



Covering Advanced Construction Management Topics with Diverse Student Body

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Abstract

Advanced Construction Management is a graduate level course offered at the University of Texas at San Antonio, Master of Science Program in Architecture. The course objectives are composed of the understanding of emerging project delivery approaches, sustainability and technology driven project environment and the near future of construction project environment at the strategic level. Students in the program have diverse educational backgrounds, therefore advanced topics are taught without excluding their fundamentals. The paper presents a term project example showing how this is accomplished. Each student is given a different topic. The given topic includes the analysis of conventional project delivery methods to see if certain characteristics can be extracted to define a sustainable project delivery. It is aimed that a student without a construction related bachelor's degree investigates the components of a sustainable project delivery as an advanced topic, and learns about the conventional delivery methods as the fundamentals of the topic at the same time. The reason for such research topic comes from the current trends in the industry. Building project stakeholders discuss the alternate delivery methods for green building projects to obtain a better performance during the project life cycle. There are efforts to define innovative delivery methods but so far, there is no set method for green building project delivery. Recent literature review on the topic emphasizes the importance of project planning due to the collaboration requirements between wide ranges of project participants. Well-structured planning phase provides effectiveness in construction as well as maintenance/operation and demolition phases. Since the top green building construction providers are construction management at risk (CM at Risk) and design-build (DB) contractors, it is suggested that is necessary to explore characteristics that can be extracted from those delivery methods to apply into a sustainable delivery method. The findings indicate that there are many characteristics of conventional delivery methods that can contribute to various project phases of a sustainable project delivery. Therefore, defining a sustainable building project delivery method needs to include many components from conventional methods. The described teaching methodology in this course helped students not only get the advanced knowledge but also the fundamental knowledge of the given topic. Students submitted their study in the form of a research paper that is expected to improve their writing skills towards their Master of Science thesis.

Introduction

Advanced Construction Management is a graduate level course offered at the University of Texas at San Antonio, Master of Science Program in Architecture. The course objectives are composed of the understanding of emerging project delivery approaches, sustainability and technology driven project environment and the near future of construction project environment at the strategic level. Students in the program have diverse educational backgrounds, therefore advanced topics are taught without excluding their fundamentals.

The topics in Advanced Construction Management include project delivery systems, building information modeling, knowledge management in construction industry, innovative technologies' integration to buildings process, and business topics for construction firms both domestic and international levels. Every week, one of the topics is covered; the respective topic related peer reviewed papers are presented by the lecturer. The following week, the students present a peer reviewed paper on a topic that was covered the week before by the lecturer. In addition, the students choose one particular topic and prepare a research paper. Throughout the semester they become familiar with research papers in advanced construction management, discussion is made both on the topic and the structure of the peer reviewed publications. The term project gives them the opportunity to make a research in one of those topics and write a technical paper. This way, the course helps them to build writing skills especially towards their Master of Science thesis. This paper presents a term project example showing how this is accomplished.

The topic includes the analysis of conventional project delivery methods to see if certain characteristics can be extracted to define a sustainable project delivery. It is aimed that a student without a construction related bachelor's degree investigates the components of a sustainable project delivery as an advanced topic, and learns about the conventional delivery methods as the fundamentals of the topic at the same time.

Building project stakeholders discuss the alternate delivery methods for green building projects to obtain better performance during the project life cycle. So far, there is no set method for green building project delivery. The current project delivery systems do not show a means of delivering projects with minimal wastes and minimal project delays, but the systems do show the ability to adapt. Certain characteristics of a sustainable project delivery can be extracted from construction management at risk (CMR), design-build (DB) and design-bid-build (DBB) to define a method for green building project delivery. Exploring the characteristics of conventional delivery methods for sustainable delivery solutions can both help learning about the conventional delivery methods and both researching about the advanced sustainability driven solutions.

Literature Review

The existing literature on construction project delivery methods has been explored in detail by the graduate student. The following paragraphs include the related literature review:

The well-known conventional project delivery in today's market is the Design Bid Build (DBB) method. This method of delivery has two distinctive phases, the design phase and the construction phase¹. Design Build (DB) is the oldest approach still regarded as an alternative to the DBB method. The contractor must bring designers and constructors together to complete a project¹. The final conventional method of delivery is Construction Manager at Risk (CMR). CMR guarantees a maximum price and caps the cost increase for the owner². The contractor takes on majority of the risk when completing the project.

In another previous research, DB and DBB were compared by surveying 129 projects through the Financial Information System (FIS). This research returned results for reduction in schedule, costs, change orders, delays, and many other measurable data which concluded that DB was by far the best method to use for reducing the schedule of projects, but not the best method in other aspects of project delivery³.

