

## International Journal of Innovative Research in Science, Engineering and Technology

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# Analysing Factors Influencing Integrated Project Delivery in Bridge Construction Projects

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**ABSTRACT:** Indian construction industry is one of the largest industry of country which plays a major role to the economic growth of country. But, there are issues regarding to the productivity, projects that are behind schedule and over budget, waste issues as well as relationship among the project participants which obstruct the effectiveness of construction industry. So, there is a critical need to find out new technologies and project delivery concepts to overcome these issues. Traditional project delivery methods have its own limitations and barriers. Thus, Integrated project delivery emerged as a solution towards it. IPD is a collaborative process which harnesses expertise of the participants. IPD focuses on the end product rather than each participant focusing on their part of construction work. However, implementation of IPD is not without challenges. The objective of this paper is to find out the factors affecting implementation of integrated project delivery in bridge construction projects. This study states that IPD has eight different phases to execute the project. These factors and phases are analysed by Analytic Hierarchy Process(AHP). The purpose of this paper is to investigate these factors and suggest its probable use in future.

**KEYWORDS:** Project delivery, Integrated project delivery(IPD), Analytic hierarchy process(AHP), Bridge construction projects.

### I. INTRODUCTION

The concept of IPD was developed by Toyota in their Toyota Production System and computer technology advances. As per American Institute of Architects **Integrated project delivery (IPD)** is a collaborative alliance of people, systems, business structures and practices into a process that harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction.[1]

There are eight main sequential phases to the integrated project delivery method:

- conceptualization phase [expanded programming]
- criteria design phase [expanded schematic design]
- detailed design phase [expanded design development]
- implementation documents phase [construction documents]
- agency review phase
- buyout phase
- construction[construction/construction administration] phase
- closeout phase

American Institute of Architects(AIA) identified major nine characteristics of IPD which can solve the issues of construction industry. Principles of IPD are given below in fig. 1 for its successful implementation.

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Figure 1: Nine IPD Principles[2]

IPD Principles	Effect to the construction
Open communication	Flow of communication should be without barriers and transparent. Everybody can talk to anyone.
Mutual respect	Each party should respect and understand the capabilities and limitations of each other.
Collaborative decision making	All decisions made by everyone in the early stage of planning about every part of construction
Intensified planning	Everybody aware and ready to face the problem that might happen, supply arrives on time
Early goal definition	Goal been set in early planning, everyone knows what and when to start their job on time
Multi party agreement	Each party in the team agreed to take responsibility in the construction project punctuality timing and job to be done
Shared risk and reward	Everyone responsible to any problem in construction and earn reward for the success
Early involvement of key participant	Key participants involve in the project planning process and plan the action
Organization and leadership	The construction process more organized lead by champion (construction manager)

Table 1: The effects of IPD Principles in Construction Processes[2]

From Table 1, it can be seen that by applying the principles of IPD, the interaction of the construction team within the project can lead to reducing the time over-run, cost over-run, waste generation during the construction process. Therefore, the productivity and efficiency of construction processes can be maximized, as well as reducing the adverse relational problems that is often mentioned in the construction industry in the long run.

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## II. RELATED WORK

Nida Azhara ,Youngcheol Kanga, and Irtishad U. Ahmada(2014)[1] discussed in this paper concept and key characteristics of IPD. Then it was attempted to address the underlying issues that influence the adoption and implementation of IPD in public sector. Researchers observed that while some of the issues require substantial changes like changing procuring laws related to public construction, others could be achieved through utilizing tools that are already in use. Researchers discussed few areas where the highlighted issues can actually be improved through the use BIM technology. In this paper, several links have been established between IPD and BIM.

Barry Jones (2014)[3] discusses a proposal for an integrating partnership for decision-making at pre-construction stages of major construction projects. IPD linked to the “Big Room” concept in this research. The paper will focus on some of the challenges that are presented and ways that might assist in creating a safer, greener, more sustainable environment. The research demonstrates that an environment can be built that assists an AEC collaborating team in their search for alternative solutions which satisfy the criteria and constraints imposed by a client’s project requirements. The computer environment explored is extendable to include all project participants whose input to the design process is desirable. The problem-solving domain of construction management is represented in such an environment.

