free flow of water (Chile, Uruguay) Without damages and deformations (Chile, Peru)

2.3 Method-based Prescriptive Specifications

The technical specifications from the tender document for Construction of 37.93 Km long Lakhnadon Ghansor Road in District Seoni, Madhya Pradesh (Notice No. TCIL/05/527/299/2012/ACD) and the tender document for Construction of P.H.C. Main Building Quarters and Internal Roads at Waluj Tq. Gangapur, were referred and some points as a summary of the Prescriptive specifications to carry out the works are as mentioned further.

1. The contractor has to confirm exactly, fully and faithfully to the designs, drawings and instructions in writing, relating to the work signed by the Engineer-in-charge. The contractor is liable for damage done and for imperfections within a specified period after commissioning the work or 60 months from the date of completion, whichever earlier.
2. Rectifying and setting right the defects strictly in accordance with and in the manner prescribed and under the supervision of the Executive Engineer.
3. The Executive Engineer should get the work executed and carried out departmentally or by any other agency if the contractor fails to rectify the damage; on account and at the cost of the contractor.
4. All approvals for testing and clearances are to be taken from the Engineer-in-charge.
5. Grade of cement is specified; Paver-laying Machinery to be used is specified; Method of construction of pavement (Tremix Method) is specified.
6. For Bituminous pavement, sand/grit size is specified; roller capacity is specified; size of stone aggregates is specified.

2.4 Performance-based specification

The technical specifications from the bidding document for Procurement of Contract under Output and Performance Based Road Contract (OPRC) (Asset Management Contract) For Improvement, Rehabilitation, Resurfacing & Routine Maintenance Works of Roads of Sangrur-Mansa-Bathinda Contract Area (Contract Number: PSRSP/WB/OPRC/1/ICB) were referred and some points as a summary of the Prescriptive specifications to carry out the works are as mentioned further.

1. A Detailed design for construction works/items is to be proposed by the contractor on the basis of indicative Conceptual design provided by the Employer.
2. The contractor is to verify the properties of materials to be used in construction works.
3. The design proposed should be for 'Cost-effective long term' treatment.

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III. METHODOLOGY

Defects encountered in the items of Plastering/Rendering and Painting have only been considered for the questionnaire survey. Literature was reviewed to identify these defects. The defects identified were then transformed to statements of performance criteria and a questionnaire was carried out to find how important it is to consider the statements framed, as a basis for specifications to be adopted in a Performance-based contract for a residential building. The layout of the Questionnaire Survey form has been included in Appendix 1 and Appendix 2 for Plastering/Rendering and Painting, respectively.The respondents selected for the questionnaire were users/occupants of residential buildings and Civil Engineers. The Performance criteria are statements that act as solutions to the user requirements.

The responses for the questionnaire were taken on a Five-point Likert-type scale. In a Likert-type scale, while multiple questions may be used in a research instrument, there is no attempt to combine the responses from the items into a composite scale. The questions use some aspect of the original response alternatives.

As the responses of the questions are in an order of magnitude, an ordinal scale was adopted. The responses were taken for the 'importance' of the statements to use as a basis for specifications, ranging from 'Not important' to 'Very Important'. The score for importance category on the Likert scale of five-point stood as,

1. Not important
2. Slightly important
3. Moderately important
4. Important
5. Very important

Also, as there is a possibility of a user/occupant or an engineer not being aware of the statement representing a defect, a category of 'Not aware' is also included in the scale for each question with a 'zero score'.The respondents selected for this questionnaire survey are Engineers and Residential building occupants/users. A total of 20 respondents, 10 respondents of each, the engineer and occupant are approached for the survey.

3.1 Findings from the Questionnaire analysis

Based upon the overall RII, the performance criteria that turned out to be of high importance for Plastering/Rendering and Painting items for formulation of Performance-based specifications are as mentioned in the sub-sections 3.4.1 and 3.4.2, respectively. As the objective of the research is to check the applicability of the Performance-based specifications in the building infrastructure, only the highly important criteria are considered to test it. This does not imply that performance criteria of medium and low importance in each building item are not important to bring out the best performance from a building. The findings of the analysis are solely based upon the responses received for the Questionnaire survey. The results may be subject to change for another group of sample taken from the population of occupants and engineers. As it is only the criteria that need to be identified to proceed with the framing of performance-based specifications, the findings of this questionnaire shall be deemed suitable for this research. For each of the performance criteria highlighted a quality characteristic for that item shall be related to frame performance-based specifications.

3.2 Performance criteria of high importance for formulation of Performance-based specifications for Plastering/Rendering

1. No peeling-off of top plaster layer.
2. No de-bonding of plaster.
3. Leak-proof plaster surface.
4. No signs of softness (excessive dampness).

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5. No long term cracks at critical junctions.

3.3 Performance criteria of high importance for formulation of Performance-based specifications for Painting

1. No signs of blistering.
2. No signs of grinning due to poor opacity.
3. No flaking of top paint coat.
4. No brush marks on wall.
5. No stains, spots, runs, sag on painted surface.

The statements are ranked for their importance relating to each other for a particular item based on the Relative Importance Index for each statement.

Gary Holt (2014) in his research has mentioned that with regard to construction management research questionnaire surveys, when Likert-type items and/or, Likert-items and/or, Likert scales as methods of attitude measurement are employed, the resulting data may be analyzed using the Relative Importance Index (RII) method.

$$\text{RII} = \frac{\sum_{i=1}^{n} i \times F_i}{AN} \times 100\%$$

Where,

i – The score of a particular response on the likert-type scale
n – Number of responses on likert-type scale
F_i - Frequency for the score i
A – Highest score on the likert-type scale
N – Total number of respondents

Based on the Relative Importance Indices obtained for each statement, the statements were ranked, in a descending order so as to consider the performance criteria for framing of Performance-based specifications based on their importance level.

IV. CONCLUSION

From the evaluation of the responses received and in milieu of the outcomes of the research, following conclusions have been drawn: The usage of Performance-based specifications in the construction contract agreements for building infrastructure is possible and also acceptable. Though, a few amendments are required, the proposed Performance-based specifications are lucid enough to highlight their motive of achieving good performance from a building item. The induction of specific performance criteria for buildings in the proposed specifications was acceptable to an important group of stakeholders, showing that with the achievement of the performance criteria while execution of construction works, the defects observed in a building item will be reduced and thus the requirements of the building users shall be addressed.

The Indian construction stakeholders need to be informed about the Performance-based concept and guided upon the usage of Performance-based specifications in the construction contract agreements.

Thus it can be suggested that with the usage of technically sound Performance-based specifications in the agreements, the concept of Performance-based Contracts that is widely being used in the road infrastructure can also be adopted in the building infrastructure.

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