All of the conventional delivery methods lack in some area when it comes to meeting the goals of sustainable projects. DBB is known for the low initial price because of the competitiveness of the bidding process, but the lowest bidder is not always the best value for the owner and the method is inflexible and sequential and cannot be used for sustainable project delivery². Alike, CMR has its downfalls in delivering projects. This method is known for its GMP, but is also known for not having competitive pricing and not having the promotion of fairness towards subcontractors. Because of the various downfalls of each method of delivery, researchers have begun working to draft a sustainable project delivery method. Researchers have realized the need for drafting a more ideal method because of the inefficiencies of the conventional delivery methods⁴. The idea of SPD integrates design and construction to optimize and perform analyses and energy modeling⁵. The market has no clear method capable of conducting such an analysis, hence the reason for this paper to create a basis for a new method of sustainable delivery.

In the current environment, the earth's resources are being consumed faster than they can be replenished; meaning that sometime in the future the market will have to perform without these resources. The public is becoming more aware of the benefits of green construction as prominent politicians, celebrities, documentarians, and journalists highlight the built environment's impact on greenhouse gas emissions and natural resource consumption⁶. The professionals of the construction industry are currently working on to develop more sustainable buildings by implementing sustainable designs with more feasibility and less overall cost, shorter turnover of construction projects, quality construction and more energy efficient buildings, as well as designing projects for deconstructability. The conventional delivery methods are best suited for conventional building types and are often unresponsive to the needs of sustainable building projects⁷. In prior research, DBB was noted to actually constrain the constructor's ability to assist in achieving sustainable objectives⁴. DB has great coordination, but still faces problems with inconsistent application of the design and construction process and infrequent feedback⁸. CMR falls somewhere between DB and DBB project delivery methods in that it has contractually facilitated communications during the design phase. However, the point in design at which the constructor is hired can greatly impact the level of team integration⁹. The weaknesses in the conventional delivery methods limit performance typically expected from a sustainable project delivery; therefore, the industry has a need for better ways of delivering sustainable projects. The

ideas outlined in this paper aim to provide a delivery method that can respond to the needs of the emerging sustainable projects. The idea of more sustainable design and low overall cost has very limited empirical data, but the current processes are often full of wasteful rework, delays, changes, and overproduction¹⁰. The continuation of these problems is not necessary if the professionals within the industry are willing to make a change now.

The initiation of sustainable project delivery can be the source of numerous benefits including energy efficiency, improved indoor environment quality, increased health and occupant productivity, and the minimization of resource usage during the construction and operation of the building¹⁰. These results are not only owners' desires, but they are also desired by construction managers because of the cost savings in system selection, material selection, production costs, and schedule reduction.

Conventional delivery methods are not designed to compete in the emerging sustainable markets, but within the context of sustainable projects they may be contributing to the project in a positive and efficient manner. DBB offers field engineering for feasibility because of the increasing technological demand on AE firms to produce improved drawings relative to technology materials and products. DBB also has a competitive edge in pricing through the method of bidding. DB offers a single point of contact to ensure the convenience and ease of access for the owner. DB also offers an accelerated schedule due to reduction of change orders and RFI's. In the operations and maintenance phase, DB offers many different contractual variations.

CMR grants the owner a GMP because of the level of input experienced in the design stage. CMR also gives the owner confidence in the delivery of the project because this method places all liability on the construction firm, which drives competitiveness in the construction phase relative to cost and schedule length². CMR offers Value Engineering (VE), the ability to choose materials that reduce cost without affecting the value of the product and its design.

The above conventional methods can be used to accommodate the delivery of more sustainable projects; however the concepts cannot drive sustainable delivery alone and must be accompanied by new concepts of delivery.

The demand for sustainable buildings is growing⁷. While traditional design and construction activities focus on cost, performance and quality issues, sustainable design and construction adds the issues of minimization of resource consumption, environmental degradation and the creation of a healthy built environment as well as ensuring human health and comfort¹¹. The greater parts of project delivery no longer rest with production but rather with the reproduction of knowledge¹². As an organization, the construction industry is expected to turn focus towards preserving and reproducing sustainable project delivery ideology rather than only focusing on the traditional thoughts of simply decreasing the overall schedule and minimizing total costs. The developing delivery systems must have characteristics that reflect the need for environmental sensitivity, positive attitudes about social equity, and the desire to have economic prosperity¹²

The information stated in the previous section describes the concepts that should be used along with the new ideas of sustainable project delivery. Those conventional but sustainable concepts

of development, knowledge, and skills are already being used and should be the starting points from which the current project delivery methods can be redirected onto more sustainable paths.

As contributors to the current environmental conflicts, the AEC professionals are working to create sustainability in the environment. The construction industry contributes largely to resource shortages and global climate change because it accounts for 33% of all material and energy flows worldwide. The industry is required to reduce its impact at least 50% in the next half century by increasing efficiency of buildings and reducing the current carbon footprints placed on the environment. The efficiency of buildings indirectly affects the livelihood of the occupants that use the facility also⁵.