Reza Ghassemi and Burcin Becerik-Gerber(2011) [8] investigated how successful IPD projects overcome legal, cultural, financial, and technological barriers in an effort to achieve wider adoption of IPD by the industry and to provide lessons learned to industry professionals interested in implementing IPD as a delivery method. A brief review of the current situation of the AEC industry; semistructured interviews with leading AEC professionals in nine IPD projects are given. The study finds that successful IPD projects are achieved through proper selection and involvement of all main players as well as these main players achieving trust in each other. Training, procurement ability, and collaborative technology are also among the key factors for a successful transition to IPD.

## III. NEED OF STUDY

More than 90% of bridge construction projects in India suffered from the time over-run and cost over-run. Therefore, we really need to drag our attention towards efficient management and procuring techniques that can eliminate these major issues of bridge construction projects. Adoption of new techniques and methodologies required proper investigation and training for its execution. IPD is a new concept for Indian construction world and its implementation also needs significant amount of work. Thus, in this paper factors influencing implementation of IPD are found out and analysed using Analytic Hierarchy Process.

## IV. OBJECTIVES

- ❖ To identify and study the factors that influences the implementation of IPD in bridge construction projects.
- ❖ To find out most vulnerable factors in implementation of IPD.
- ❖ To develop a framework for effective implementation of IPD.

## V. METHODOLOGY

First step in this research is to understand the concept of integrated project delivery. For that various research papers and studies has been analysed and core concept of integrated project delivery has been evaluated. After that the complications in adopting this method has been found out. The barriers which obstruct the use of integrated project delivery has been identified through literature reviews. According to those factors questionnaire has been designed for survey. This research is done on bridge construction projects of Surat, Gujarat. Questionnaire was also validated through non structure interviews with the experts who has been worked under bridge projects for around 20 years. The questionnaire has been distributed to engineers, architects, consultants and contractors who has ever been worked on

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bridge construction projects. The collected data then analysed by the Analytic Hierarchy Process(AHP). With the help of AHP method in each phase of IPD which issues predominantly affect the implementation of IPD is figured out. Analysis by AHP is done in Excel sheet and ranking of the issues in each phase of IPD has been computed. Following Table 2 shows the major factors and their sub factors which influence the implementation of IPD.

No.	Factors	Sub factors
1	Legal issues	Different criteria for service procurement
		Risk allocation
		Minimizing adversarial relationships
		Checks and balances
		Regulatory and statutory requirements
2	Organizational issues	State budget and funding cycles
		Project management
		Organizational culture
		Work processes
		Completion on schedule
		Attaining highest overall quality
		Capitalizing on a well defined scope
		Potential for changes during construction
		Level of in house management experience
		Stability of owner's requirements
3	Technological issues	IT infrastructure
		Information management protocol
4	Financial issues	Interoperability
		Integration
		Skilled personnel
		IPD compensation structure
		Sharing cost saving and overruns
		Profit pooling
		Completion with budget
		Early estimates
		Delaying or minimizing expenditure rate
		Payment method
5	Cultural issues	Integrating project personnel
		IPD training
		Trust building activities and tools
		Management experience
		Project management resources

Table 2: Factors influencing integrated project delivery

Here, in table 2 factors affecting adoption of IPD are classified in major five factors which are legal, organizational, technological, financial and cultural. These factors are further classified in sub factors then they are analysed by Analytic Hierarchy Process.

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- Analytic Hierarchy Process(AHP):

The **Analytic Hierarchy Process (AHP)** is a multi-criteria decision-making approach and was introduced by Saaty (1977 and 1994).

The **AHP** has attracted the interest of many researchers mainly due to the nice mathematical properties of the **method** and the fact that the required input data are rather easy to obtain. The analytic hierarchy process (AHP) is a structured technique for organizing and analysing complex decisions.

