Alliance Models and Lean Construction in Construction Projects

Master Thesis

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Topic: Alliance Models and Lean Construction in Construction Projects

Construction projects have become more complex and uncertain during recent years due to their dynamic nature. Even in these challenging situations, the construction industries demand high-quality outcomes with reduced project costs and time. To meet these demands, the traditional approach of contracting can be ineffective and incompatible as creating a collaborative environment between involved parties is challenging for multidisciplinary projects. Alliance contracting is a project delivery model where the owners, contractors, and consultants work collaboratively as an integrated team to achieve a common goal. The commercial interests are aligned so that each participant will share in the success or failure in decision making and risk management.

On the other hand, adopting the lean philosophy has also increased. Lean construction ideology examines the scope of project organisation by developing integrated and cross-functional teams and the alignment of the participant's goals. Lean construction intends to mitigate the barriers between various organisations. Lean construction promotes the alignment of different organisational objectives and between the employees. The linking of alliancing and lean construction could help deliver more excellent value to the organisations.

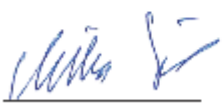
The study's primary goal is to determine how to use an alliance model with a lean philosophy. This study will be based on international literature research and questionnaire. Also, this study will analyse the cases where alliance models are used.

The goals related to case study will be:

- To identify and clarify different contractual arrangements in the construction industry
- To identify the critical requirements for alliance contracting to work well
- To determine the suitability of the alliance models
- To analyse the barriers of the alliance models
- To analyse the status quo of the alliancing in different countries
- To analyse how lean construction is used in the alliance models

The research will finally provide the answer to the following questions:

1. What kind of contractual arrangements there are in the construction industry?
2. How is the alliance model used in the construction industry?
3. How are Lean Management principles used in an alliance model?
4. What are the requirements and barriers for the alliance model?
5. What is the best practice to use alliancing?
6. In which countries, alliance models are used?



Mika Lindholm

Abstract

Construction projects suffer from many pitfalls such as low productivity, cost overruns, delays, disputes. These issues mostly come as a result of the complexity of the project. As a result, productivity improvement initiatives have triggered a spike in interest due to the industry's importance and uniqueness. A successful construction project demands an innovative project delivery method that improves efficiency in work environments. Project alliancing has evolved as an innovative project delivery method in the construction sector throughout many countries. Additionally, construction projects have also adopted lean philosophy to improve productivity in the workplace. This thesis aims to analyze the correspondence between project alliancing and lean construction principles.

This study clarifies different practices of contractual agreements in the construction industry. Further, the study explains the concept of alliancing as a project delivery method and the impacts of lean principles in the construction industry. In order to analyse the current practice of alliancing, a web-based questionnaire is conducted. In addition, two case studies are included to examine the integration of alliancing and lean techniques in construction projects.

Based on the literature review, this research indicates that the concept of alliancing correlates with lean principles, specifically on organizational and commercial levels. Findings from the questionnaire show that the alliancing requires improvement in the workplace. In addition to that, the case studies outcomes reveal that a project could deliver significant results by linking alliancing with lean tools and techniques.

Keywords: Project Alliance, Lean Construction, Project Delivery Method, Construction Industry, Contractual Agreements

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List of Abbreviations

BOQ	Bill Of Quantities
GMP	Guaranteed Maximum Price
DBB	Design Bid Built
DB	Design Bid
CMAR	Construction Manager At Risk
CMMP	Construction Management Multi-Party
PPP	Public-Private Partnerships
IPD	Integrated Project Delivery
PA	Project Alliancing
BP	British Petroleum
UK	United Kingdom
VFM	Value For Money
AM	Alliance Manager
ALT	Alliancing Leadership Team
AMT	Alliance Management Team
WPT	Wider Project Team
OP	Owner Participants
NOP	Non-Owner Participants
PAB	Project Alliancing Board
IPT	Integrated Project Team
TOC	Target Outturn Cost
KPI	Key Performance Indicators
DCP	Defects Correction Period
KRA	Key Research Areas
ADR	Alteration Dispute Resolution

ACA	Australian Contractors Association
LPS	Last Planner System
WWP	Weekly Work Planning
TVD	Target Value Design

1. Introduction

More than any other industry, construction continuously has a significant impact worldwide. Its reach extends beyond the built environment to include economy, technology, and the environment. Construction prospects are expanding, but project complexity is increasing as well. The construction firms are already operating under slight profit margins; the production setbacks could wipe out the entire firm’s profits. Project complexity has been identified as the catalyst for traditional project management approaches to become less efficient.

It has become a significant challenge for construction entities to choose a suitable contractual agreement that helps overcome the project's productivity and efficiency concerns. The traditional contracts bring uncertainties in project implementation in built environments, numerous interfaces, interest groups, and site work's demanding nature. The uncertainty that comes with challenging tasks reveals the flaws in typical contracts. Changes during the project also tend to increase conflicts of interest between the participants. Most traditional contracts do not thrive under changes but rather see them as barriers. Usually, the project owners see the contracts as a legal shield to transfer the risks to the contractors. Trust lacks in traditional contractual relationships. McInnis (2003) stated that the success of contractual relations depends on participants' attitudes towards future events rather than what has been agreed.

Project alliancing provides innovative solutions to improve productivity in complex projects. Originating from the UK, alliancing has emerged as a unique project delivery method in many countries. The new concept of alliancing differs significantly from traditional approaches. It motivates the involved parties to operate as an integrated team by aligning commercial interests. Similar to alliancing, the construction industry is turning towards lean philosophy to improve process management. The lean approach helps construction companies to enhance their performance significantly. The lean philosophy was introduced to improve worker productivity and eliminate waste in a car manufacturing company. Subsequently, the lean principles were applied in the construction industry to achieve the project outcomes with better quality and cost-efficiently. In this study, the relation between alliancing approach and lean principles is analysed. As a result, the outcomes and recommendations will be provided.

1.1 Overview

This study contents and analyses the following:

Chapter 1: Introduces the study and indicates the challenges that the construction industry faces with traditional contractual agreements in brief. It also provides research's goals, questions, and methodology.

Chapter 2: Analyses and clarifies different types of contractual agreements in the construction industry.

Chapter 3: Discusses the concept of alliancing in detail. Besides, it provides the suitability and success factors and barriers that the project entities face for the implementation. In addition, it provides a list of countries that are using alliancing in construction projects.

Chapter 4: Contains the concept of lean principles and their use in construction. Also, it discusses the success factors of lean implementation and several lean construction tools and techniques.

Chapter 5: Provides two case studies from the Finnish construction sector to analyse the outcomes from integrating alliancing with lean principles.

Chapter 6: Discusses the findings from a questionnaire. Further, it analyses the correspondence between alliancing and lean principles. Lastly, it differentiates the area of alliancing where lean techniques could be used.

Chapter 7: Provides outcomes and the conclusion of the thesis research in brief.

1.2 Research Goals

The goals of this study are:

- To identify and clarify different contractual arrangements in the construction industry
- To identify the critical requirements for alliance contracting to work well
- To determine the suitability of the alliance models
- To analyse the barriers of the alliance models
- To analyse the status quo of the alliancing in different countries
- To analyse how lean construction is used in the alliance models

1.3 Research Questions

The study intends to find the answers to the following questions:

- What kind of contractual arrangements there are in the construction industry?
- How is the alliance model used in the construction industry?
- How are Lean Management principles used in an alliance model?
- What are the requirements and barriers for the alliance model?
- What is the best practice to use alliancing?
- In which countries, alliance models are used?

1.4 Research Methodology

The research methodology of this study consists of the following:

- Literature review
    - Based on previous research papers, journals, and articles related to the topic or the thesis research.
- Questionnaire
    - A web-based questionnaire to gain insights from experienced professionals in alliancing.
- Case studies
    - Liekki Railway Renovation Project Lielahti – Kokemäki (2011 – 2015)
    - Rantatunneli Alliance Project (2011 – 2017)
- Outcomes
    - Identifying areas of alliancing to integrate lean techniques for maximizing the project value.

2. Contractual Arrangements in Construction

In the construction industry, multiple factors impact the costs of the projects. Contractual arrangements, while less observable than others, have a significant impact on these costs. The participants involved in a construction project are constrained by risks, hazards, various factors such as time, money, and quality. The owners, however, are unaware of the cost savings that may be obtained by taking a more strategic approach on how time and money are spent with improved contracting techniques.

Risk management plays a critical role when it comes to making the right decision for the contracting strategy. The owner must assess the risk and potential negative consequences of an event throughout the project. He must know the responsible participants for these risks and share or transfer with them based on the capability of his organization. After that, the owner can establish a contracting strategy that aligns his goals and resources. Figure 1 shows the different types of contractual arrangements in construction projects.