Sustainable project delivery considers the future of building occupants and the people affected by the emissions and wastes of the building. A sustainable method of delivery is sought because of their ability to reduce energy and water consumption, minimize the impacts of projects on ecosystems, and promote increased use of environment friendly materials⁴. The sustainable delivery system must have flexibility in order to adapt to the changes of resources of projects. The new delivery system should also empower project communities, and ensure project autonomy. The professionals in construction need to get involved personally, understand their place in society, and become more responsible for their actions¹².

Methodology, Findings and Analysis

This paper presents an example of a term paper written by a graduate student.

The study first investigates on different delivery methods. The advantages of all the delivery methods, according to the previous researchers, are presented in Figure 1. It shows the major stages of project delivery such as: Design Phase, Construction Phase, Operation/Maintenance Phase, and the Demolition Phase. Each phase is outlined with the basic principles that need to be placed in each of the stages for sustainable project delivery. Following that, the reason for the contributions from each method is defined.

The Design, Construction, Operation/Maintenance, and Demolition Phase of sustainable project delivery should be inclusive of conventional concepts combined with the new ideas of project delivery to create the best method for delivering sustainable projects.

ANALYSIS OF PROJECT DELIVERY TYPES IN DIFFERENT PHASES

Design Phase

Design Bid Build Project Delivery

Although DBB does not provide integration because of its relatively traditional characteristics of defining distinct and separate roles in delivering a project, it does provide the owner the confidence of building by guaranteeing a low starting price because of the competitive nature of

the bidding process². The owner has the confidence that the contractor they select to perform the work is doing it for the best possible price relative to other construction firms.

Design Build Project Delivery

The DB method of delivery is ideal for the design phase of the suggested sustainable project delivery method because of the addition of the builder in the design phase. The builder's expertise in the design phase has the ability to assist in elimination of many change orders, RFIs, and delays within the schedule³.

CM@ Risk Project Delivery

The CMR method of delivery uniquely offers an incorporated design stage that includes a design firm and a contractually separated building contractor. The builder has very significant input in the design stage to help decrease complications, i.e. delays, costs, and reworks, which may arise later in field production¹³. The builder is now able to offer the owner a GMP because of the level of input he/she had in the design of the project⁹.

Idea of Sustainable Project Delivery

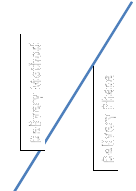
In addition to the advantages of DB and CMR, sustainable project delivery should contribute Deconstructability and Operations and Maintenance in the design phase of delivery. This provides owners with a means of optimizing and then 'softly' ending a project's life cycle, relative to environmental control and environmental preservation efforts¹².

Construction Phase

Design Bid Build Project Delivery

The DBB method of delivery is known for the field tasks completed with the help of building professionals' previous knowledge and experience. The new method of delivery should include design implementation in the field because construction design generally cannot account for every obstacle builders may face in the field; it is a simple case of theory vs. practice, and practice is more ideal for project delivery¹⁴.

Figure 1. Design of the Preferred Sustainable Project Delivery Method

	DESIGN/BID/ BUILD (DBB)	DESIGN/BUILD (DB)	CONSTRUCTION MANAGER AT RISK (CMR)	SUSTAINABLE IDEAS (SI)	SUSTAINABLE PROJECT DELIVERY METHOD (Combination of DBB, DB, CMR, SI)
DESIGN	Design Design Design Design Design Design Design Design Design Design Design Design Design Design	Incorporates the builders in the beginning stages of design as well as the specialty contractors	Early teaming of the builder and the design entity	Gathers all necessary information in order to input and maintain one source of medium for every entity to utilize. Broader stakeholder input	Incorporates builders and specialty contractors in the design stage with the intent of early teaming. Establishes one medium of information for every entity to utilize. Allows stakeholders to have a broader influence.
CONSTRUCTION	Performs field engineering tasks in order to maintain feasible solutions for the project	Accelerates the schedule and reduces the number of C.O.'s. Encourages innovative design solutions	Establishes GMP. More accurate and timely delivery because the liability is on the builder instead of the owner	Constructed with more accuracy and knowledge. Uses BIM software to help aid builders in obtaining information	Encourages innovative design solutions in design and field phases for increased feasibility. Accelerates schedule, establishes GMP for the owner, uses BIM software to aid in information sharing and accuracy of delivery.
OPERATION/ MAINTENANCE	Maintenance Operation Maintenance Operation Maintenance Operation Maintenance	Many different variations that enable flexibility in contract documents (DBO, DBOT, DBOM, DBFO)	Maintenance Operation Maintenance Operation Maintenance Operation Maintenance	Operation/Maintenance is done with a higher level of sophistication and technological aid	Operation/Maintenance are completed with the aid of technology. Contractual variations are readily available for the owner when deciding how to obtain ideal delivery.
DECONSTRUCTION	Deconstruction Deconstruction Deconstruction Deconstruction Deconstruction Deconstruction Deconstruction	Deconstruction Deconstruction Deconstruction Deconstruction Deconstruction Deconstruction Deconstruction	The builder presents the owner with VE possibilities that are used to minimize environmental impact	Recyclable Materials are reused for other projects rather than thrown away to avoid environmental complications from waste	The builder presents VE possibilities such as more sustainable products and materials, recyclable materials, and minimization of wastes in order to minimize overall environmental impact.

