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The Prioritization of Different Stages of PPP Project Using AHP Technique: In Context to Indian Road Project

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ABSTRACT

Public-Private Partnerships (PPPs) have become a critical approach for delivering infrastructure projects across the globe, particularly in the construction industry. However, the successful execution of PPP projects requires effective decision-making at various stages, from planning through to operation. One of the challenges faced by decision-makers is the prioritization of these stages, which is often subjective and leads to delays, cost overruns, and misalignment with stakeholder interests. The Analytic Hierarchy Process (AHP) has been increasingly applied to address this issue by providing a structured and systematic framework for decision-making. This paper reviews the application of AHP in PPP construction management, exploring its use in evaluating and prioritizing project stages, and examines the benefits and limitations of this approach. The paper synthesizes findings from various studies on PPP frameworks, challenges in project management, and the application of AHP, highlighting key insights for improving PPP project outcomes. Finally, the paper identifies gaps in the current literature and proposes areas for future research.

Keywords: Analytic Hierarchy Process, Decision-Making, stakeholder management

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1. INTRODUCTION

Public-Private Partnerships (PPP) have become increasingly vital in the realm of infrastructure development, particularly in construction management. These collaborative arrangements leverage the strengths of both the public and private sectors to deliver essential projects efficiently and effectively. As countries seek to improve their infrastructure while managing limited public resources, the need for effective decision-making in the prioritization of project stages has never been more critical

The Analytic Hierarchy Process (AHP), a structured decision-making tool developed by Thomas Saaty in the 1970s, offers a solution to these challenges by providing a systematic approach for evaluating alternatives based on multiple criteria. Also, PPPs are particularly valuable in construction management because they combine the strengths of both sectors: the public sector's capacity for large-scale funding and regulatory oversight, and the private sector's efficiency in execution and management.

2. PRINCIPLES OF PPP IN CONSTRUCTION MANAGEMENT: A REVIEW OF THE APPLICATION OF AHP

In the Analytic Hierarchy Process (AHP), complex decisions are broken down into a tiered framework, starting from the overarching objective at the top. Beneath the goal lie the evaluation criteria—such as risk, cost, and quality—followed by the possible options or alternatives, like project proposals or funding methods. This layered arrangement makes the problem more manageable by allowing decision-makers to tackle each part individually, leading to a clearer and more organized evaluation process.

AHP employs pairwise comparisons to judge the importance of each criterion and the preference between alternatives. Instead of evaluating all elements at once, two elements are compared at a time, with numerical values assigned to express the intensity of preference. This method transforms subjective opinions into quantifiable data and is particularly effective in Public-Private Partnership (PPP) projects, where decision-makers must weigh competing priorities like cost efficiency versus service quality.

An essential feature of AHP is the emphasis on logical consistency in the decision-making process. For example, if one factor is judged more important than a second, and the second more important than a third, then the first should be more important than the third. AHP uses a Consistency Ratio to measure

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how logically consistent the comparisons are, flagging inconsistencies so they can be addressed before finalizing the results.

Once comparisons are made, AHP aggregates the data to calculate weightings for each criterion and alternative. These weights represent the relative importance and performance, guiding decision-makers toward the most appropriate solution. The option with the highest cumulative score is typically selected as the best fit, reflecting a balanced consideration of all relevant factors.

AHP also includes sensitivity analysis to determine how the final decision would respond to changes in input values—such as adjustments in weightings or judgments. This is especially valuable in PPP projects, where external conditions like market trends or policy shifts could affect outcomes. Sensitivity analysis helps ensure that the chosen alternative remains valid even if assumptions or circumstances change.

Reported operations Public Private Partnership in Asia from record Handbook

Figure 4.1

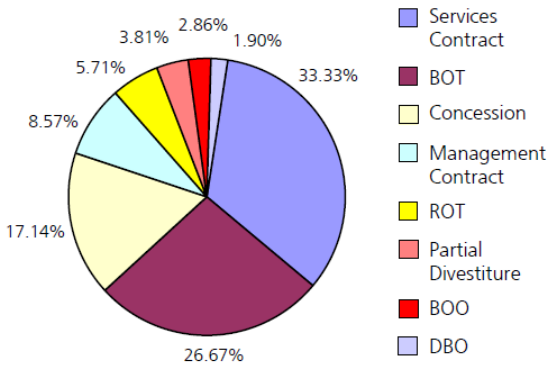
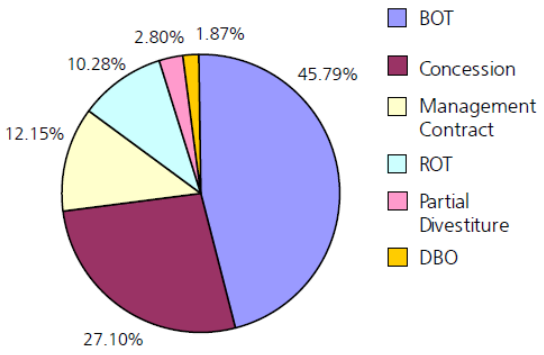


Figure 4.2



BOO = build-operate-own, BOT = built-operate-transfer, DBO = design-build-operate, ROT = rehabilitate-operate-transfer.
Source: Weitz, Almud, and Richard Franceys, editors. 2002. *Beyond Boundaries, Extending Services to the Urban Poor*. Manila: ADB.