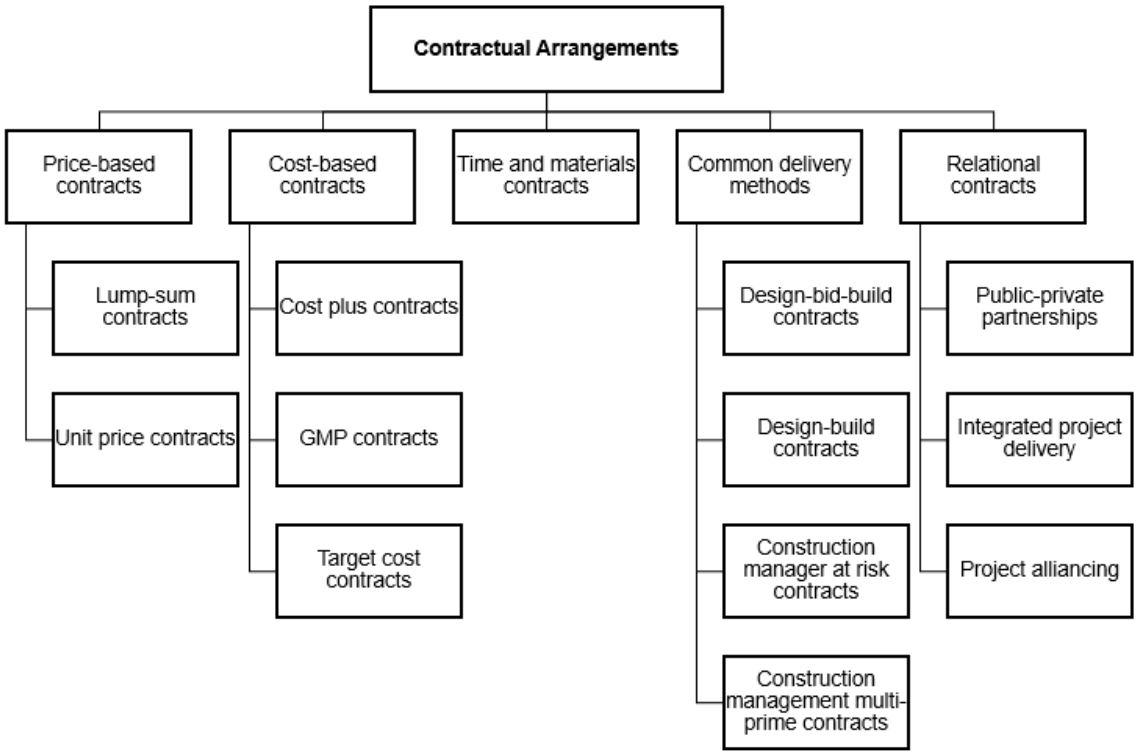

Figure 1: Contractual arrangements in construction projects Source: The author

2.1 Price-based Contractual Arrangements

2.1.1 Lump-sum Contracts

Lump-sum contracts that are commonly known as fixed-price contracts, are the most basic types of contracts. The lump-sum contractual approach requires the owner to pay a pre-agreed sum regardless of the actual cost incurred during the project. The payment is not made against the measurement of actual work but according to the schedule of the payments. Usually, whenever the predetermined milestones are finished, or the project is completed. The lump-sum pricing is affected by claims, modifications, and corrections based on the specific contractual risk allocation. (Drawert, 2020)

The pre-agreed sum or the lump sum must include expected costs, overhead, profit, and risk surcharges. The key benefit for the owner is easier contract administration and the certainty of costs. However, the certainty of cost is difficult when the surcharge is too high. The risks of a specific project are hard to assess. The corrections, additional works, and claims must be resolved by predefined criteria or a common-sense and impartial manner by all concerned parties. (Klee, 2018)

The lump-sum is also called the functional description of performances. The scope of work is defined with only the final objectives. However, the planning process is more or less undefined. Meaning, the contractor need only execute the services that are defined in the agreed lump sum contract. The main benefit of this agreement is that the contractor takes the project's risks and is responsible for the planning process. Thus, his expertise can be beneficial to the project. On the other hand, the owner remains in a "black box" since he does not control the project. This type of contract is suitable when the agreement does not require detailed estimates or when the owner does not want to participate in the execution phase. (Drawert, 2020)

2.1.2 Unit Price Contracts

Unit price contracts, also known as measurement contracts, break down the total amount of work needed to finish a project into smaller units. The actual work is measured using the re-measurement method, which is based on the individual rates and

prices offered by the contractors in their bill of quantities (BOQ) bid. The bill of quantities includes specific items and provides a description of the work and their quantity. In order to prevent any disputes, it is necessary that each item, as well as the rate or price associated with it, must be carefully considered. Also, the content should be thoroughly understood. The estimation in the unit price contract specifies unit costs that may include materials, labour, overhead, supplies, and profit. However, these estimates are not always accurate as they can differ significantly from the actual price. Especially when the prices are taken from previous contracts. (Klee, 2018)

The essential advantage of a unit price contract is that the owner is involved in the planning process. Therefore, he has control over the project. Though, the owner must take risks and responsibilities to complete the project. The other drawback is that the owner cannot take advantage of the contractor's expertise since he has less influence over the project. This type of contract is suitable when the projects are repetitive, or the cost is highly dependent on materials. Usually, unit price contracts are used in public construction works. (Drawert, 2020)

2.2 Cost-based Contractual Arrangements

2.2.1 Cost Plus Contracts

A cost-plus contract pays the contractor for all project expenses plus predefined profit, commonly expressed as a percentage of overall contract costs or a fixed fee. However, the contractor is still required to provide an estimate rather than a lump sum to give an idea of the project's expected cost. In some situations, the owner may ask the contractor to limit the project's maximum cost. Also, the contractor is obliged to justify the costs and present comprehensive cost records. The owner has the authority to conduct an audit of the claimed cost to make sure that the incurred cost is reasonable. (Woodruff, 2020)

The owner is responsible for all risks in this agreement. He collaborates with the contractor to oversee the project execution. The cost-plus contract is favourable to the contractors as there is no risk to him if the project's cost rises. Nonetheless, there is no reward for an early completion either. This sort of contract is suitable when the

scope of the project is undetermined at the early stages. Moreover, the contractor can begin working on the project even before the design phase is finished. (Jain, n.d.)

The benefit of this contract is that the owners have flexibility. They can closely monitor the project's progress and expense because they are being charged when the new materials are purchased. Since the owners bear the cost of materials, the contractor is motivated to use the materials with higher quality. On the other hand, there could be disputes between two parties if the cost records are not provided to the owner. Also, in the owner's interest to keep the project cost to a minimum, the higher the cost, the higher the "plus" part of the contract becomes. (Accent Estimating, n.d.)

2.2.2 Guaranteed Maximum Price (GMP) Contracts

A guaranteed maximum price (GMP) contract sets a limit or maximum price on the project's budget. Regardless of the incurred cost, the owner must pay this maximum price to the contractor. The price limit on the contract cannot be exceeded. The contractor is obliged to pay the exceeding cost. Therefore, GMP contracts are beneficial to the owners since a considerable amount of risk is transferred to the contractor (Benarroche, 2019). Figure 2 reflects the typical model of guaranteed maximum price.

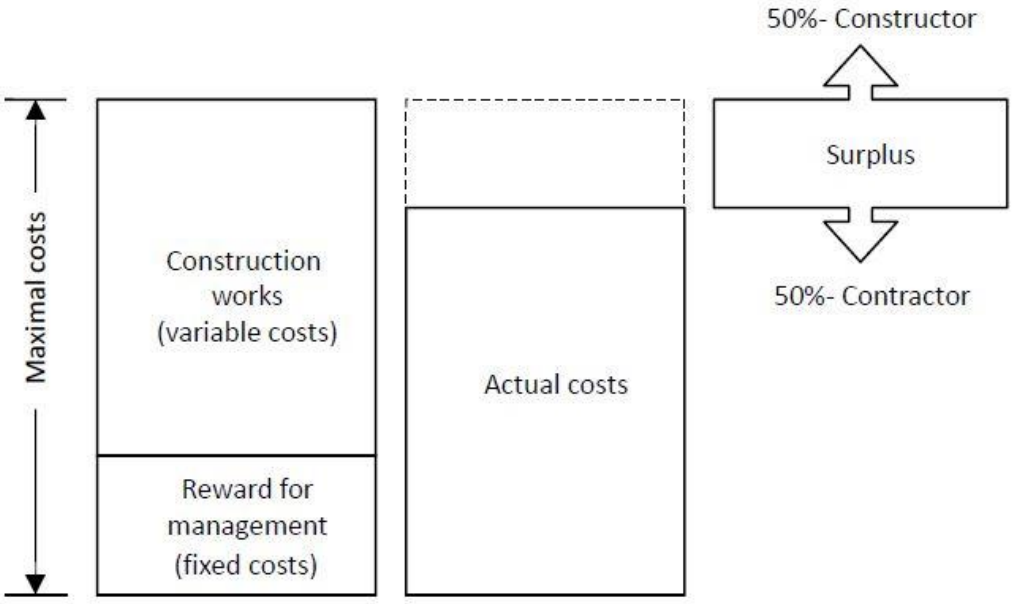

Figure 2: Guaranteed Maximum Price (GMP) model Source: (Riediger, 2019)

It is essential to set the terms of agreement before starting the work as under the circumstances of being under budget, the owner can either reap the benefits or share

with the contractor. This arrangement works as an encouragement to the contractor to finish the project on time and within budget. (Riediger, 2019)

2.2.3 Target Cost Contracts

Target cost contracts can also be termed cost-reimbursement contracts. Besides the reimbursement of the actual cost-plus percentage fees, the profit is also shared with the contractor should there be any saving between actual and target cost. The contractor fees are lowered in case if the actual cost exceeds the target. The target amount should be reasonable. Also, the incentive amount should be sufficient to work as a motivation factor for the contractor. The target cost can be modified in case of significant changes during the work. Although, the specified risks are not considered in the target cost. In such a case, the target cost is adjusted. (Elbeltagi, 2009)

It is critical to establish a target price at a reasonable level that is both feasible and realistic. The incentive mechanism is unlikely to work as planned if the target is too high or too low. The typical way to ensure that the target is set is to involve the contractor in the early stages of the project (Klee, 2018). Figure 3 highlights the level of risks associated with construction contracts.