Design Build Project Delivery

DB provides very substantial contributions such as accelerated schedule and encouragement of innovative design solutions¹⁵. DB contributes to the construction phase because of faster construction speed and lower unit costs. When all other variables were held constant, the effects of project delivery system indicated DB projects to be at least 12% faster than DBB and 7% faster than CMR¹⁶. When all other variables were held constant, the effects of project delivery

system indicated DB projects to be at least 6.1% cheaper than DBB and 4.5% cheaper than CMR¹⁶.

CM@ Risk Project Delivery

CMR is the owner of the unique GMP and price certainty method of service. This method is ideal for the owner because of the owner's ability to relax with a great amount of confidence in their CM's ability to get the project delivered in budget and on time. This method is very 'on the edge' for the contractor and more accurate for the owner¹⁷.

Idea of Sustainable Project Delivery

The ideal sustainable project delivery method should place every stakeholder on the same level and forces a merger of talents in order to create one large building program. This merged entity has the determination to work as a team to receive the largest benefit overall, for the owner and the contractually obligated¹⁸.

Operation/Maintenance Phase

Design Build Project Delivery

DB offers contractual flexibility for the owner and DB entity when delivering a project. DB offers many variations that allow for financing, operation, maintenance, and transferring of the project after a specified time such as design-build-operate-transfer (DBOT), design-build-operate (DBO), design-build-transfer (DBT), design-build-finance-operate (DBFO), etc. This type of flexibility allows the owner of the project a variety of choices so that they may pick the most appropriate method with the least amount of limitation¹⁹.

Idea of Sustainable Project Management

The ideal sustainable project delivery method offers the use of technology as a means of maintaining and operating a project. Technology can provide the owner with dates of scheduled maintenance, information about replacement equipment that may not otherwise be readily available, as well as usage of energy and probable causes of losses in operation²⁰.

Deconstruction Phase

Idea of Sustainable Project Management

AEC professionals plan to optimize the life cycle of buildings by implementing renovation tactics instead of immediate demolition of buildings²¹.

The findings indicate that DB and CMR delivery methods can contribute to sustainable project delivery method since they can facilitate the integration of builders and designers at the design stage. When it comes to DBB, many of the design related issues are resolved in construction phase. Builders in DBB projects need to procure detailed design documents from their subcontractors¹⁴. This mechanism could be the major contributing factor to sustainable project delivery. DB is a fast track delivery. Even though sustainable projects do not seem motivated by quick turnarounds, ability to provide design solutions during construction is a major advantage since knowledge driven sustainability processes may require innovative solutions during

construction. On the other hand CMR brings competitive cost supervision during the construction phase. Different variations of DB such as DBOT, DBO, DBT, and DBFO could make major contributions for sustainable projects' operations and maintenance phase. Thinking about deconstruction is common for sustainable projects, and CMR delivery could set a good example with its value engineering (VE) sessions which can be performed for deconstructability analysis.

Conclusions

This paper presented the positive aspects of the conventional delivery methods in cross reference with the new ideas of sustainable delivery. As indicated in Figure 1, the developing sustainable project delivery methods should be modeled to include a mixture of all the current and future processes that increase efficiency and sustainability in project delivery. All conventional delivery methods can contribute at some degree to the idea of sustainable project delivery but CMR and DB definitely have lot to offer in this process.

This research is mainly based on the literature review on conventional delivery methods and the features of sustainable project delivery. In the future, this research can be expanded with the integration of statistical and empirical evidence which can be gathered to incorporate effects of each phase of project delivery on micro-levels such as contract obligations/liability, systematic development, feasibility of design, etc. The modeled sustainable project delivery features should be used in a case study of multiple construction projects to compare any areas of deficiencies.

Integrated project delivery (IPD) is not included in this study since it is relatively new in AEC industry of the United States. According to CMAA²²;

“IPD contracts have not yet been tested in law, so the result of a failure within the team is unpredictable.”

Therefore, the study has investigated what can be extracted from existing and proven project delivery methods.

This study is a good example of covering an advanced topic while teaching fundamental knowledge of construction management at the graduate program with a diverse educational background student body.

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