Fig. Systematic view of PPP in management system

3. STAGES CATAGORIZED IN PPP PROJECTS

a) Feasibility Stage:

A feasibility study is conducted during the (project's) Appraisal phase and it verifies whether the proposed project is well-founded and likely to meet the needs of its intended target groups beneficiaries. The study should design project in its operational details which in terms of taking account of all policy such as technical economic financial institutional management environmental socio-cultural gender-related aspects. The feasibility study will provide the EC and partner government with sufficient information to justify acceptance modification or rejection of the proposed project for further financing.

b) Tendering Stage:

Tendering is the process of making an offer, bid or proposal, or expressing an interest in response to invitation or request for tender. The organizations will seek other businesses to respond to a particular need, such as supply of goods and services, and will select an offer or tender that meets their needs and provides the best value for money.

c) Financing Stage:

PPPs in infrastructure are normally financed on a project basis. This refers to financing in which lenders look after the cash flows of an investment for repayment, without recourse to either equity sponsors or the public sector to make up for any short fall. This arrangement has several advantages: reducing the financial risk of the investors; may allow more debt in the financing structure; results in limited liability on project sponsors and more careful project screening.

d) Design Stage:

It is a clear and coordinated description of all aspects of the design including Architectural, Mechanical, Plumbing, Electrical and Fire Protection Systems worked out providing a basis for the preparation of construction documents. Construction Manager assists Owner and architect for determining potential cost savings, energy efficiency, and constructability improvements. At the end of the design development phase the architect provides the client with drafted to-scale drawings that will illustrate the project as it would look when it's constructed. These drawings specifically define the site plan, floor plans and exterior elevations. It is important that clients provide input to the architect currently as the design development drawings are used as basis for the construction drawings and preliminary cost estimates in building a home.

e) Operation stage:

After the testing and acceptance of delivered works, the contract management process will move to monitoring operation of the project. This monitoring should focus on measuring the main outputs from the project—for example, for a port project, the port is achieving the specified cargo throughput and vessel service times thus to meet contractual specifications.

It should not be concerned with the details of the concessionaire's operations or in trying to measure every aspect of the service provided—to do so will be hugely burdensome for both parties.

4. CASE STUDIES OF AHP APPLICATION IN PPP CONSTRUCTION PROJECTS

Several case studies highlight the practical application of AHP in PPPs, particularly in construction:

Case Study 1:

One of the papers dealing with PPP project is "Finance-Related Critical Success Factors for the Briefing of PPP Projects in Construction" by Jinxing ZHAO, Min GOU and Long LI(2013). In this paper six finance-related factors that could lead to the success of the project in the briefing stage were identified based on a comprehensive review of literature followed by personal interviews. The importance of these factors was rated using a questionnaire survey in Hong Kong and Australia. A custom-made weighted ranking method was developed, which enabled an estimation of the weighted importance of finance-related factors. A comparative study of the results between Hong Kong and Australia was conducted. Then discussion was provided to describe how these factors can help improve the briefing stage of PPP projects.

Case Study2:

Another paper dealing with PPP is "Fuzzy AHP-Based Risk Assessment Methodology for PPP Projects" by Jie Li and Patrick X. W. Zou (2014). This paper deals with identification of different risk involved in a PPP project. Fuzzy AHP technique was then used to assess the proposed risks. For AHP questionnaire was prepared and was floated and the result obtained was used in AHP. With the result of AHP the risks involved in PPP project were assessed. In this paper a comparison of result from fizzy AHP and straight line AHP was also done.

Case Study 3:

Many studies have also been done using A HP technique for rating. One of them is "An Innovative Application of AHP and Value Engineering Techniques in Project Management of High-Rise Buildings [7]" by Chong ZHOU, Bing WANG and Yong GUO (2014). Paper used value engineering analysis model, using the theory of value engineering and analytic hierarchy process (AHP) for high rise building to evaluate its cost, function and to deduce the corresponding model parameter. To achieve such as safety, quality, period of construction and cost a multi-objective optimization management goal.

5. CHALLENGES AND LIMITATIONS OF AHP IN PPP PROJECTS

Challenges of PPP in India

There are various types of challenges that PPP models are facing in India. These challenges are:

Risk allocation: Infrastructural projects sometimes carried out some risk related to construction risk, financial risk, market risk, demand risk etc. This risk goes to concessionaire parties depending on the type of PPP model used for the project.

Land Acquisition: Most of the roadway project delays due to acquisition of land because of various policies. The land acquisition issue is the primary one in which landowners is compensated based on the value of land prior to development.

Project Cost: Some projects of PPP model fail due to project cost which is not match the overall cost of the project. Delaying of the projects due to lack of sufficient finance which is not provided by the government bodies in time to meet project completion in estimated time.

Corruption: Due to the involvement of too many people and processes PPP projects are always subjected to the risk of corruption.