**The procedure for using the AHP can be summarized as:[11]**

1. Define the problem and determine its goal.
2. The hierarchy from the top (the objectives from a decision-maker's viewpoint) through the intermediate levels (criteria on which sub sequent levels depend) to the lowest level which usually contains the list of alternatives.
3. Construct a set of pairwise comparison matrices(size  $n \times n$ ) for each of the lower levels with one matrix for each element in the level immediately above by using the relative scale measurement. The pair-wise comparisons are done in terms of which element dominates the other.
4. There are  $n(n-1) / 2$  judgments required to develop the set of matrices in step 3. Reciprocals are automatically assigned in each pair-wise comparison.
5. Hierarchical synthesis is now used to weight the eigen vectors by the weights of the criteria and the sum is taken over all weighted eigenvector entries corresponding to those in the next lower level of the hierarchy.
6. Having made all the pair-wise comparisons, the consistency is determined by using the eigenvalue,  $\lambda_{max}$ , to calculate the consistency index, CI as follows:  $CI = (\lambda_{max} - n) / (n - 1)$  where  $n$  is the matrix size. Judgment consistency can be checked by taking the consistency ratio (CR) of CI with the appropriate value. The CR is acceptable, if it does not exceed 0.10. If it is more, the judgment matrix is inconsistent. To obtain a consistent matrix, judgments should be reviewed and improved.
7. Steps (d-f) are performed for all levels in the hierarchy.

## VI. DATA ANALYSIS

The collected data has been analysed using the AHP method to rank the issues according to their importance of occurring. In each phase of IPD ranking of the issues has been done through AHP.

AHP method has been explained above from that following results has been derived.

**Phase 1 : Conceptualization phase**  
**Table 4 : Ranking of issues as per AHP for phase 1**

Rank	Issues	Average of ratings given by respondents
1	Financial	0.283375
2	Technological	0.278248
3	Legal	0.195465
4	Organizational	0.131252
5	Cultural	0.11166

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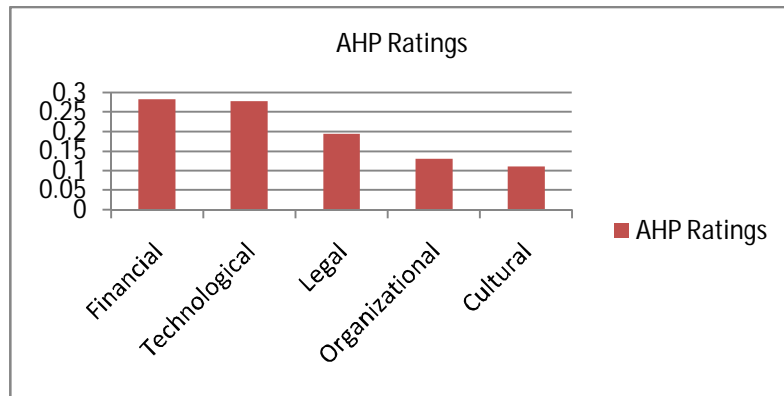


Fig 2: Bar chart analysis of factors influencing implementation of IPD for phase 1

Here table 4 shows the ranking of the issues for successful application of IPD in conceptualization phase. While adopting IPD in the very first phase of its one should concentrate on financial and technological issues as they predominantly influence the IPD implementation in conceptualization phase. In fig. 2 there is a bar chart analysis of the issues for conceptualization phase so one can easily understand the framework of how to eliminate this barriers to conduct conceptualization phase of IPD.

## Phase 2 : Criteria Design phase

Table 5 : Ranking of issues as per AHP for phase 2

Rank	Issues	Average of ratings given by respondents
1	Technological	0.345407
2	Financial	0.265859
3	Legal	0.162513
4	Organizational	0.136329
5	Cultural	0.089892

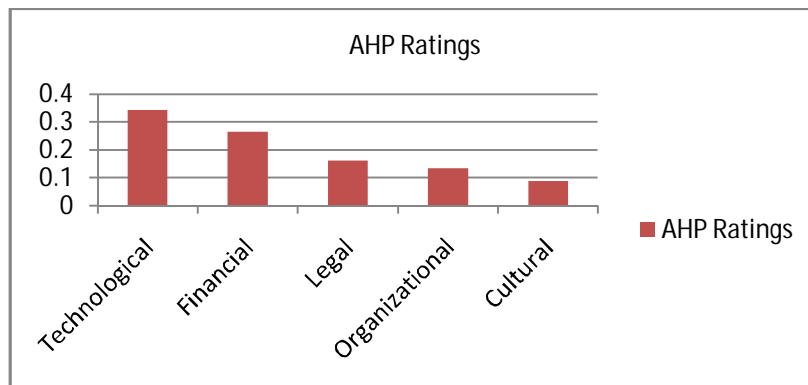


Fig 3: Bar chart analysis of factors influencing implementation of IPD for phase 2

In table 5 analysis of factors for criteria design phase is shown. In this phase technological, financial and legal issues are most vulnerable issues to execute this phase. So during criteria design phase firstly one should design

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how to avoid this factors so that smooth working in this phase can be done. Fig. 3 shows the bar chart analysis of the AHP ratings given by the respondents to phase 2 of IPD.

