Structured Literature Review of Design-Build/Bridging, Design-Bid-Build & Design-Build

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Abstract

This paper is a systematic literature review of journal papers and articles on the three project delivery systems (PDS), design-build/bridging (bridging), design-bid-build (DBB) and design-build (DB). Mean estimated project cost, project schedule and market share for these three types of PDS were studied and a comparison is shown in this paper. Upon the comparative study, the benefits of bridging over DBB are outlined. The paper finds out that despite the benefits of bridging over DBB, very few projects in the industry have used this system as a choice of project delivery. This is due to lack of information on this project delivery method among the construction industry professionals. Hence, structured literature review, combined with cost and schedule data comparisons, has highlighted the advantages and disadvantages of the bridging method of project delivery. The scope of this research is limited to projects in the United States.

Key words: Design-Build/Bridging, Design-Bid-build and Design Build

Introduction

Professionals in the 21st century construction industry believe that for effective completion of a construction project, selection of a suitable project delivery system is essential. Design-bid-build (DBB) is one of the conventional project delivery methods extensively used in construction for defining contractual responsibilities to various parties involved in a construction project. However, with the advent of sophisticated technology and level of specialization required, a new project delivery system was introduced in 1990 by George Heery (chairman Bookwood Group) and Charles Thomsen (former chairman 3D/International) (McNall 1998) . Initially, this project delivery system was introduced as "Concentrated Risk Contract" now recognized as "Design-build-Bridging" or "Bridging". Bridging is a combination of design-bid-build and design-build project delivery system. The purpose of development of this project delivery system was to overcome flaws in the traditional DBB and DB.

Bridging is a hybrid project delivery system which combines design-bid-build and design-build in a systematic manner so as to adopt the benefits of both. The essential difference in bridging is, the owner appoints a bridging designer/contractor who will be a representative of the owner in the entire design and construction process. A separate contractor is appointed through the bidding process, and the contractor's architect and bridging architect work together for completing the design and construction documents. Moreover, bridging architect is responsible for overseeing the construction and to approve progress payments to the contractor hired. With contractor and bridging architect working together, the number of litigations is reduced. Eventually, reducing the project cost and time required to complete the project.

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A feasible project delivery system must address the requirements of an architect, owner, contractor and the end user. A successful construction project is one which, fulfills the requirements of the end user, contractor earns a profit, is completed on scheduled time and within the stipulated budget, avoids excessive change orders or claims, is free of legal litigations between all the parties involved in the project, and the owner who is financing the project is ultimately satisfied with the project. To fulfill the above listed requirements of a project, selection of an appropriate project delivery system is vital (Park 2011)

Literature Review

Project delivery systems have been evolved in the past decades from traditional Design-bid-build (DBB) to Design-build (DB), Design-build Bridging and Construction Manager at Risk (CMAR) systems. Every project delivery system is developed in view to reduce construction time and at the same time maintaining the quality and containing the cost of the project (Hastak 2007). This research will compare Bridging with design-build and design-bid-build to aid the owners with regard to which project delivery system to choose for a particular project.

Due to the simple nature of construction in the past, the owners usually hired a single master builder who would design, engineer and construct a facility for them. This system was primarily used till the early 20th century. However, with the advent of technology and due to the complex nature of construction the need for different specializations on a single project increased. Hence, project delivery systems were introduced to define contractual relationships between different parties working on a project (Konchar 1998). The Associated General Contractors of America (AGC) defines a project delivery system as, "*the comprehensive process of assigning the contractual responsibilities for designing and constructing a project*" (Kenig 2011).

Design-bid-build is the traditional and widely used project delivery system used in the US. In this system the owner comes into a contract with a design firm which is responsible for the entire design of the project. The architect/engineer (A/E) firm is also responsible for all the plans and specifications, which is later used by the owner to contract a separate firm for the construction of the project.(Hale 2009)

Design-Build is a fairly new project delivery system. In this the owner contracts with a single firm for both design and construction of the project. Although, it was difficult to use any other project delivery system before 1996, but in February 1996 the U.S. Congress passed "Clinger-Cohen Act", which permitted the use of Design-build project delivery system (Loulakis 2012). Many researchers have shown in their studies that the DB project delivery system saves time. (Songer and Molenaar 1996). But in 2003 Ibbs et al. showed in their research, although Design-build system saves time, but they cost more than Design-bid-build projects.