Financial availability: The financing of PPP projects is done by debt financing and equity financing. Due to various complexities, they produce several challenges. With Indian infrastructure being highly leveraged funding, the PPP projects is getting difficult.

6. METHODOLOGY

This project employs a systematic approach to explore the prioritization of different stages of Public-Private Partnership (PPP) projects in construction management using the Analytic Hierarchy Process (AHP). The methodology consists of several key steps:

Research Design

A quantitative research design is adopted to facilitate objective analysis and prioritization of project stages. The study focuses on gathering data through surveys and expert consultations.

Identification of Stages and Criteria

Literature Review: A thorough review of existing literature on PPP projects and construction management is conducted to identify key stages involved in PPP construction projects.
Criteria Development: Criteria for prioritization, such as cost efficiency, time management, risk assessment, quality control, and stakeholder engagement, are established based on insights from the literature and expert opinions.

Data Collection

Surveys: Structured questionnaires are distributed to industry experts, project managers, and stakeholders involved in PPP projects. The surveys include pairwise comparison matrices to evaluate the relative importance of each stage based on the established criteria.
Interviews: In-depth interviews may be conducted with selected experts to gain qualitative insights and validate the quantitative findings.

Application of AHP

Pairwise Comparisons: The collected data is analyzed using the AHP technique. Participants will compare each stage of the project against others in pairs, assessing their relative importance based on the criteria.

Calculation of Weights

Using AHP software or manual calculations, the priority weights for each stage are determined. This involves:
Normalization: The values in the pairwise comparison matrices are normalized to calculate the relative weights of each project stage.
Consistency Check: The consistency ratio is computed to ensure the reliability of the judgments. A ratio below 0.1 indicates acceptable consistency.

Analysis and Interpretation

The results are analysed to determine the priority of each stage within the context of PPP construction management. The findings are interpreted in relation to the established criteria, highlighting the implications for project planning and execution.

Validation and Recommendations

The results will be validated through feedback sessions with stakeholders and experts to ensure accuracy and applicability. Recommendations for improving decision-making in PPP construction management will be derived based on the findings.

Documentation and Reporting

Finally, the entire research process, findings, and recommendations will be documented in a comprehensive project report, aimed at providing insights for practitioners and policymakers in the field of construction management. This research methodology ensures a systematic and robust approach to prioritizing project stages in PPP construction, ultimately contributing to more effective management practices and improved project outcomes.

QUESTIONNAIRE SURVEY

For this study, an online survey was utilized to gain the opinion of respondents from different PPP infrastructure sectors and from different parties.

The questionnaire is divided into two main parts: part one deals with general information (classification data) about the respondents such as the

- Name of the Respondent.
- Name of the Organization
- Department of Working

The second part of the questionnaire mainly aimed at identifying the significance of each risk factor. Likert type scale has been used as a rating system for the criticality of each factor in the questionnaire.

The questionnaire respondents were asked to list the significance of potential risks identified on a scale of 1-5, where 1 represents “Low-significant” and 5 represents “High significant”.

ANALYSIS & RESULT

Extensive analysis was done on the data received through the questionnaire technique for the industry people working in PPP projects in the transportation sector. The analyst is included the application of AHP technique over the data acquired. The analysis was done in three different forms to get three types of results. These three analyses will be explained as follows.

4.1 First Analysis

Firstly, the analysis was done on all 24 problems to prioritize all the problems for PPP road project. The data of all 24 problems were taken and AHP technique was applied on it and this gave us the order of prioritization of all the stages. It was found that 'Problem due to time over run 'had the highest score of 0. 053. Which means that most engineers think that time over run is the most important problem faced during the PPP project of road sector and thus more emphasis and concern should be shown towards it for the success of the project. Other problem in the order were 'Problem due to land acquisition (0.049)', followed by 'Problem because of Construction Cost overrun (.049)', 'Problem due to planning (0.048)', 'Problem due to high financing cost (0.047)', 'Problem due to design deficiency (0.047)'. These were the top six problems that came up with the analysis.