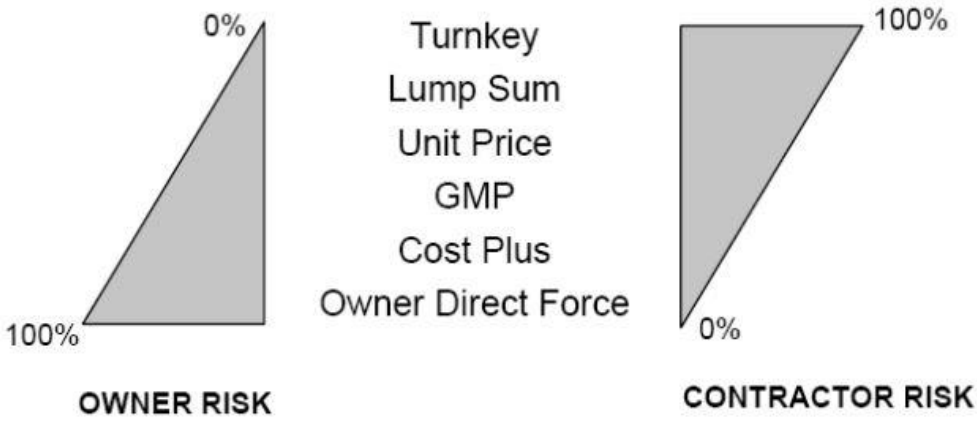

Figure 3: Level of risks associated with various contracts Source: (Elbeltagi, 2009)

2.3 Time and Materials (T&M) Contract

Time and Materials (T&M) contracts are a type of contract that combines elements of both cost reimbursement and fixed-price type contracts. There is an open-ended arrangement in this type of contract since the total expected cost is not predefined. As a result, T&M contracts might increase contract costs like cost-reimbursement contracts. In such a case where when the owner and the contractor predetermine the unit prices, this contract resembles fixed-type arrangements. (Elbeltagi, 2009)

Unlike lump-sum contracts, time and materials contracts are suitable for projects where the scope of work is undefined. The positive factor of this contract is its flexibility, as it allows simple negotiations. In comparison, one of the disadvantages of T&M contracts is that it takes time to keep track of time and materials. Keeping track of each material cost on a project is a time-consuming task. Failure to provide an exact estimation means less profit than expected. While performing this job, the participants may spend more time crunching numbers and less time doing the work. Other than that, there is no reward for efficiency since time and materials contracts are paid hourly or daily basis. Also, there is no incentive to complete a project on time. (Finity, 2020)

Nevertheless, it is common practice to include a bonus for completing tasks ahead of schedule. With T&M contracts, the owner takes a significant amount of risk. He is obliged to pay the contractor for any unforeseen costs, changes, or time overruns during the project's lifecycle, costing the owner more than anticipated. (Finity, 2020)

2.4 Common Delivery Methods

2.4.1 Design-Bid-Build Contracts (DBB)

Design-bid-build (DBB) contracts are also known as a traditional type of contract. Since the designer/architect and general contractor work directly for the owner under separate agreements, this method allows the owner to influence the project significantly. The contract documents, such as drawings and specifications, are developed by the design team, which generally works with the owner. As soon as the design is ready, general contractors submit their bids for the project. After the owner and the design

team evaluate all the proposals, the owner awards the contract to one general contractor he wants to choose. (Killough, 2018)

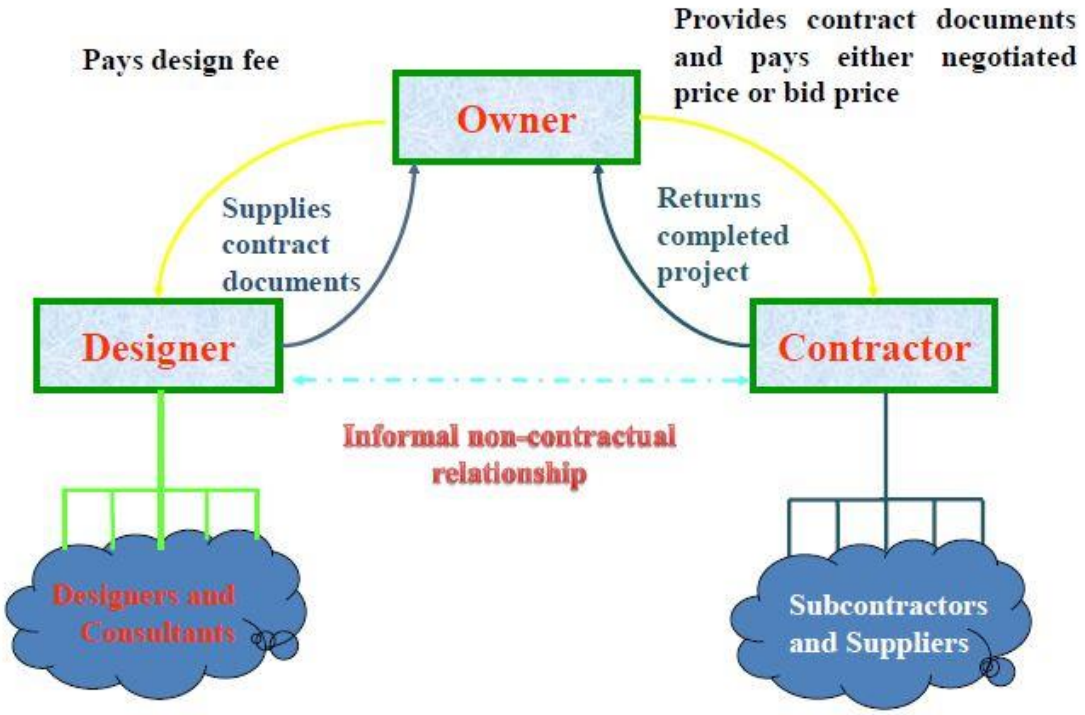

Figure 4: Traditional approach of contracting Source: (Darwish, 2017)

Figure 4 shows the involvement of participants in a traditional type of contract. Although this approach is well known, user-friendly, and familiar to the participants, it has a few disadvantages. The owner may have to pay too much money during the design phase before acquiring a precise estimation of the actual construction cost. The building process does not begin until the designs are ready, which adds more time to the project's schedule. Also, the owner cannot take advantage of the contractor's knowledge since he is not involved in the design phase. (Killough, 2018)

2.4.2 Design-Build Contracts (DB)

Design-Build (DB) is the type of contract where the contractor oversees both the design and the construction of the works. As a result, when compared to a pure construction contract, the contractor takes more risk. Therefore, a reasonable price is agreed upon; typically, a fixed lump sum amount is required for both design and construction (Bowmans). Figure 5 shows the framework of the design-build approach.

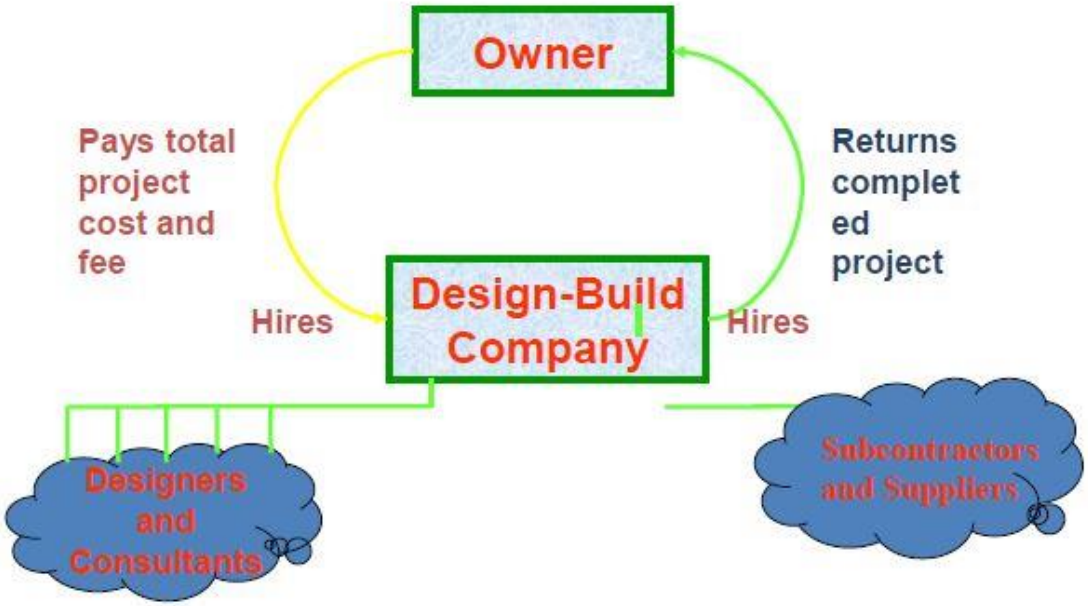

Figure 5: Design-Build approach of contracting Source: (Darwish, 2017)

In a design-build contract, the owner must engage with a single party early in the pre-construction stage. That party bears the responsibility of project phases from conceptual design to completion. These contracts are also referred to as turnkey contracts or design-manage. Although with a bit of variation of the concept. The communication in this arrangement is very smooth since the owner must coordinate with a single company only. Thus, this arrangement is beneficial to the owner because he gains the advantage of time. However, it is difficult to know the project cost before the construction begins, so the owner does not get any idea of his potential investment at the earlier stages. Also, his lack of involvement means he has less control over the project. Lastly, this contract does not give the best possible price. (Darwish, 2017)