Bridging method of project delivery is a combination of Design-build (DB) and Design-bid-build (DBB). It uses it to its advantage the benefits of each and eliminates the problems associated with DB and DBB. In Bridging, the owner hires an architectural firm or has an in-house architect to (also called "Owner's Design Consultant" or "ODC"). The ODC is responsible for the development of the preliminary design (or schematic design) as per the requirements of the owner. Occasionally, a program manager is hired by the owner, who manages both the designer and the builder. The next step in the process is Bridging Contract Documents are prepared by the architect. These contract documents serve as an agreement between the Owner and the Design-build firm which is to be hired to finish the remaining design

and construction of the project. Even though, the DB firm is hired by the Owner, the award for the design and construction is a 2-step process. The DB firm will first finish the entire design and will quote the final price for the project. It is the owner's decision to continue with the same DB firm or hire another contractor for construction (BIA 2013).

Bridging vs. DBB and DB

Design-bid-build (DBB) and Design-build have a significant number of drawbacks inherent in them. Firstly, due to the linear nature of project execution in DBB, the project schedule cannot be expedited. In addition, due to the absence of the contractor during the design process, constructability issues could not be alleviated in the beginning, which further results in a large number of change orders by the contractor. These are some of the issues which Bridging method of project delivery is capable of addressing.

Further, DB also possesses some drawbacks which are addressed by Bridging method of project delivery. The most important issue is the escalation of project cost from the initial contracted price which the owner and DB firm decide before the start of design. Also, the risk to the owner of the project is higher due to the owner being the direct point of contact with the DB firm.

While in design-build-bridging, the bridging architect or the ODC serves as a facilitator between the owner and the DB firm, resulting in less number of change orders to the owner. Contracted cost of construction is fixed, as the DB firm submits a Guaranteed Maximum Price (GMP) to the owner, while signing Bridging Contract Documents (BCD). However, problems in coordination between the owner and the DB firm could arise, due to the presence of bridging architect. Also, there might be a conflict between the bridging architect and DB firm over design responsibilities. Some of these disadvantages might suggest that there could be an increase in the project cost or there might be delays in the schedule of the project. However, the data suggests otherwise.

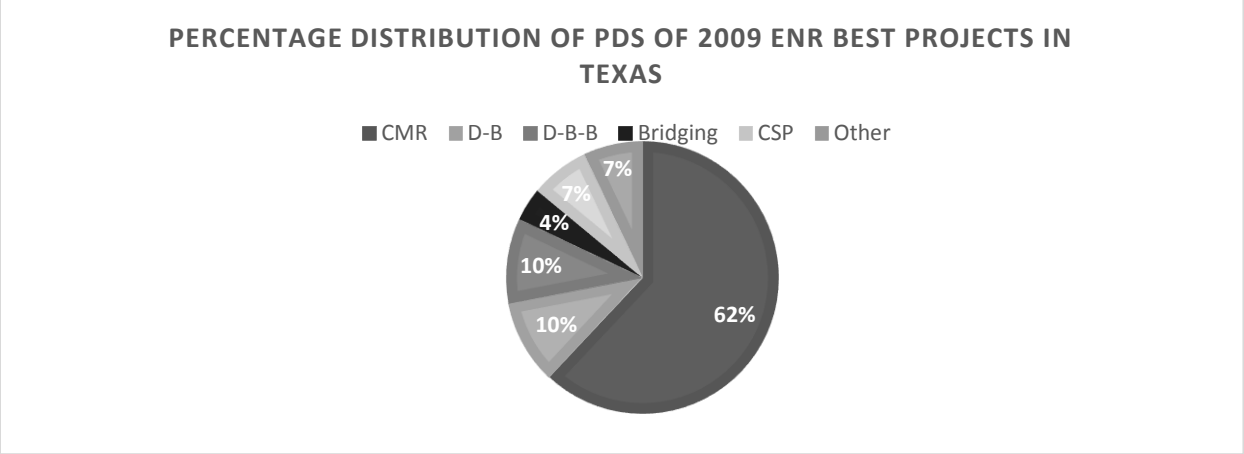
In 2009, in a paper presented at Construction research congress reported that the mean estimated total project cost in Bridging was $13,306,191, compared to Design Build which was $25,360,700 and Design-bid-build which was $39,821,994. Moreover, authors also compared the project duration starting from the design till the end of the construction phase. The data suggest that using cross-tabulations of time DBB on average has the longest duration of 2,246 days, while DB has an average of 1,850 days and Bridging has a significantly lower average of 1,099 days. In conclusion, there is a substantial diminution in project cost and schedule by using the Bridging method of project delivery over DB and DBB. (Smith et. Al. 2009).