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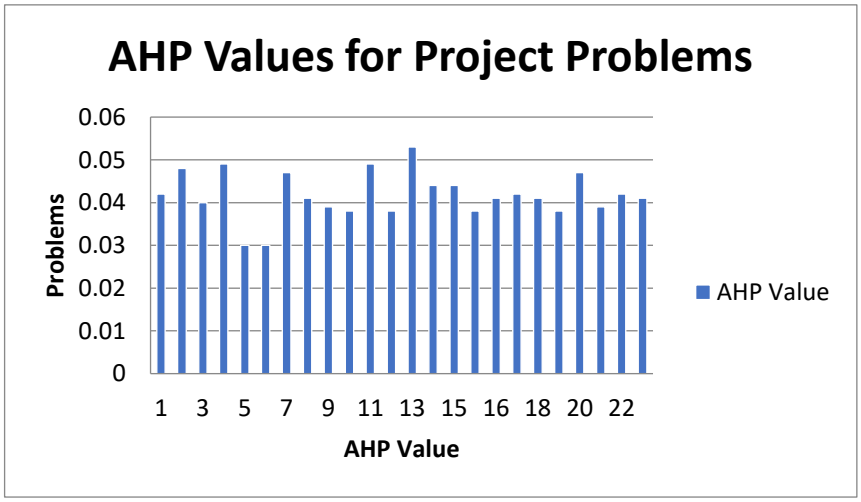
	Sr No.		ACQUIRED DATA AVERAGE	AHP VALUE
FEASIBILITY STAGE	1	Problem faced during document approval	3.300	0.042
	2	Problem due to planning	3.800	0.048
	3	Problem due to political	3.150	0.040
	4	Problem due to land acquisition	3.900	0.049
TENDERING STAGE	5	Problem due to long tender process	2.350	0.030
	6	Problem due to few eligible bidder	2.350	0.030
FINANCING STAGE	7	Problem due to high financing cost	3.700	0.047
	8	Problem because of discounted payback period	3.250	0.041
	9	Problem due to long term cash flow(for lender)	3.050	0.039
	10	Problem because of Long term demand for a product and service offered by Project	3.000	0.038
CONSTRUCTION STAGE	11	Problem because of Construction Cost overrun	3.900	0.049
	12	Problem because of Safety	3.000	0.038
	13	Problem because of Time overrun	4.150	0.053
	14	Problem because of availability problem of Capital	3.500	0.044
	15	contractors	3.450	0.044
OPERATION STAGE	16	Problem due to fluctuating demand	3.000	0.038
	17	Problem due to Operation Cost overrun	3.250	0.041
	18	Problem because of Operator inability	3.200	0.041
	19	Problem because of changing interest rate	3.250	0.041
	20	Problem because of low operation productivity	3.000	0.038
DESIGN STAGE	21	Problem due to design deficiency	3.700	0.047
	22	Problem due to design flexibility	3.100	0.039
HAND OVER STAGE	23	Problem when there less demand of the project at the time of transfer	3.350	0.042
	24	Problem because of low residual value	3.250	0.041



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Second Analysis

The second analysis was done within each different seven stages. For this AHP was applied within different individual stages, results were then studied and then accordingly each problem was prioritized within each individual stage. The following results were found.

1. Feasibility Stage

In the feasibility stage when analysis was done it was found that most of the engineers found that major problem was during land acquisition stage for PPP road projects with the rating of 0.276followed by the problem of planning with value 0.269.

1	Problem faced during document approval	0.233
2	Problem due to planning	0.264
3	Problem due to political	0.223
4	Problem due to land acquisition	0.276

Table . *Feasibility Stage*

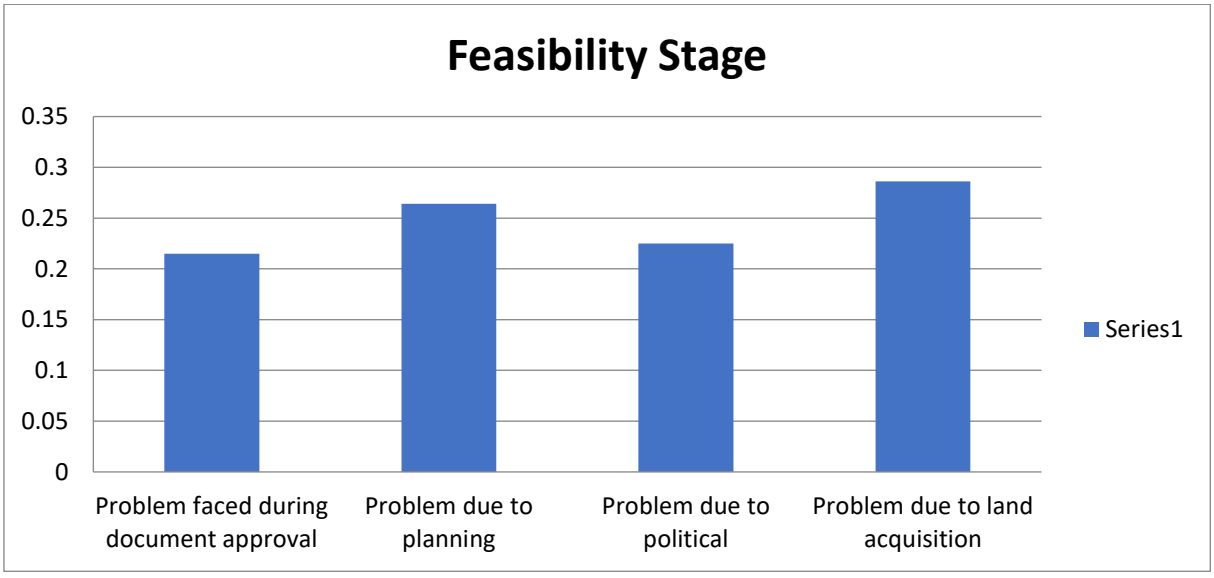

Fig . *Feasibility Stage*

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2. Tendering Stage

In the tendering stage after analysis, it was found that both the problems had equal importance, thus both the problems should be given equal time and importance.