2.4.3 Construction Manager at Risk Contracts (CMAR)

In this type of contract, the owner hires a design firm and a construction project management firm. Figure 6 depicts the role of both firms in the arrangement. In order to complete the project within a specified schedule and a price, either lump sum or guaranteed maximum price, the construction manager at risk is required to give his commitment. The construction project manager has typically two roles; (1) to advise the owner on the cost of the construction during the early stages and (2) to work as a

general contractor during the construction phase. Although the owner has separate contracts with the designer and the construction management firm, the construction manager is also involved with the architect during the project's design phase. (Zuber, Bahaudin, & Nawi, 2018)

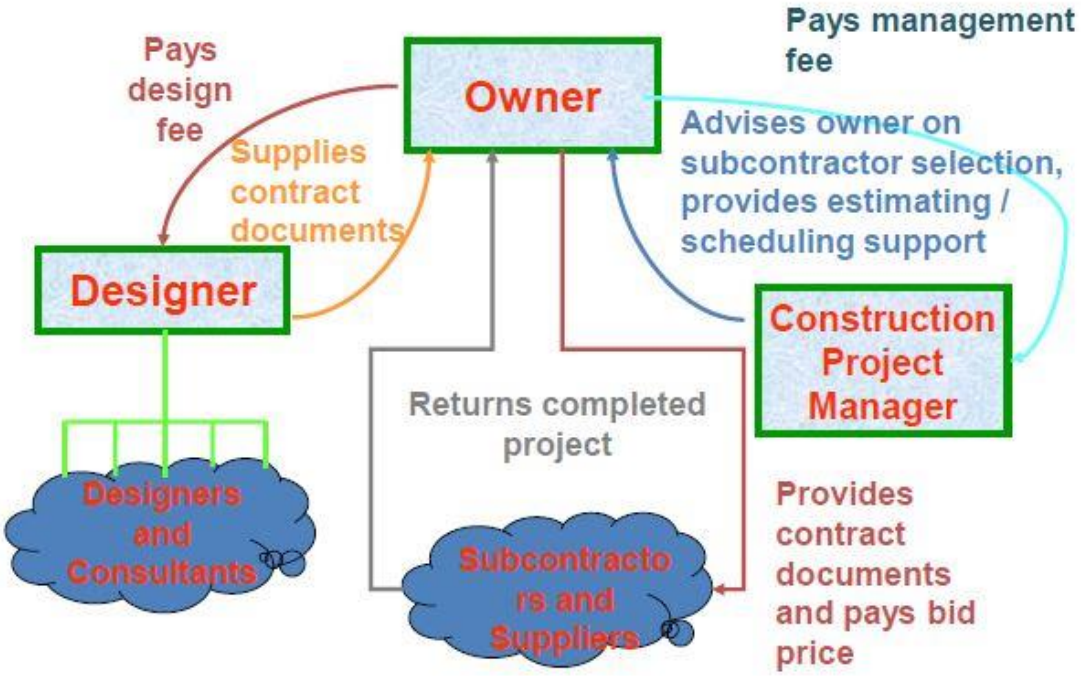

Figure 6: Construction project management approach of contracting Source: (Darwish, 2017)

The owner would benefit from the contractor's viewpoint and input in preparing the accurate estimation of the construction cost, scheduling, evaluating the design, procuring, and negotiating tenders, and managing several project tasks. Since there is no direct contractual link between the designer and the contractor, the owner would be responsible for resolving project concerns. These responsibilities include the quality of the construction, design accuracy, and impact on time and budget. (Zuber, Bahaudin, & Nawi, 2018)

Moreover, this delivery method favours the owner immensely if he is willing and actively involved in the process. He hires a capable designer and construction project manager who are willing to operate as a team. Other than that, this approach also provides the financial benefits of competitive bidding to the owner. Real estate developers commonly use CMAR contracts in the commercial sector. (Darwish, 2017)

2.4.4 Construction Management Multi-Prime Contracts (CMMP)

The construction management multi-prime projects are also termed multi-prime (MP) contracts. In this type of contract, the owner operates as a general contractor and signs a contract with each member of the design team and main trade contractors for various services such as general construction, earthwork, structural, mechanical, and electrical. The owner is responsible for the overall schedule and budget. (Killough, 2018)

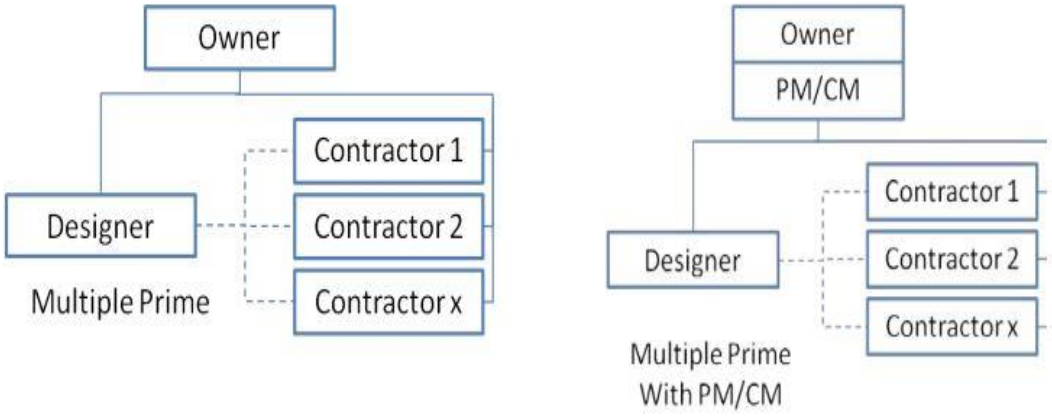

Figure 7: Multi-Prime contracts Source: (The Construction Management Association of America, 2012)

Figure 7 shows the different models of the multi-prime approach. The contract awarding process in this approach is flexible since each construction discipline is bid separately. When performance time is crucial, the fast-track approach of this bidding process can be a positive attribute. Additionally, this delivery method enables the owner to have more control over the project's schedule because he determines the timeline for bidding individual activities of the project. For instance, if the early phase of construction work is delayed, the owner can reduce the culpability for the delays by deferring the next work bidding. Another advantage of this arrangement is that it allows the owner to save money by purchasing essential material items (structural steel or mechanical equipment) directly from the manufacturers without the contractor's cut. The downside to this method is that there might be potential for numerous claims between different contractors. Also, for the owner, it is not easy to coordinate between various contractors. (The Construction Management Association of America, 2012)

2.5 Relational Contracts

2.5.1 Public-Private Partnerships (PPP or P3)

A public-private partnership, also referred to as PPP or P3 model, is an arrangement where a public entity engages a private partner, hires, manages, and pays the contractor. The private partner is involved in the project's design, financing, operation, maintenance, and execution phases. The precise role of the private partner varies significantly from project to project. Everyone's role should be clearly defined in the contract. Water and sewer systems, toll bridges, parking facilities, roads and highways, and prisons are examples of P3 model contracts. (Smith & Howard, 2017)

Each participant in the partnership has a right to bargain rather than relying on other sources of authority. In some cases, the public entity must establish a particular agency that is capable of forming a partnership before collaboration between the participants is formed. This approach also provides a long-term and stable relationship between the participants. Each participant in the PPP model brings something to the arrangement. So, to make this arrangement a genuine relationship, each participant must contribute some resources from materials to money. All these participants have the shared responsibilities for the project outcome. However, in some cases, the public entity retains full responsibility. Nevertheless, shared responsibility and mutual benefits are cornerstones of a PPP contract. (Akintoye, Beck, & Kumaraswamy, 2016)

Figure 8 reflects the PPP model.

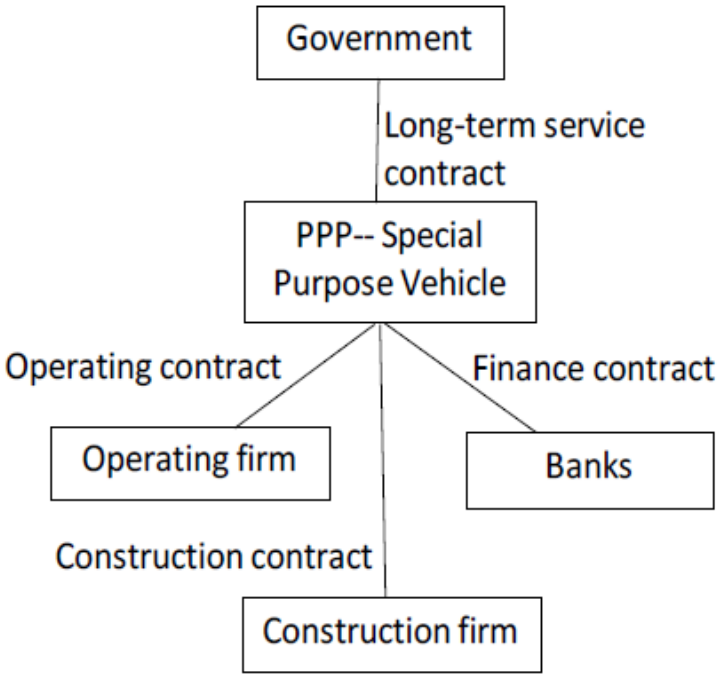

Figure 8: Public-Private Partnerships Source: (Jin & Rial, 2017)

2.5.2 Integrated Project Delivery (IPD)

Integrated Project Delivery (IPD) delivers construction projects under a single contract for design and construction. Under this contract, the project participants share the risk/reward model, develop a collaborative culture, and establish an operating system based on Lean philosophy. IPD contract is also a type of multi-party agreement. It includes the owner, the design firm, and the contractor (see Figure 9). In some cases, the vendors or the trade partners are also included. Usually, the subcontractors are covered by the contractor's part of the agreement. IPD distributes the project's risks and rewards among the participants based on the outcome of the project. Generally, this type of contract includes design and construction costs and contingency. The project participants agree to receive lump sum profit for their costs if they meet the financial targets. (Ellis, 2021) In IPD contracts, the participants can receive incentives, which are based on performance and predefined indicators. The IPD team is motivated to enhance their performance since the members have their stake in the project. (Cicero & Gallo, 2019)