Problem Statement

In a research report by Construction Management Association of America (CMAA), the results showed that currently in the United States, one of the most predominantly used project delivery system in the United States is Design-build with a market share of 60% compared to Design-bid-build with a share of 15% (CMAA 2012). Despite the multitude of advantages of Design-build-bridging over DB and DBB, there is still a lack of adoption of this project delivery system in the construction industry, due to lack of awareness among construction industry professionals. A systematic literature review of the current journal papers and articles on these project delivery system would be beneficial to educate the industry, which would further serve as a decision

support model for the owners. In another research conducted by N. Rajan on Analysis of 2009 ENR Best projects in Texas revealed that only 4% of the projects in the study have Design-build-Bridging as a choice of project delivery method as compared to a 62% share of Construction Manager at Risk and 10% share of Design-build and Design-bid-build. (Rajan 2010).

Figure 1. Percentage Market share of 2009 ENR Best Projects in Texas (Rajan 2010)



Research Methods

The research would be primarily based on a literature review of articles and journal papers. However, an organized approach would be used for the review of these journal papers and articles. The research would use popular databases like the American Society of civil engineers (ASCE), Construction Industry Institute (CII), Compendex and Georef to extract research papers related to project delivery systems, using a specific set of keywords to find peer-reviewed journals in these databases. To date, there has been an exhaustive list of keywords that were used to search papers pertaining to this research like project delivery system, design-build/bridging, bridging method of project delivery, design-build/assist, design-bid-build and design-build, construction project delivery systems. Using a combination of the aforementioned keywords (Refer Table 1), about 800 research papers were found pertaining to project delivery systems, about 380 papers were eliminated due to duplicity within the search pattern, out of the remaining 290 papers were eliminated from this study due to being out of scope of this area of research. About 130 papers were related to project delivery systems in construction and out of which about 19 papers (Refer Table 2), articles or journals which are related to Bridging, DB and DBB, and are referred to compare the project delivery systems in the study.

Table 1. List of Keywords used in the study

S. No.	Keyword Sets
1.	Project delivery system, design-bid-build, design-build
2.	Project delivery system, design-build/bridging
3.	Bridging method of project delivery
4.	Design-build/assist, design-build, design-bid-build
5.	Design-build-bridging, design-build, design-build

6.	Construction project delivery systems
7.	Design-build, Bridging, project delivery methods

Table 2. List of Journals Papers and Articles referred

S.No	Name of the article, journal or book (source)	Author	Year	Times Cited
1.	Comparison of United States project delivery systems (ASCE journal of construction engineering and management)	Konchar M. Sanvido V.	1998	414
2.	Empirical comparison of Design-build and Design-bid-build project delivery methods (ASCE journal of construction engineering and management)	Hale D. R. Sreshtha P. P. Gibson G. E. Jr.	2009	105
3.	Comparing procurement methods for Design-build projects (ASCE journal of construction engineering and management)	Wardani M. A. Messner J. I.	2006	100
4.	Collaborative Planning of AEC projects & partnerships (Automation in Construction)	Verheij H. Augenbroe G.	2006	27
5.	Effect of project delivery methods on design performance in Multifamily housing projects (ASCE journal of construction engineering and management)	Hyun C. T. Cho K. M. Koo K. J. Hong T. H.	2008	25
6.	An Empirical analysis of United States Navy Design-build contracts (Defense Technical Information Center)	Askew L. III	1995	10
7.	Project Manager's Decision Aid for a Radical Project Cycle Reduction (ASCE journal of construction engineering and management)	Hastak M. Gokhale S. Goyani K. Hong T. H.	2007	4
8.	Bridging: An alternative project delivery method (Texas Tech University)	McNall T. W.	1998	3
9.	Effects of regulatory environment on Construction project delivery method selection (Construction Research Congress)	Smith V. R. R. Castro-Lacouture D.	2009	3
10.	Analysis of 2009 ENR best projects in	Rajan N.	2010	2