1	Problem due to long tender process	0.5
2	Problem due to few eligible bidder	0.5

Table 5. *Tendering Stage*

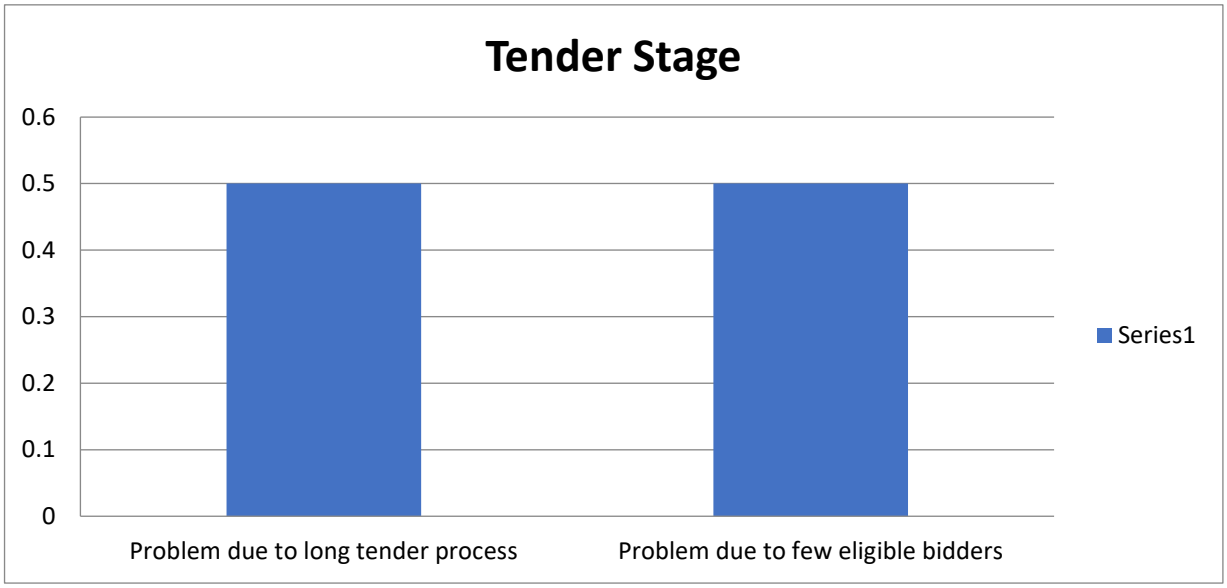

Fig . *Tendering Stage*

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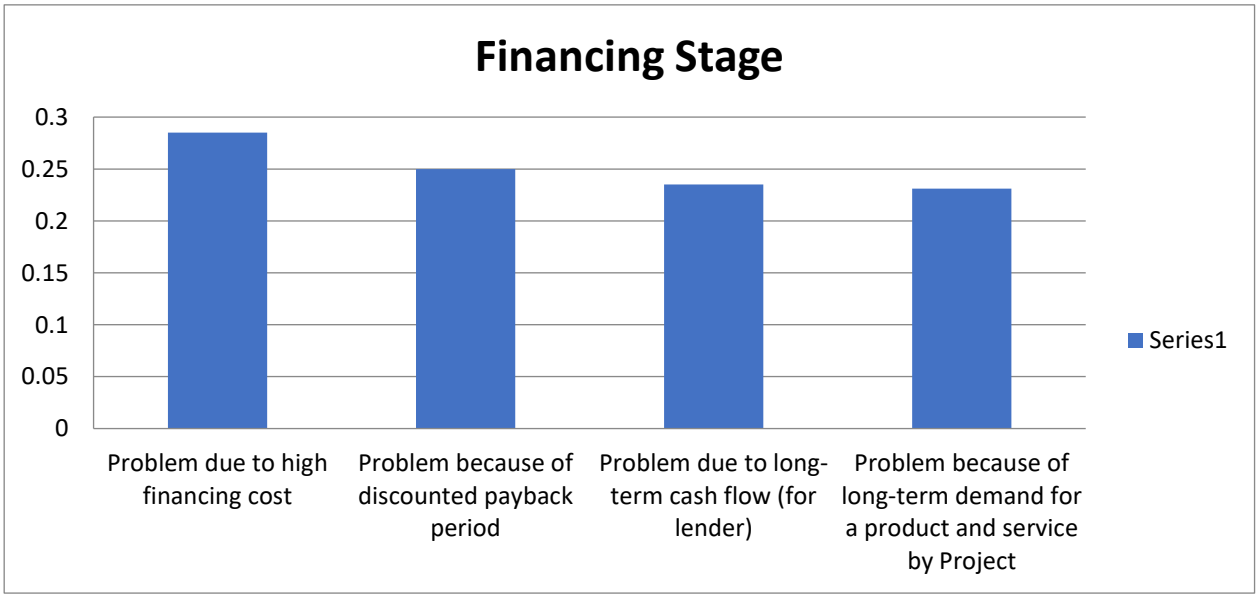
3. Financing Stage

After the analysis done within the financing stage it was found that the main problem faced in the PPP road project during the financing stage was due to high financing cost with a rating of 0.285 followed by the problem because of discounted payback period and long-term cash flow for lenders.