### Phase 3 : Detailed Design Phase

**Table 6 : Ranking of issues as per AHP for phase 3**

Rank	Issues	Average of ratings given by respondents
1	Technological	0.333345
2	Legal	0.242645
3	Financial	0.210938
4	Cultural	0.113784
5	Organizational	0.099289

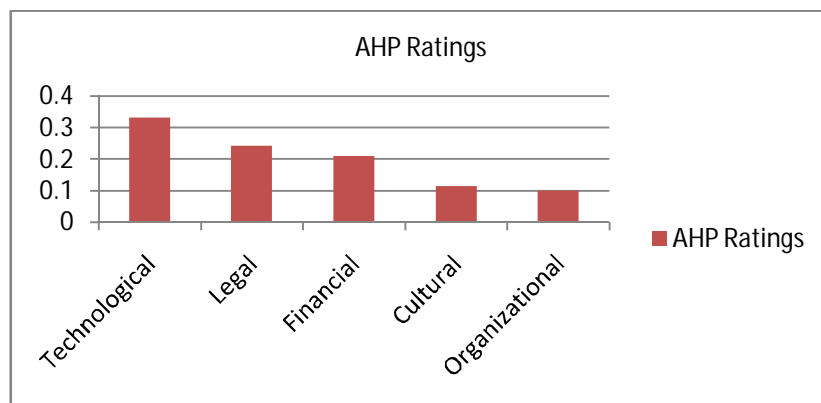


Fig 4: Bar chart analysis of factors influencing implementation of IPD for phase 3

Table 6 indicates the analysis of detailed design phase in which technological, legal and financial are top 3 issues which need to be mitigate in this phase. In this phase cost structure and schedule structure is established to high level of precision so that this top issues should be effectively mitigated. Fig.4 shows bar chart analysis of this phase from which we can say that technological issues are the highest affecting and organizational issues have the lowest impact factor in this phase.

### Phase 4 : Implementation Documents Phase

**Table 7 : Ranking of issues as per AHP for phase 4**

Rank	Issues	Average of ratings given by respondents
1	Legal	0.346481
2	Technological	0.21621
3	Financial	0.195544
4	Cultural	0.129746
5	Organizational	0.112019

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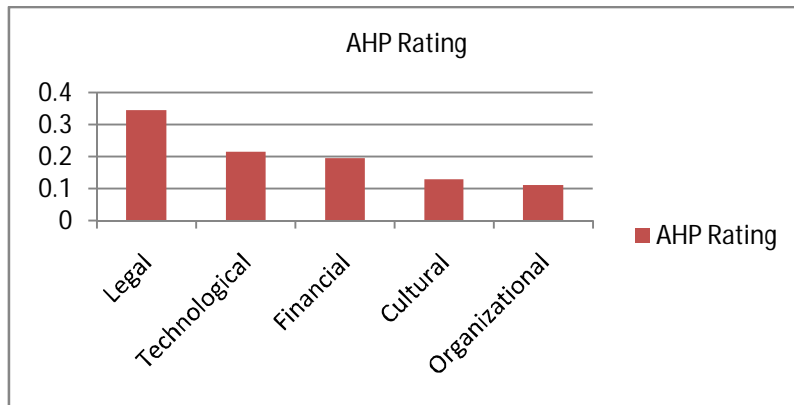


Fig 5 : Bar chart analysis of factors influencing implementation of IPD for phase 4

Here, in implementation documents phase as per result of IPD most dominating factors which affect IPD implementation are legal, technological and financial. Organizational issues are the least important in this phase. In this phase final cost model and schedule model are prepared. Then this models are approved and verified by the regulatory bodies. Thus, legal issues are the most predominant in this phase.