	Texas to determine the impact of project delivery system used (Texas A&M University)			
11.	Commissioning of Design/Build projects (ASHRAE Journal)	Jung M. H. Hwang S. H.	2012	1
12.	Design-Build and CM at Risk-comparative analysis for owner decision making based on case studies and project surveys (Texas A&M University)	Park S. R.	2012	0
13.	An Owner's guide to Project Delivery Methods (Construction Management Association of America)	CMAA	2012	0
14.	Bridging Documents: Project Delivery for Today's Marketplace (American Institutes of Architects)	Lee Askew III	2007	0
15.	Advancing the Interests of the Owner in design and construction with the Bridging Method (Bridging Institute of America)	BIA	2012	0
16.	49ers use 'Integrated Bridging Design-build' to speed stadium construction (Engineering News Record)	Nadine M.	2012	0
17.	Advancing the interests of the owner in design and construction with Bridging method (Bridging Institute of America)	Heery G.	2012	0
18.	Bridging documents: Project delivery for today's marketplace (The American Institute of Architects)	Askew L. III	2007	0
19.	New Design-Build Bridging method – Design-build "Lite" (University of North Carolina at Chapel Hill)	Houston N.	2014	0

Findings

This paper is an attempt to satisfy the needs of an owner to make an educated decision in choosing a project delivery system for their project. With the introduction of the Bridging method of project delivery, it is a challenging task for the owner to make a decision about the most suitable method of project delivery for the geographic location of their project. As,it requires historical data about performance of similar projects or the owners can obtain data from research conducted by scholars/organizations.

Comparison of PDS based on data from Private sector projects

A comparison of 2009 ENR Best Projects in Texas to determine the impact of Project delivery systems that are commonly used in the state of Texas. The project delivery system under this study are Design-bid-build, Competitive Sealed Proposal, Construction Manager at Risk, Design-build, Design-build-Bridging, and Job Order Contracting. However, for the purpose of this study only the data pertaining to DBB, DB and Bridging was used. (Rajan 2010)

This paper used Engineering News Record's data which is a weekly magazine published by The McGraw-Hill Companies providing news, analysis, data an opinion for the construction industry worldwide. The paper analyzed the performance of Best projects according to ENR in the year 2009 in Texas and using the project data of thirty two construction projects compared the project delivery systems on the following factors:

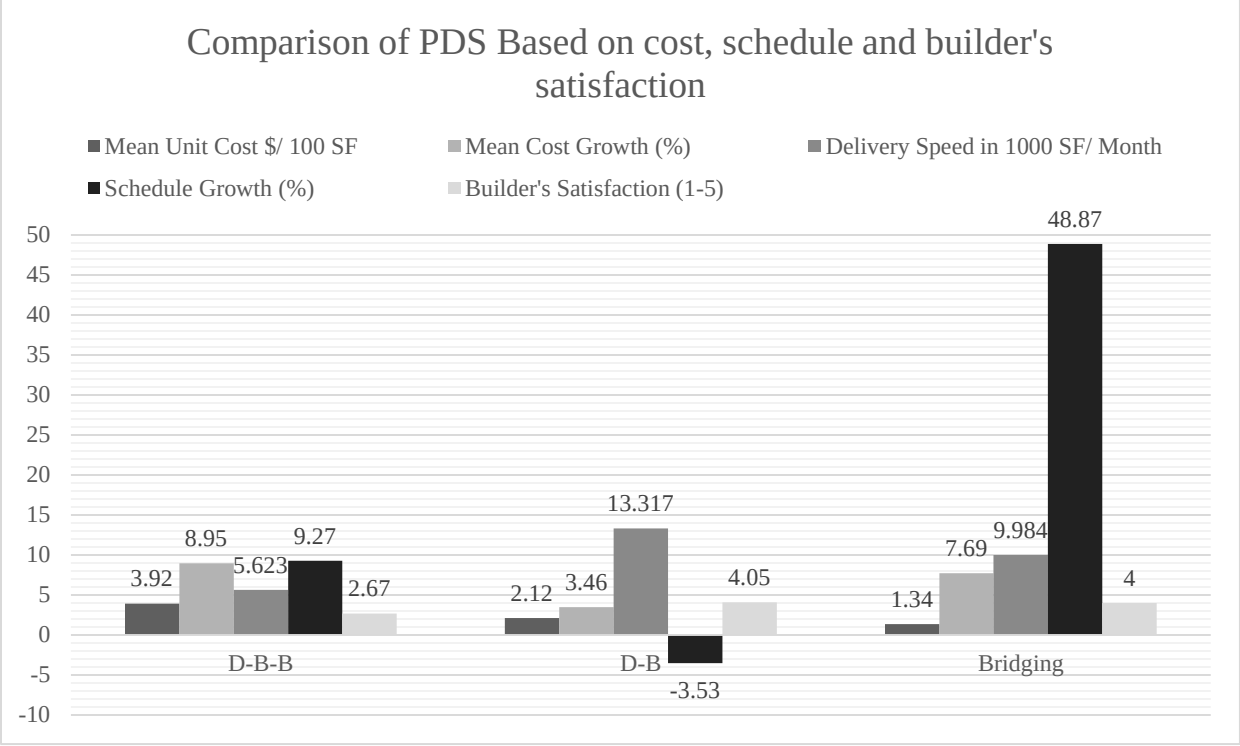


Figure 2. Comparison of PDS based on Cost, Schedule and Builder's Satisfaction (Rajan 2010)

i. **Unit Cost ($/SF):** Mean construction cost in US dollars required to build one square foot of the facility. The formula to calculate the unit cost is:

$$Unit\ Cost = \frac{As-built\ Construction\ Cost}{Size\ of\ the\ facility\ in\ Square\ Footage}$$

The mean unit cost values of the projects ranged from approximately $100/SF to $400/SF, and the comparison clearly depicts that using the Bridging method of project delivery has given the lowest mean cost in comparison to other project delivery systems. (Rajan 2010)

ii. **Cost Growth:** Cost growth is the percentage mean change in the cost of the project as compared to the contracted cost of the project. The formula to compare the cost growth is:

$$Cost\ Growth = \frac{(Contracted\ Construction\ cost) - As - built\ Construction\ Cost}{Contracted\ Construction\ Cost}$$

The mean cost growth in the cost of construction when compared to the contracted cost is the highest in Design-bid-build and is the lowest in Design-build. The approximate values of mean cost growth and lie in the range of 3% to 9%. (Rajan 2010)

iii. Delivery Speed (SF/month): Average SF construction that was delivered in one month divided by 30 days.

The range of delivery speed lies approximately between 5000 to 13000 SF/month. D-B-B has the lowest delivery speed and D-B has the highest. (Rajan 2010)

iv. Schedule Growth (%): Schedule growth is a percentage of increase in the duration of the project compared to as-planned duration. It is computed using the following formula:

$$Schedule\ Growth = \frac{As\ planned\ duration - As\ built\ duration}{As\ planned\ duration}$$

D-B system outperformed all the project delivery system in terms of Schedule Growth. The negative figure indicates that the projects under D-B project delivery system were completed before the scheduled completion date. However, the worst performing system in the regard was Bridging. (Rajan 2010)

v. **Builder's Satisfaction (1-5 Scale):** This research conducted surveys of project participants on the project delivery system and Builder satisfaction is a scaled measure of satisfaction in terms of overall project performance and is based on the inputs of project participants of each project under this study.