1	Problem due to high financing cost	0.285
2	Problem because of discounted payback period	0.250
3	Problem due to long term cash flow (for lender)	0.235
4	Problem because of Long term demand for a product and service offered by Project	0.231

Table . *Financing Stage*

Fig .



Financing Stage

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4. Design Stage

In the analysis done in design stage it was found that problem due to design deficiency plays more important role than problem because of design flexibility.

1	Problem due to design deficiency	0.544
2	Problem due to design flexibility	0.456

Table . *Design Stage*

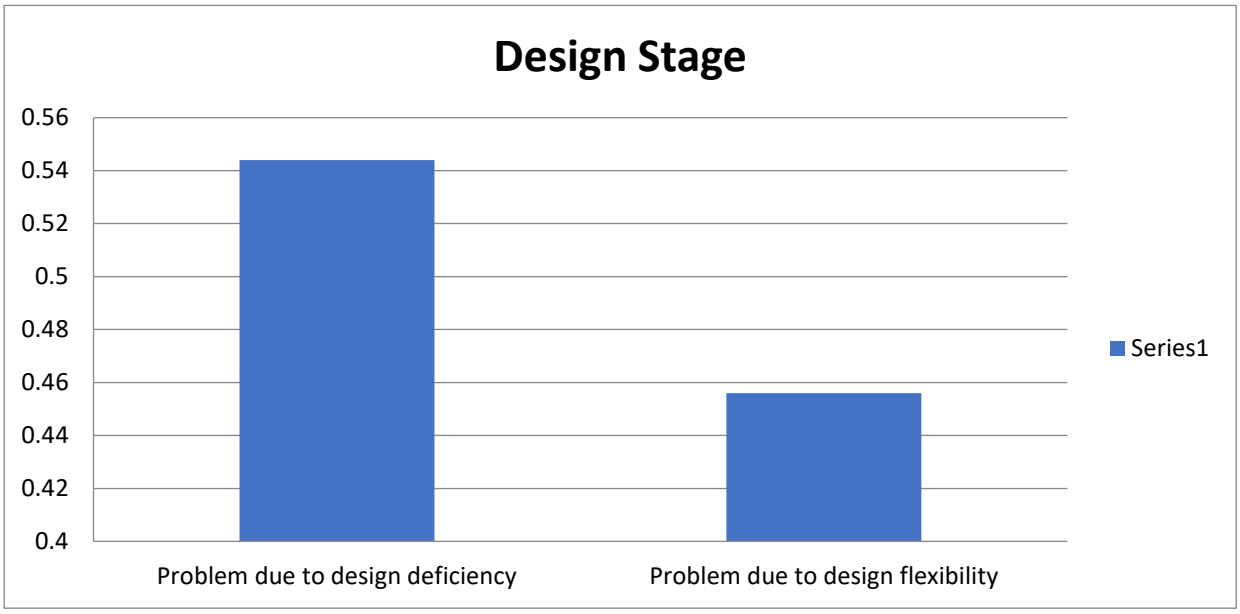

Fig . *Design Stage*

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5. Construction Stage

An analysis was done individually on the construction stage, and it was found from the study that time over during the construction stage is the most important problem faced and thus for the success of any PPP road project first time overrun should be controlled by all methods. Another important problem faced in construction stage was the construction cost overrun.

1	lem because of Construction Cost overrun	217
2	lem because of Safety	167
3	lem because of Time overrun	231
4	lem because of availability problem of Capital	194
5	lem because of lack of coordination of Sub-contractors	192