### Phase 5 : Agency Review Phase

**Table 8 : Ranking of issues as per AHP for phase 5**

Rank	Issues	Average of ratings given by respondents
1	Technological	0.272170299
2	Financial	0.237769101
3	Legal	0.182287495
4	Organizational	0.155893605
5	Cultural	0.151879499

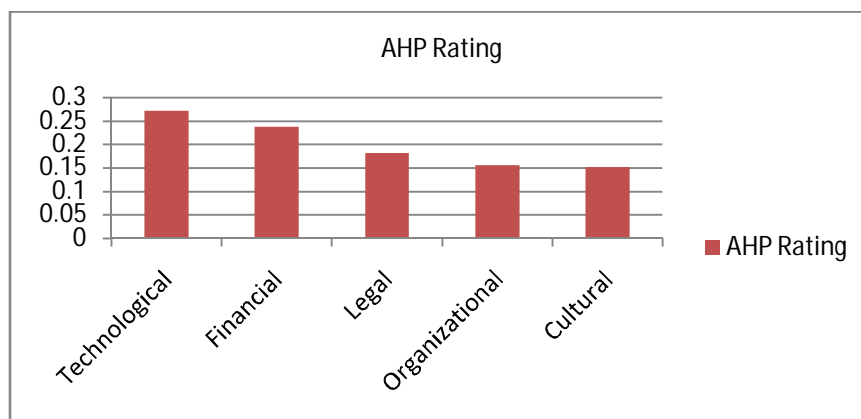


Fig 6 : Bar chart analysis of factors influencing implementation of IPD for phase 5

In agency review phase analysis denotes that technological and financial are most effective issues since it creates a barrier for implementing IPD. In this phase all the approvals and permits are done. In addition, analysis software can



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use the model information to generate performance or criteria analyses that validate the design. Thus technological and financial issues should be eliminated as soon as possible to execute this phase.

### Phase 6 : Buyout Phase

**Table 9 : Ranking of issues as per AHP for phase 6**

Rank	Issues	Average of ratings given by respondents
1	Financial	0.263107
2	Technological	0.249972
3	Legal	0.226558
4	Organizational	0.151161
5	Cultural	0.109202

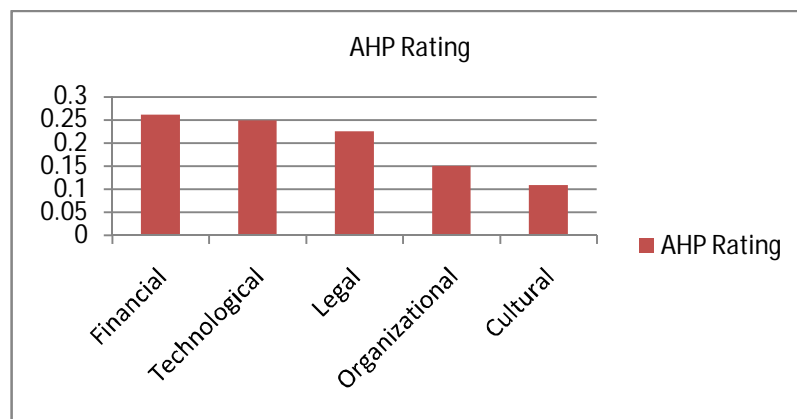


Fig 7 : Bar chart analysis of factors influencing implementation of IPD for phase 6

From table 9 it is concluded that in buyout phase of IPD financial and technological factors are most influencing one. In this phase all the necessary Commitments are in place for all work, materials and equipment needed to complete the project. Thus, financial and technological issues should be eliminated for successful execution of buyout phase. Fig. 7 shows bar chart analysis of buyout phase which indicates financial issues have the highest impact and cultural issues have the lowest impact in this phase.