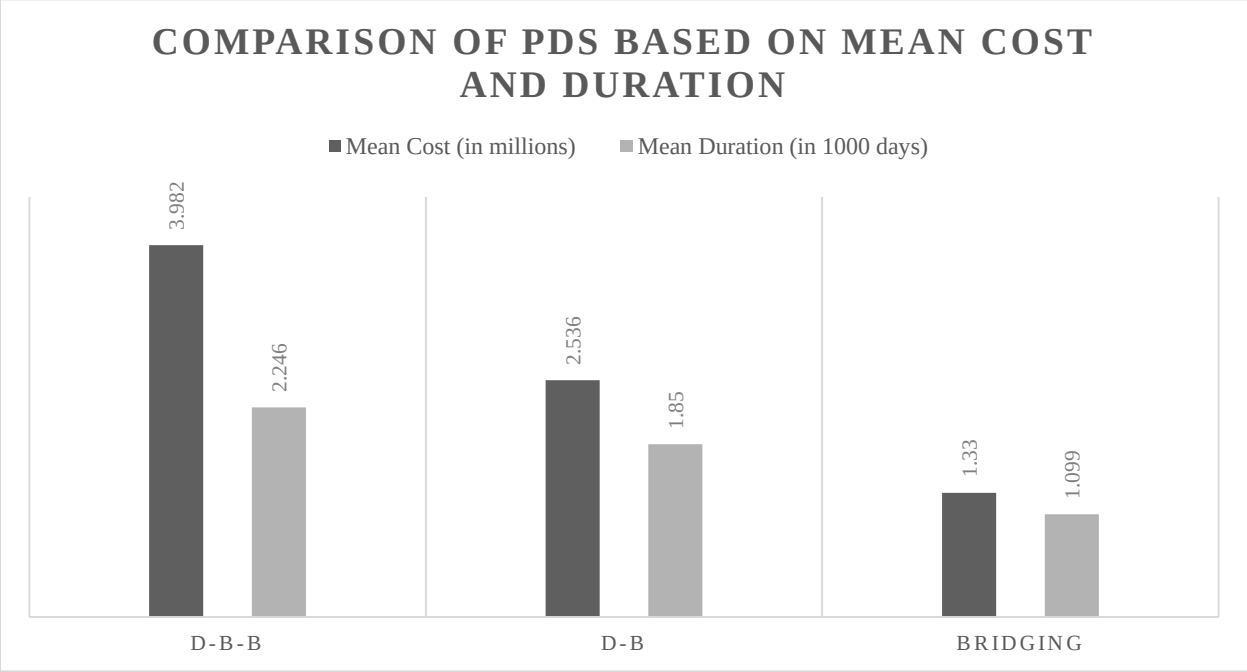
D-B-B is the least performing project delivery system in terms of Builder's Satisfaction with a score of 2.67. However D-B and Bridging have approximately the same values in terms of builder's satisfaction (Rajan 2010).

Comparison of PDS based on data from Federal and State projects

In 2009, in a paper presented in the Construction Research Congress by authors Smith, Castro-Lacouture and Oberle compared the effect of regulations and statutes on Federal and State government projects pertaining to the choice of project delivery method. The paper presented an analysis using cross-tabulation of project data from U.S. General Services Administration Capital Construction Project. Although, no project delivery system is better than the other, it is a matter of best choice for a particular project. (Dell'Isola et al. 1998). Research scholars and experts are always working on determining the best suited project delivery method for a particular project. (Smith et. Al. 2009). The data collected from the Project Information Portal (PIP) from the General Services Administration (GSA) revealed the following information:

1. Estimated Total Project Cost (ETPC): The total cost of designing and constructing a particular project.
2. Mean Duration of Design Start to Construction Finish.