Table . *Construction Stage*

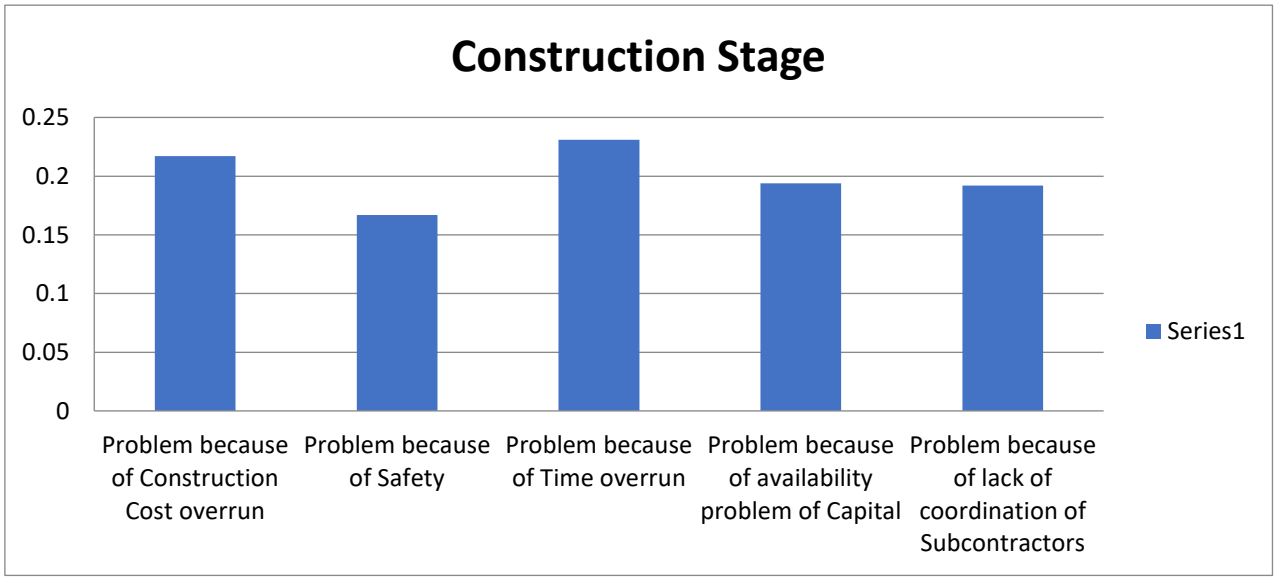

Fig . *Construction Stage*

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6 Operation Stage

AHP analysis over the operation stage gave the result that problem due to operation cost overrun and problem due to changing interest rate had the equal most important influence over the performance of the PPP road project.

1	Problem due to fluctuating demand	0.191
2	Problem due to Operation Cost overrun	0.207
3	Problem because of Operator inability	0.204
4	Problem because of the changing interest rate	0.207
5	Problem because of low operation productivity	0.191

Table . *Operation Stage*

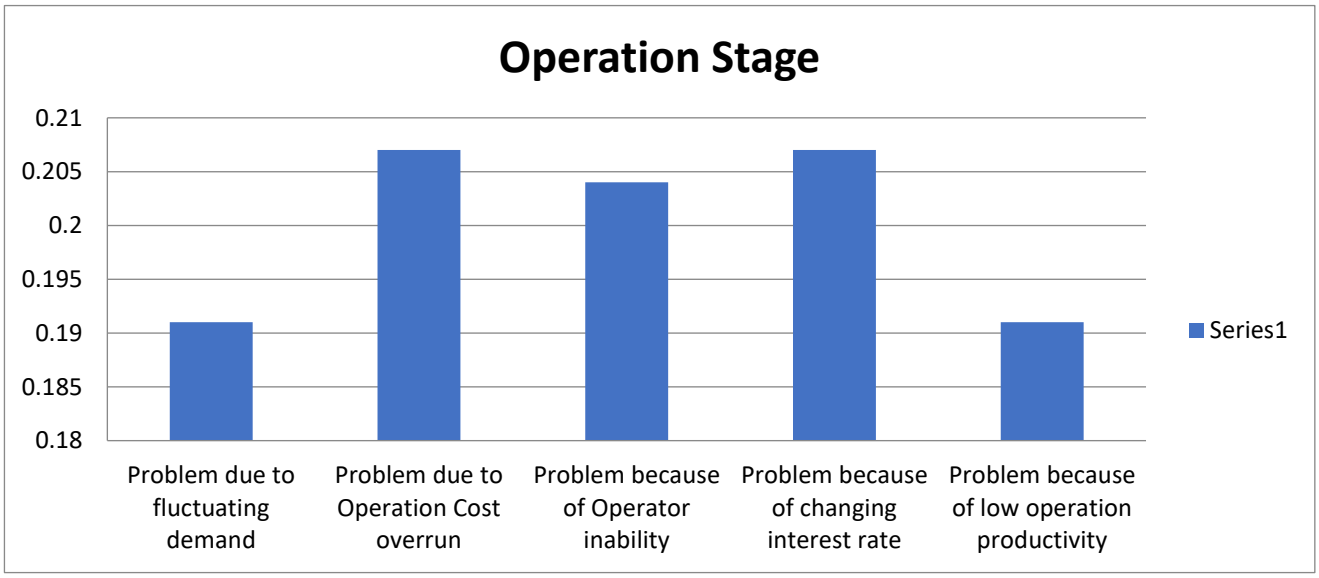

Fig . *Operation Stage*

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7 Handover Stage

In the analysis done in handover stage it was found that problem when there less demand of the project at the time of transfer is the more important problem during handover stage with respect to problem because of low residual value.

1	Problem when there is less demand for the project at the time of Transfer	0.508
2	Problem because of low residual value	492