### Phase 7 : Construction(Construction/Construction Administration) Phase

**Table 10 : Ranking of issues as per AHP for phase 7**

Rank	Issues	Average of ratings given by respondents
1	Technological	0.294835
2	Financial	0.245423
3	Legal	0.199807
4	Organizational	0.172249
5	Cultural	0.087686

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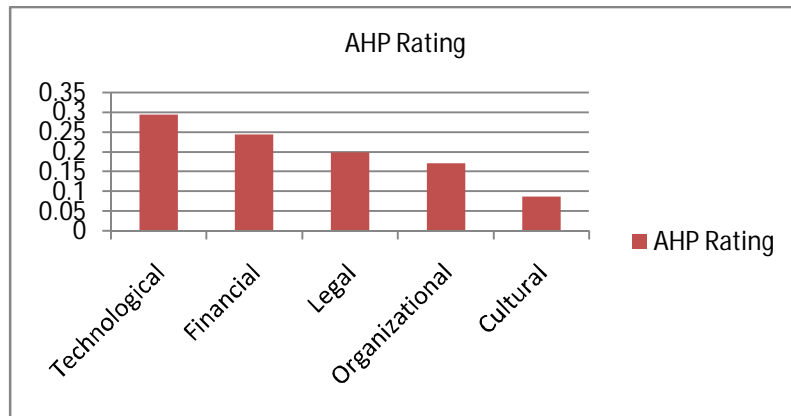


Fig 8 : Bar chart analysis of factors influencing implementation of IPD for phase 7

In table 10 there is analysis for construction phase which shows technological issues have the highest AHP rating and cultural issues have lowest ratings that means technology should be well updated and advanced for carrying out construction activities. Apart from technological factor another major factor is financial which should well taken care for smooth flow of construction activities. Thus, result of this phase majorly focus on these two issues.

## Phase 8 : Close Out Phase

Table 11 : Ranking of issues as per AHP for phase 8

Rank	Issues	Average of ratings given by respondents
1	Legal	0.313893
2	Technological	0.208231
3	Cultural	0.182954
4	Financial	0.164156
5	Organizational	0.130766

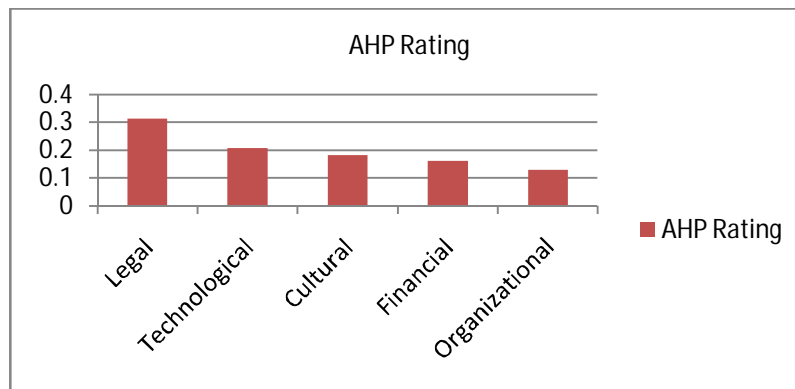


Fig 9 : Bar chart analysis of factors influencing implementation of IPD for phase 8

In the final close out phase AHP analysis focuses on legal factors. Closeout of an integrated project greatly depends upon the business terms agreed by the parties. So it demands statutory and legal requirements. Legal barriers should be

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eliminated first for delivering this phase. After that technological factor is of great importance so that with help of new techniques work can be terminated speedy and effectively.

## VII. CONCLUSION

This paper first presented the core concept of integrated project delivery. Then factors influencing implementation of IPD were identified. Those issues were analysed by Analytic Hierarchy Process(AHP). With the help of AHP method in each phase of IPD most vulnerable issues which obstruct successful adoption of IPD were ranked. This study can be used as a base for any project which aims to go for IPD. The summarized result of AHP is given below which shows ranking of factors in each phase.

Table 12 : Summarized result of AHP

P1	P2	P3	P4	P5	P6	P7	P8
Financial	Technological	Technological	Legal	Technological	Financial	Technological	Legal
Technological	Financial	Legal	Technological	Financial	Technological	Financial	Technological
Legal	Legal	Financial	Financial	Legal	Legal	Legal	Cultural
Organizational	Organizational	Cultural	Cultural	Organizational	Organizational	Organizational	Financial
Cultural	Cultural	Organizational	Organizational	Cultural	Cultural	Cultural	Organizational

Here, in table 12 phase wise AHP result is shown. In each phase of IPD ranking of the factors is determined. Thus, this framework will be useful in pure IPD implementation.

However, this paper will prove to be a foundation for bridge construction projects which opt for IPD and how to apply this concept, how to deal with the issues and how to avoid them. Thus, it will help in reducing project over runs, wastage, improving efficiency and safety of bridge construction projects.

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