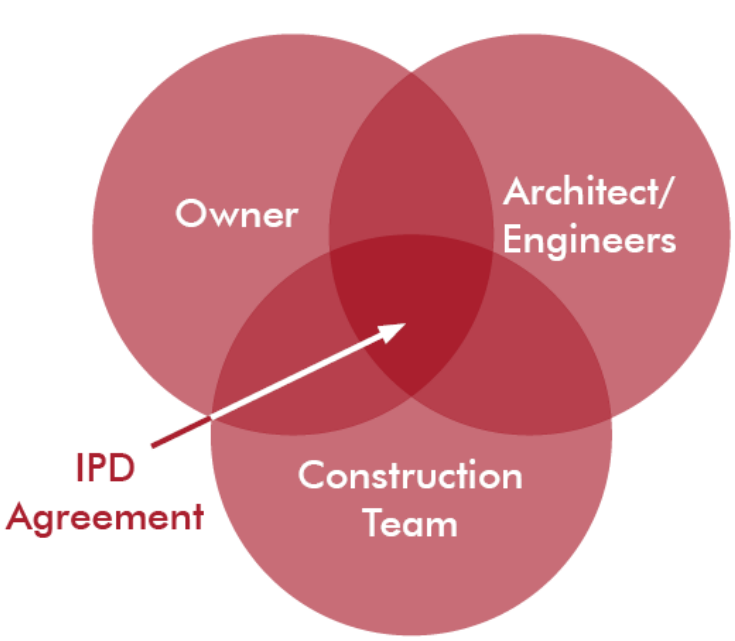

Figure 9: IPD agreement Source: (Cicero & Gallo, 2019)

IPD contracts provide certain benefits over traditional contracts as they are popular among teams that value innovation and collaboration. They foster a sense of ownership and teamwork because all parties must collaborate to achieve the desired results. Also, they transfer the risk and reward more evenly among parties and nurture greater transparency for the project outcomes. However, in order to achieve these outcomes, IPD contracts demand that each participant remain committed to this approach. Since this model is relatively new to the construction sector, some contractors and design companies may not want to participate as they have difficulty obtaining financing for these projects. (Ellis, 2021)

2.5.3 Project Alliancing (PA)

Alliance Contracting falls under the category of multi-party contracts. Alliancing is similar to IPD contracts in many ways. Alliance partners are committed to working on a notion of collaboration. However, this commitment is joint rather than shared. Unlike typical contracts, an alliance provides the feature of selecting the participants based on performance and qualification. Thus, the owner has more control over crucial aspects like financing, scheduling, building functionality, and sustainability. (Raisbeck, Millie, & Maher, 2010)

As per Lahdenperä (2012), IPD has primarily been used to construct a social structure or vertical buildings. There is a large room for uncertainty to complex systems, adaptability, functionality, and the owner's needs. On the other hand, alliancing is mainly used in infrastructure projects where underlying risks are different. These risks include stakeholder concerns, construction time traffic arrangement, and site conditions. The concept of the alliance is emerging and gaining more popularity as a viable project delivery method. In the following chapter, the theory and the evolution of Project Alliancing are discussed thoroughly.

3. Theoretical Background of Project Alliancing

This chapter reviews the literature from related studies to discuss the framework of alliancing. The chapter includes ten sections. The first section discusses the origin of alliancing. The second section (3.2) introduces the alliancing concept into the construction. Section 3.3 identifies the core principles of alliancing, The next section (3.4) explains the framework to use alliancing in construction projects. Further, section 3.5 examines the critical features of alliancing. Section 3.6 gives an overview of the alliancing value for money debate. The following section (3.7) analyses the factors of alliancing to work well. Section 3.8 identifies the suitability of alliance implementation. Section 3.9 discusses the barriers and obstacles of alliance implementation. Lastly, section 3.10 provides a list of countries where alliancing is gaining popularity.

3.1 Origin of Alliancing

The construction industries are becoming more competitive, yet it demands high quality with less time and cost. With the traditional approach, it can be challenging to overcome these demands as construction projects are complex and dynamic.

During the early 1990s, the concept of the alliance was introduced by the offshore oil and gas industry, British Petroleum (BP), in the UK. The industry wanted to increase the North Sea's oil reserves. However, it was not approachable due to the high cost of creating the infrastructure. As a result, to make a profit, it was required to lower the high development expenditures. Considering this matter and rising competition in the oil sector, BP chose to adopt a new business strategy and chose Andrew Oil Field as a pilot project to test the new framework of "Pain-share/Gain-share" based on team building strengthening relationships and trust. Eventually, this approach was termed "Project Alliancing". This strategy aimed to transfer the risk across all participants by determining whether there were any under- or over-runs. Aside from that, the members had to be carefully chosen. Therefore, the contractors were chosen based on their abilities and commitment to the project (Frame, Picarel-Pechdimaldjian, & Bartz, 2019). For the Andrew Field project, this alliancing approach was turned out to be successful as the development cost was reduced by 20-30%, and the project was finished six months earlier than scheduled. British Petroleum's experience indicated

that it could be beneficial for all the participants to form an alliance relationship. (Chew, 2004)

Alliances are widely used in Australia; however, the Australian construction industry had initiated several creative alternatives to the traditional approach earlier. However, none of them was a successful insignificant and non-conflictual relationship between participants. In the mid-1990s, following the experience from the UK, project alliances in Australia were formulated in major projects stated as below: (Abrahams & Cullen)

- The Wandoo Oil alliance for Ampolex
- The East Spar Gas Field alliance for Western Mining Corporation
- The Port Hedland iron ore alliance for BHP
- The Roxby Downs metal ore alliance for Western Mining Corporation

In 1994, Australia initiated the first project, The Wandoo Oil, with an alliancing approach to minimize the development cost and share risks between participants. The selection of these participants was based on non-legal aspects such as openness, good faith and trust. In addition to that, the participants were required to bring out Value for Money (VfM) for the project by working in innovative ways so that the cost and completion time can be reduced with better quality. The alliancing model became advanced from 1995 to 1998 as new principles were implemented such as the motive of "best for the project", no blame culture and forming own accountabilities of participants. As the construction sector developed, the model also evolved as a standard approach to delivering projects. (Department of Treasury and Finance, Victoria, Australia, 2009)

3.2 Introduction to Project Alliancing

Alliancing is the term used to describe the relationships between the project participants. Alliance also refers to various events and partnerships. The general context of alliancing in the commercial market is illustrated in Figure 10. This research focuses on the concept of alliancing. The project owner agrees with other service providers such as designers, contractors, and vendors to deliver a project on agreed terms. In this section, the owner is termed as owner participant, and the service providers are termed, non-owner participants.

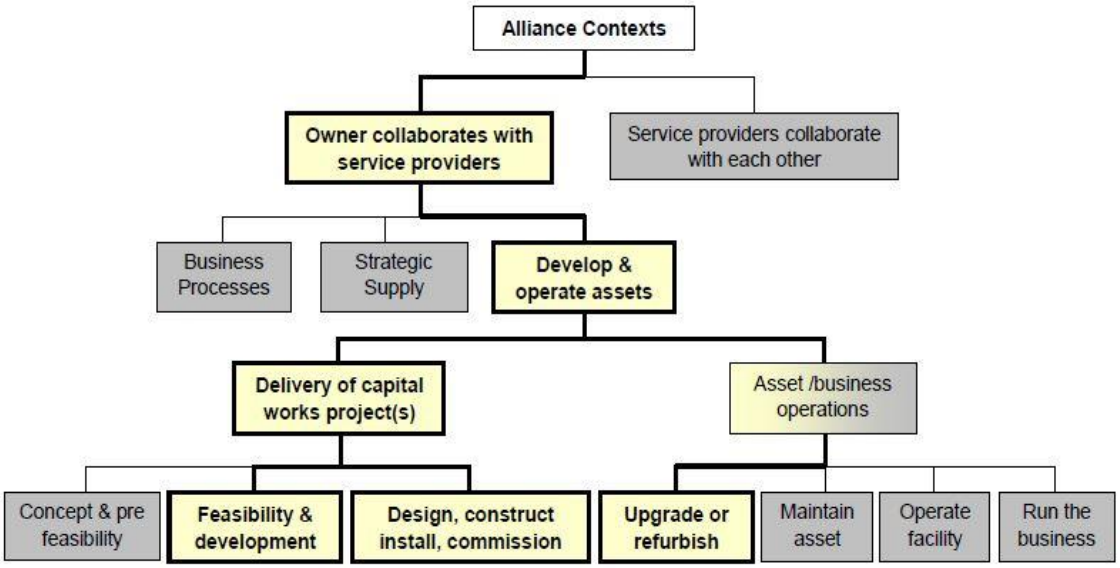

Figure 10: The context of alliancing Source: (Ross, 2009)

An alliance is an agreement between project participants to work collaboratively as an integrated team to achieve a common goal. This concept is intended to foster trust, openness, and a collaborative and creative mindset. Commercial interests are linked such that each member shares in the decision-making success or failure. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

The alliance can be basic or pure. As cooperative management between the client and the contractor is performed in both alliances. Basic alliancing is generally for contracts that are tailored for specific requirements. There is a possibility of limited claims between parties. On the other hand, pure alliancing is a multi-party agreement among essential players, including the owner, contractor, architect, engineer, and potential subcontractors. There are no disputes permissible between the partners unless there is a contract violation or deliberate negligence. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

The alliance model eliminates organizational barriers, exploits the relationship between participants and enhances the relationship with the owner. The alliance contracts of project delivery are based on collaborative management of risks and opportunities. The project outcomes are shared between participants, which is the main difference between alliance contracting and the traditional approach of contracting. Whereas, in

traditional contracts, the participants bear the risk of outcomes. The conventional approach is suitable when the outcome with few unknowns is predictable. (Department of Infrastructure, Regional Development and Communications Australia, 2015)

Table 1 shows the difference between alliance contracts and traditional contracts. The table reveals how the project participants operate throughout the project in different construction phases. The most notable difference between the alliancing and traditional contracts is that the collaborative environment. In traditional agreements, the participants do not have any incentive-based system to improve productivity, whereas the alliance facilitates it. On the other hand, the bidding is non-existent in the alliance. Traditional contracts provide competitive bidding with a risk of legal conflicts since the participants share the risks. In contrast, the participants solve all the risks together in alliancing.