Table . *Handover Stage*

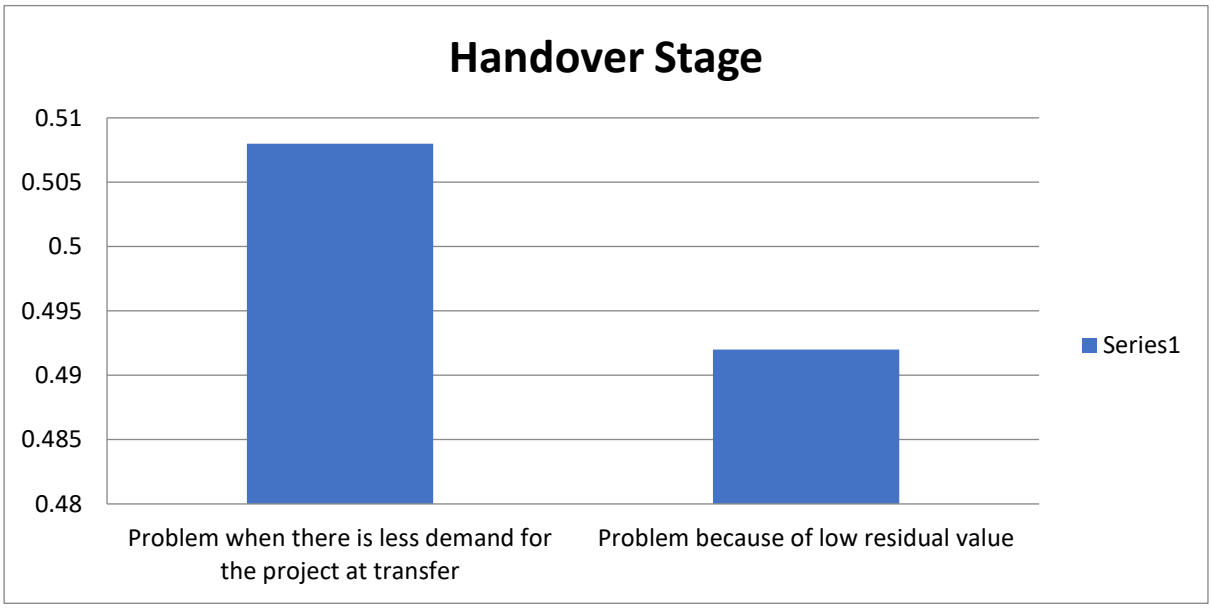

Fig . *Handover Stage*

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Third Analysis

Third analysis was among the seven stages to prioritize the seven stages. For this analysis first each stage was taken, and their average input data was taken for each problem and then this matrix was multiplied with the AHP value these data which we already had. This gave us one value for one stage. This value was use to prioritize these stages. It was found from the study that construction stage was the most important stage among all the stages and tendering stage is the least important stage for PPP road projects.

1	CONSTRUCTION STAGE	3.643611
2	FEASIBILITY STAGE	3.566254
3	DESIGN STAGE	3.426471
4	HANDOVER STAGE	3.300758
5	FINANCING STAGE	3.273462
6	OPERATION STAGE	3.144268
7	TENDERING SATGE	2.35

Table . *Different Stages of Project*

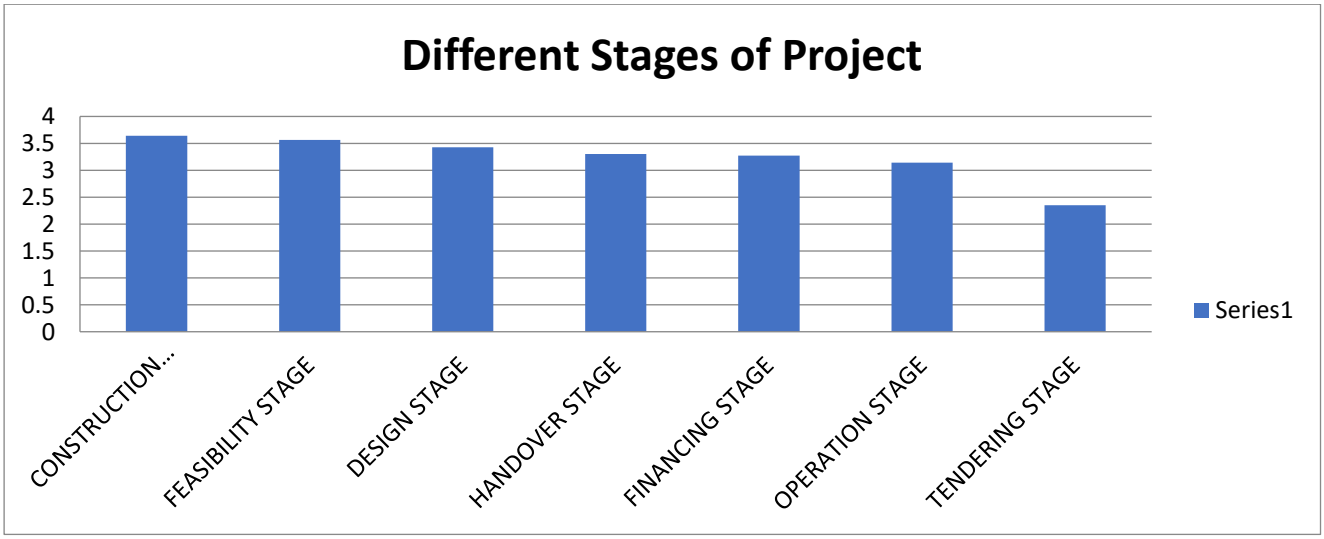

Fig . *Different Stages of Project*

CONCLUSION

The application of **AHP** in **Public-Private Partnerships (PPP)** in construction management has proven to be an innovative approach to improving decision-making. By providing a structured, transparent, and multi-criteria evaluation process, AHP helps stakeholders assess various alternatives in terms of cost, time, risk, and quality. Through systematic and rational decision-making, AHP aids in the optimization of resources, the alignment of stakeholder interests, and the achievement of long-term project success. While challenges remain, the continued evolution of AHP, along with the integration of advanced technologies, holds promise for even greater efficiency and innovation in the future.

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