Figure 3. Comparison of PDS based on Mean Cost and Duration of State and Federal Projects



(Smith et. Al. 2009)

Cross tabulation of data from GSA projects reveals that the mean cost of projects in D-B-B have the highest mean cost of 3.98 Million dollars while projects using Bridging have the lowest mean cost of 1.33 Million dollars. Furthermore, projects using D-B-B have the highest duration of 2,246 days from design phase to the end of construction, while projects using Bridging have the lowest mean duration of 1099 days. (Smith et. Al. 2009)

Conclusion

In the construction industry, selecting the most-suitable project delivery method for construction projects has been a prominent area of research of scholars and researchers. Even though, structured literature review revealed a great deal of information about Design-build/Bridging in terms of cost and schedule performance of projects using this project delivery system. Additionally, these two variables play an important role in the selection of a suitable project delivery system, but other variables like government regulations, litigations, change orders, organizational structure, project type, location of the project and nature of owner (public or private) are some of the other factors that come into the picture in the selection criteria. Findings of this paper revealed that Design-bid-build was the least performing project delivery method in terms of cost and schedule performance combined and builder's satisfaction. Bridging performed better than design-build and design-bid-build in public sector projects, due to the complex nature of specifications of federal and state government. Design-build has been the choice of project delivery system by project owners after the congressional approval of Clinger-Cohen Act in 1996. Only four projects chose Design-build as a project delivery method before 1996, but after 1996 seventy three had Design-build as a choice of project delivery method. In conclusion,

structured literature review revealed that the use of alternative project delivery method increased after the Clinger Cohen Act was passed in 1996. However, more research on Bridging is required for the industry professionals to understand the advantages and disadvantages of this project delivery method.

References

An Owner's Guide to Project Delivery Methods. (2012). Retrieved from The Construction Management Association of America: http://cmaanet.org/files/Owners%20Guide%20to%20Project%20Delivery%20Methods%20Final.pdf

Askew, L. (2002). Bridging Documents: Project Delivery for Today's Marketplace. The American Institute of Architects.

Dell'Isola, M., Licameli, J., & Arnold, C. (1998). How to form a decision matrix for selecting a project delivery system .

Hale, D. R., Shrestha, P. P., Jr., G. E., & Migliaccio, G. C. (2009). Empirical Comparison of design/build and design/bid/build project delivery methods. Journal of Construction Engineering and Management.

Hastak, M., Gokhale, S., Goyani, K., Hong, T., & Safi, B. (2007). Project Manager's Decision Aid for a Radical Project Cycle Reduction. Journal of Construction Engineering and Management.

Heery, G. (2012). Advancing the Interests of the Owner in design and construction with the Bridging Method. The Bridging Institute of America.

Houston, N. (2014, February 6). New Design-Build Bridging Construction Method – Design-Build "Lite". Retrieved from http://canons.sog.unc.edu/: http://canons.sog.unc.edu/?p=7519

Hyun, C., Cho, K., Koo, K., Hong, T., & Moon, H. (2008). Effect of Delivery Methods on Design Performance in Multifamily Housing Projects. Journal of Construction Engineering and Management.

Keeble-Allen, A. A. (2008). Undertaking a Structured Literature Review or Structuring a Literature Review: Tales from the Field. The Electronic Journal of Business Research Methods.

Konchar, M., & Sanvido, V. (1998). COMPARISON OF U.S. PROJECT DELIVERY SYSTEMS. Journal of Construction Engineering and Management .

McNall, T. W. (1998). Bridging: An Alternative Project Delivery Method.

Park, S. R. (2011). Desing-Build and CM At Risk- Comparitive Analysis For Owner Decision Making Based on Case Studies And Project Surveys.

Post, N. M. (2012, October 31). 49ers Use 'Integrated Bridging DesignBuild'. Engineering News-Record.

Rajan, N. (2010). Analysis of 2009 ENR Best Projects in Texas to Determine the Impact of Project Delivery System Used.

Roth, M. B. (1995). An Empirical Analysis os United States Navy Design/Build Contracts. Defense Technical Information Center (DTIC).

Smith, V. R., Castro-Lacouture, D., & Oberle, R. (2009). Effects of the Regulatory Environment on Construction Project Delivery Mehod Selection. Construction Research Congress, 211-218.

Turner, S. C., Jung, M. H., & Hwang, S. H. (2012). Commissioning Design/Build projects. American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

Verheij, H., & Augenbroe, G. (2006). Collaborative planning of AEC projects and partnerships. Automation in Construction.

Wardani, M. A., Messner, J. I., & Horman, M. J. (2006). Comparing Procurement Methods for Design-Build Projects. Journal of Construction Engineering and Management .