Project Phase	**Traditional Contracts**	**Alliance Contracts**
Pre Design	• The owner and Design consultants • No collaboration • Early cost estimation	• Alliance formation between the owner, contractor and principal consultants • Cost estimation and performance targets defined • No collocation
Design Development	• Cost estimation	• Use of BIM at the discretion of stakeholder
Construction Documentation	• Cost estimation • No integration with subcontractors	• Use of BIM at the discretion of stakeholder
Bidding/Tendering	• Tendering or Bidding • Bidding costs incurred by contractors	• No tendering or bidding process • GMP developed in the SD stage
Construction	• Contract governance • Disputes resolved through adversarial negotiation	• Alliance team governance • Disputes resolved within the leadership team
Post Construction	• Adversarial negotiations • Litigation a possibility	• Profit shared based on a predefined formula • No recourse to litigation

Table 1: Comparison of traditional and alliance contracts through different project phases
Source: (Raisbeck, Millie, & Maher, 2010)

3.3 Project Alliancing Core Principles

Project alliancing requires the owner and non-owner participants to share responsibility for risks to achieve specific project objectives. This model provides a contractual framework in which all participants win or lose based on their performance against bespoke objectives. As a result, the model motivates the participants to work "best for a project". Project alliance is reliable on the commitment of participants, which is based on the following basic principles: (Ross, 2006)

- Owner and non-owner participants face the win-win or lose-lose situation based on the outcome of a project
- Collective responsibilities as an integrated team rather than transferring it to individuals
- No-blame culture
- All participants share the risks and rewards equally
- In the case of decision making, all participants have an equal right to voting
- Important decisions are made based on what is best for a project rather than individual positions
- Joint management
- Open-book transactions
- Communication is clear, open, and honest as all participants share the same goals
- The participants are motivated to work with innovative ways for better performance

Based on these principles, the following are the core principles of project alliance for successful delivery: (The State of Queensland, 2015)

Risk and Opportunity Sharing

Unlike traditional contracts where only one participant becomes successful, alliancing provides a concept of risk-sharing, which encourages the collaboration between the participants in profit or loss from the project. The commercial interests of all the participants are aligned. Thus, this model will carry the burden of a weak participant.

Commitment to 'No Disputes'

In most alliance agreements, there is a 'no disputes' clause. The participants are obligated not to sue each other unless there are exceptional conditions. The primary idea behind this clause is to mitigate legal conflicts.

Best-For-Project Decision-Making Processes

In an alliance agreement, the members are required to make choices that are 'best-for-project'. This principle encourages the participants to put their decisions for shared vision ahead of their self-interests. These choices are made in a way that demonstrates the participants' commitment.

'No-Fault – No Blame' Culture

Under an alliance agreement, if a problem, a mistake, or a lack of performance, the participants commit that they will not blame other participants. However, instead, they will accept a joint responsibility and consequences. The participants must agree and work together to find a solution. As a result, the alliance models eliminate legal disputes between participants.

Operate According to Good Faith and Integrity

Each of the principles of alliancing is anchored by the commitment to behave in good faith and integrity. The behaviour and shared cultural norms that the participants aspire to achieve to complete the project are referred to as "good faith." There are several elements of good faith, including commitment of the participants to work together to achieve common goals, compliance to acceptable conduct standards, a responsibility to act honestly, which includes refraining from gaining a commercial advantage at the expense of other participants, and an obligation not to engage in a way that rise conflicts.

Transparency

For an alliance agreement to work effectively, both the owner and non-owner participants must agree to an 'open book' arrangement. It will broader the access to the information. Also, with such transparency, the participants will have the ease to understand the objectives of the project.

A Joint Management Structure

An alliance arrangement is a structure of joint management that includes groups made of the owner and non-owner participants such as Alliance Leadership Team (ALT), Alliance Manager (AM), Alliance Management Team (AMT), and Alliance Project Team (APT). Representatives make all the decisions related to project objectives from each

of these groups. Also, they are responsible for project risks. Each member of the Alliance Leadership Team has a right to vote in the decision-making process.

3.4 Typical Framework of Project Alliancing

In construction projects, project organization plays a vital role to deliver a project. In alliancing approach, the alliance formed between the owner and one or more non-owner participants functions as a "virtual organization". A project alliance's organizational structure or framework can be used for governance, management, and leadership. (Ross, 2006)

3.4.1 Organization Structure

Figure 11 shows the typical framework of alliancing in the Australian construction industry. This framework consists of Owner and Non-owner Participants (NOP) Organizations, Alliance Leadership Team (ALT), Alliance Management Team (AMT) and Wider Project Team (WPT).

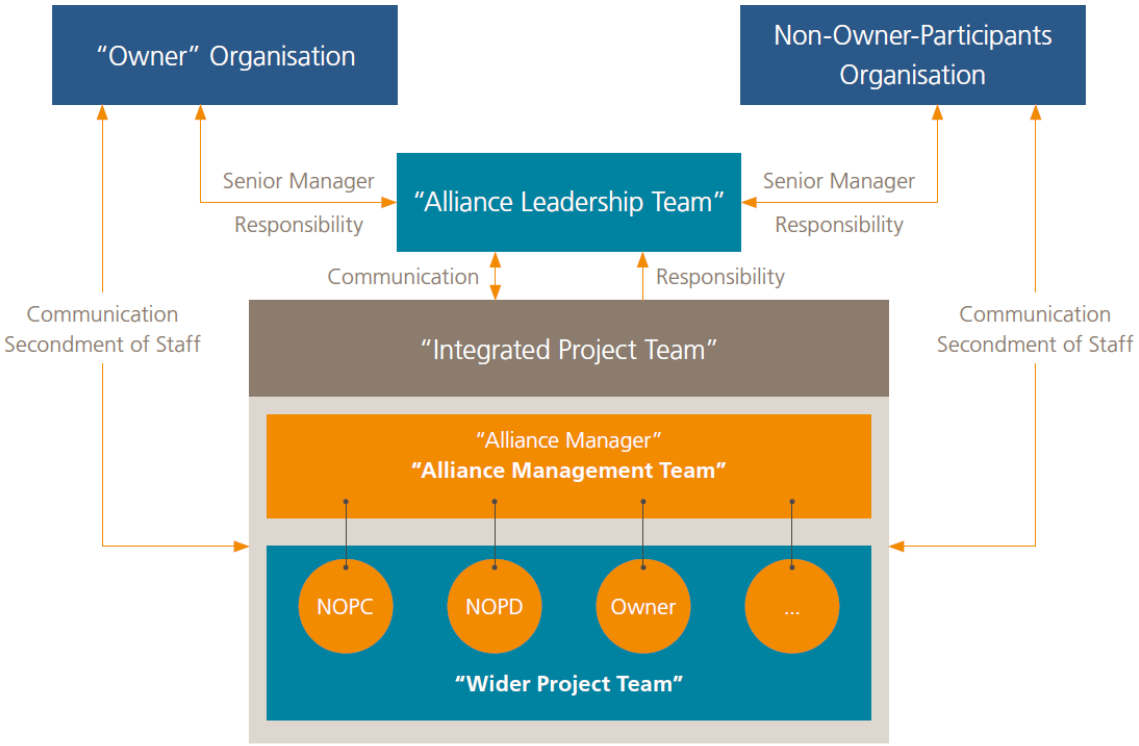

Figure 11: Organizational structure of a project alliancing in Australia. Source: (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

As mentioned earlier, the owner and non-owner participants work collectively on the basis of "best for a project". They provide clear expectations and objectives and are also responsible for procuring the best resources. Both organizations have a say in decision making. However, the owner organization is responsible for capital authorization. Additionally, these organizations fulfil other duties required to deliver a project, such as planning, designing, procurement, execution and monitoring, coordination with participants, managing plants and assets. The alliancing model enhances a relationship between participants to work "as if they own the company". Eventually, it leads to an increase in the productivity and capability of resources. (Ross, 2006)

3.4.2 Alliance Leadership Team

The Alliance Leadership Team (ALT) can also be termed Alliance Leadership Group or Project Alliance Board (PAB). Generally, the Alliance Leadership Team requires senior members from both owner and non-owner participants as one representative may be able to control resources and influence the management processes. In contrast, the other representative may have experience and technical skills to mitigate project challenges. These representatives must be beneficial to the project as it advances. Therefore, the following points are essential while forming the ALT: (Morwood, Scott, & Pitcher, 2008)

- Limiting the size of ALT by 6 to 8 members (may vary) in order to optimize their performance and to ensure that they fulfil respective obligations
- Existing ALT members must have the potential to contribute to the project. In such a case where it is complicated to resolve the challenges, then a new member with suitable skills should be added to the ALT
- The members should be flexible and should adapt according to the nature of the project
- The appointed chairperson for the ALT should have knowledge, strong leadership skills and previous alliance experience.

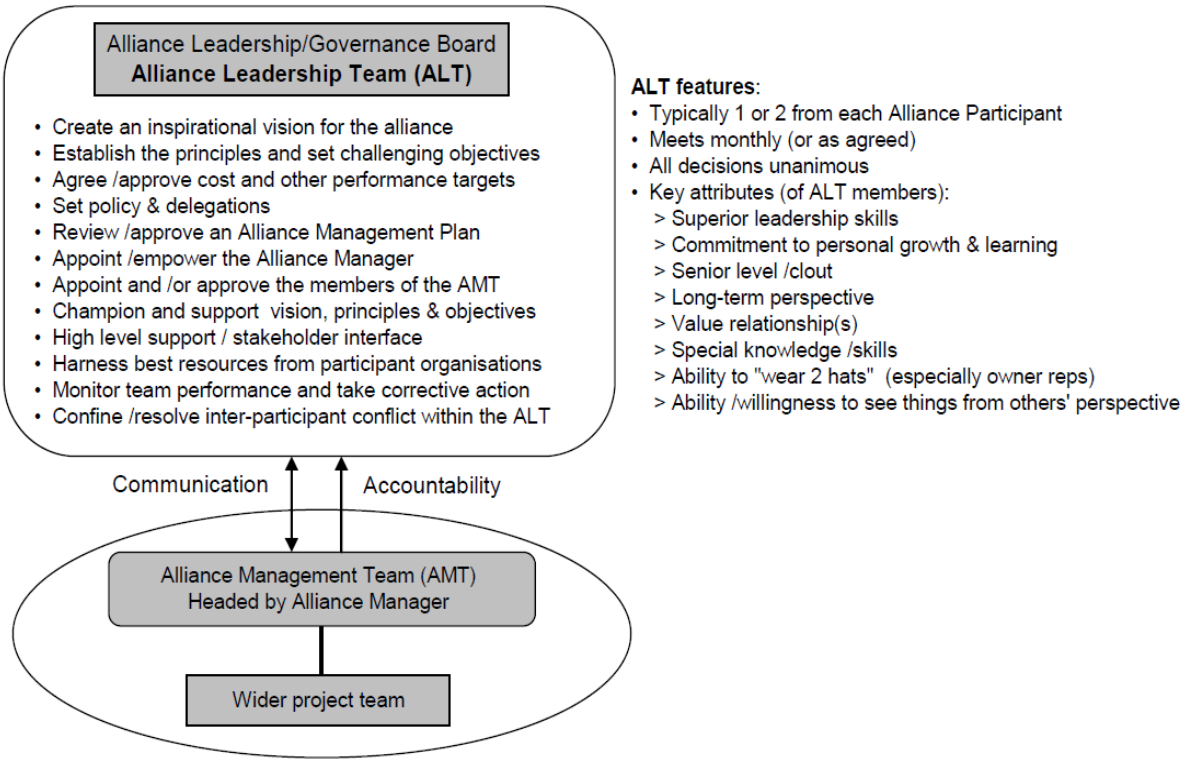

Figure 12: Duties and Characteristics of the Alliance Leadership Team. Source: (Ross, 2006)

Ross (2006) highlights insight into the ALT's duties and characteristics, shown in Figure 12. The decisions taken by the ALT should be unanimous, where each member has equal rights to present their view. The ALT members must be critical of their ideas and the potential to make high-level decisions to enhance their leadership skills. Moreover, the members must have a long-term outlook for their respective organization's goals and respect for the alliance with other participants.

3.4.3 Alliance Participants

The Alliance Manager (AM) or Alliance Project Manager (APM) leads the Alliance Management Team (AMT). The alliance manager has a central role in the alliance as he is accountable for project delivery. The AM should have strong leadership and project management skills as he provides a gateway for AMT to the rest of the alliance. Usually, a non-owner participant (constructor) heads the role of AM. However, the owner participant can also represent this role on the "best for the project" principle. (Morwood, Scott, & Pitcher, 2008)

Alliance Management Team (AMT) is responsible for the day-to-day business of a project. The AMT includes managers from various disciplines such as construction, planning and design, environment, quality control, and safety. The structure of AMT is supported by the Alliance Leadership Team (ALT). However, forming the AMT is challenging as it requires 12 or more members, and it can be challenging to find the right person who can fulfil the role within time. These members have to fulfil the following responsibilities: (Morwood, Scott, & Pitcher, 2008)

- Form and motivate Wider Project Team (WPT)
- Executing the decisions taken by the Alliance Leadership Team (ALT)
- Delivering alliance objectives
- Reporting of the performance to the ALT
- Addressing and solving problems promptly
- Risks mitigation

Wider Project Team (WPT) consists of planners, engineers, site managers, buyers, admin officers, specialists for safety and the environment. The combination of AMT and WPT is also called Integrated Project Team (IPT). Members from both teams seamlessly work together. The primary aim of WPT is to align the interests of all the participants. (Schlabach, 2013)

Morwood, Scott, and Pitcher (2008) identify the characteristics of the WPT as following:

- The members must be experienced and skilled in order to execute their duties efficiently.
- The members must be familiar with the alliancing approach and the goals and vision of the project.
- The members must be ready to take total responsibility for the quality of their work.
- The members must cooperate and respect other participants.

3.4.4 Project Alliance Typical Phases

Figure 13 shows the summary of typical phases for forming of project alliancing structure. According to Scott (2000), the owner needs to analyze the circumstances and requirements and alternative strategies for the project before choosing an alliance approach. Additionally, the owner must make sure that all the stakeholders are aligned

and committed. In the selection phase, the parties are chosen by a tender process that involves documentation such as preliminary plan, alliance contract and compensation model. The owner chooses them according to predefined criteria followed by their interviews. During the development phase, the focus is given to various tasks. These tasks include team building, developing innovative processes and relationship principles, developing Target Outturn Cost (TOC), and setting Key Performance Indicators (KPIs) for the execution stage. Also, the interim alliance agreement is formed between participants.

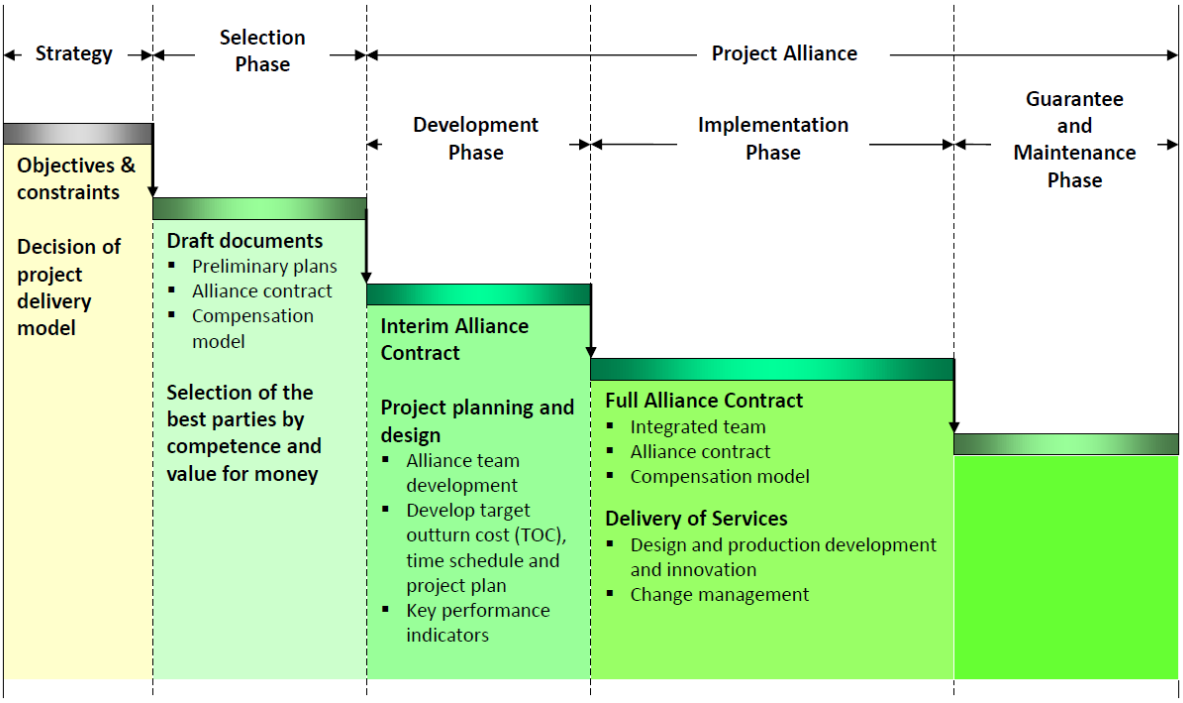

Figure 13: Typical phases of project alliance Source: (Saarinen, 2014) (Ross, 2006)

In the implementation phase, the alliance contract is finalized, forming an integrated team and compensation model. The owner works with the participants as an integrated team in order to achieve all the objectives. The compensation model indicates that the participant will share the risk according to the success or failure of the project. Lastly, at the maintenance phase, the owner and participants are responsible if there are any defects. This phase can also be termed the Defects Correction Period (DCP). The alliance remains until the end of this phase. (Ross, 2006)

3.5 Key Features of Project Alliancing

3.5.1 Risk Allocation

As per Frame, Picarel-Pechdimaldjian, Bartz (2019), the alliance can be termed a culture of "Risk Embrace". The participants embrace risks and try to manage them in a collective manner rather than transferring them.

Figure 14: Risk allocation approach in traditional and alliance contracts Source: (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

Figure 14 shows the difference in risk allocation between traditional and alliance approaches. With the traditional type of contracts, each participant holds his obligation, which he needs to fulfil. The risk is transferred to the appropriate party. In case of failure or poor performance, there will be financial and legal consequences which the responsible party has to bear. Whereas, in the alliance form, the risks are shared between all owner and non-owner participants as they hold the obligations collectively. The participants presume to have collective ownership or risks and responsibilities once the project's objectives are achieved. They share the outcome of the project based on 'Pain' and 'Gain', meaning they equally bear the loss in case of failure and equally share the profit in case of success. (Ross, 2006)

3.5.2 Project Alliance Compensation Framework

The compensation model is a cornerstone of the project alliance. The model is developed by the alliance participants based on the 'open book' culture. This compensation model is comprised of three stages as below: (Sakal, 2005)

- Limb-1: Direct costs of project and overhead
- Limb-2: Corporate overhead and profit (margin/fee)
- Limb-3: Risk/Reward arrangements (pain share/gain share) based on the outcome of the project

3.5.2.1 Limb-1 Reimbursement of Project Costs

Limb-1 includes direct costs and overheads related to the project and costs related to mistakes and reworks. The non-owner participants (NOPs) are reimbursed for the limb-1 costs by the owner regardless of their performance and the project's outcomes. However, reimbursement does not apply to any costs which are not directly related, such as admin activities expenses. Hence, the classification of direct costs should be deliberately evaluated in the alliance agreement. Nevertheless, it is pivotal that all the NOPs deliver their duties with the maximum effort since their reimbursement for limb-1 costs is certain. The NOPs should not be encouraged to do more work than it is necessary to achieve targets as the direct cost does not include any extra expenses. (Department of Treasury and Finance, 2006)

Figure 15 shows the compensation framework of alliancing.

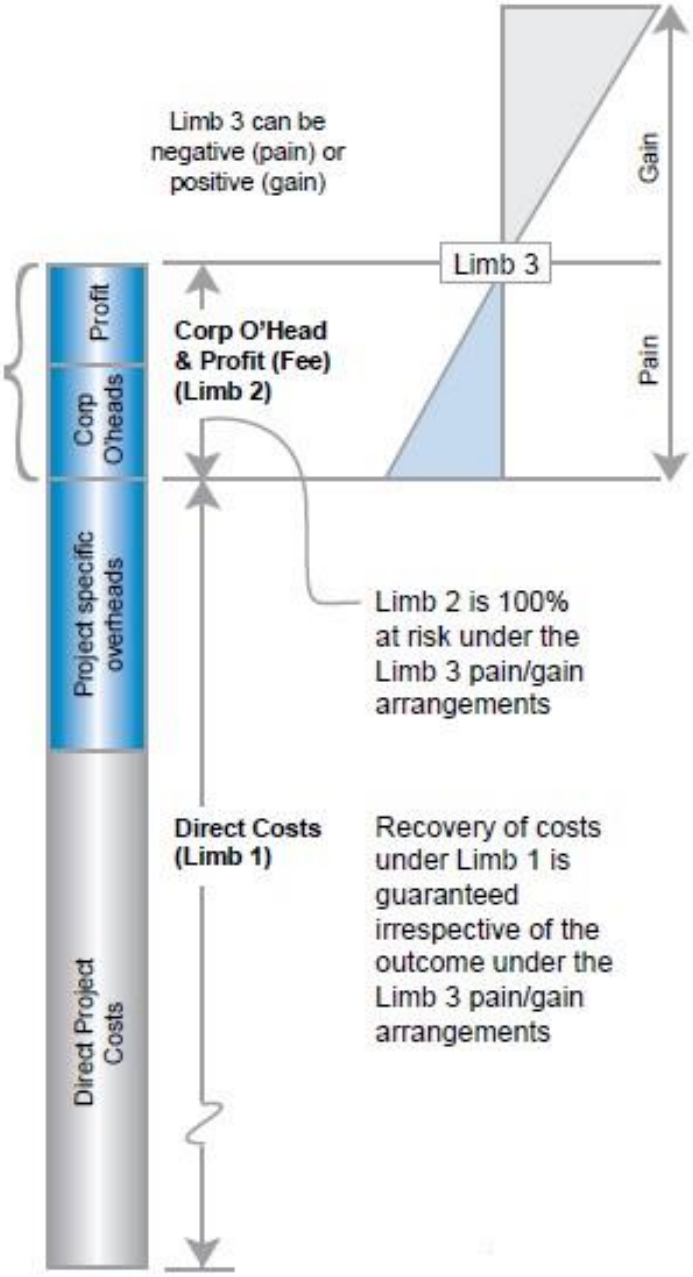

Figure 15: 3-Stage Compensation Model in Project Alliance Source: (Morwood, Scott, & Pitcher, 2008)

3.5.2.2 Limb-2 Fee / Margin

Limb-2 costs consist of margin for corporate overhead and profit (fee). Generally, limb-2 is comprised of two stages. In the first stage, the financial accounts of non-owner participants are checked by the financial auditor. The second stage includes the communication between the owner and the NOPs concerning past performances

considering present and prospective market situations for the alliance project delivery. (Morwood, Scott, & Pitcher, 2008)

Further, according to Morwood, Scott, and Pitcher (2008), limb-2 is generally considered a percentage of limb-1 costs. Limb-2 percentages vary from participant to participant according to their accountabilities of delivering the project. For example, the limb-2 percentage is significantly lower for constructors than designers. Subsequently, the construction and designer can have an agreement where there is an average distribution of limb-2 percentage from the constructor's and the designer's part.

3.5.2.3 Limb-3 – Risk / Reward Arrangements

Limb-3 is also termed as gain share/pain share or risk/reward arrangement. The purpose of this regime is to share the profit or loss with non-owner participants. The owner determines the profit or loss as a result of tremendous or poor project outcomes. By doing so, the commercial interests or the owner and non-owner participants are aligned. (Hayford, Collaborative Contracting, 2018)

Figure 16 shows the gain share – pain share model of alliancing.

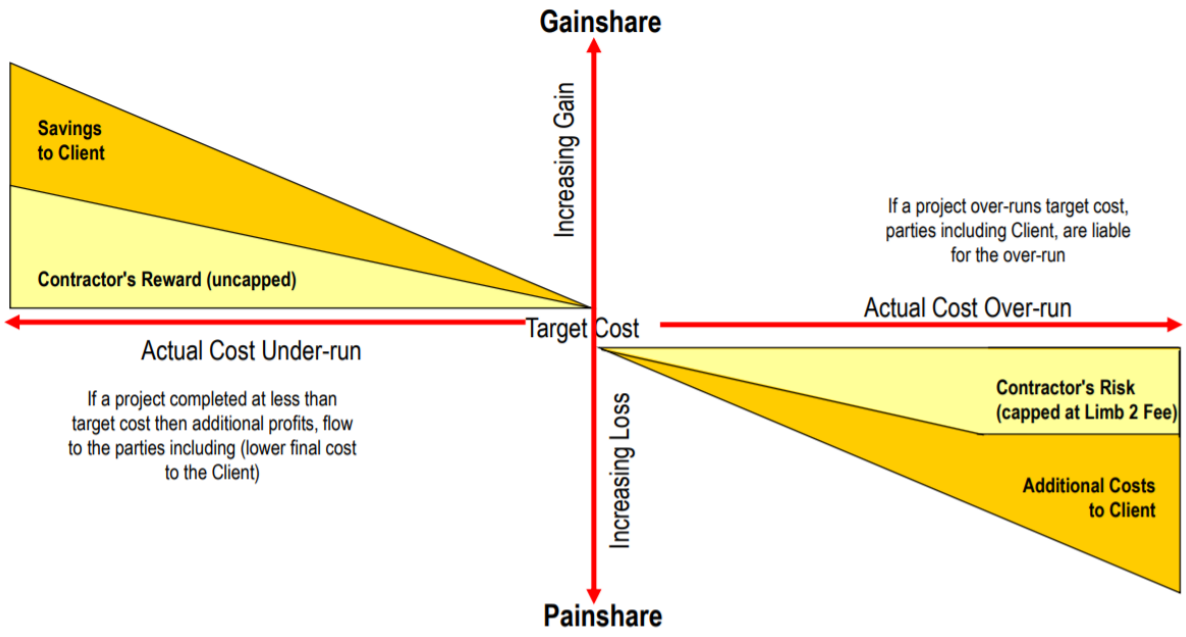

Figure 16: Gain share/Pain share Model Source: (Weatherall, 2013)

According to Morwood, Scott, and Pitcher (2008), it is challenging for project participants to agree on the measure that is used to determine the project performance as it

can result in conflicts between them. This measure should be defined so that any propensity to compromise performance in one area in exchange for rewards in another is discouraged.

Based on the owner's project objectives, the gain share privileges or the pain share liabilities are set for the non-owner participants. Time, cost, and non-time or non-cost performance measures are always included in the owner's objectives. Non-cost or non-time performance measures are also referred to as Key Result Areas (KRAs), such as quality, sustainability, aesthetics, functionality, efficiency, safety metrics, and community satisfaction. (Hayford, Collaborative Contracting, 2018)

Gainshare for the cost target is the most straightforward. NOPs share a percentage (typically 50) of cost overruns or underruns against the Target Outturn Cost (TOC). In case of variations, an adjustment of percentage is included for gain share for successful outcomes in time and performance KRAs. On the other hand, the total amount paid as pain share by each NOP is generally limited to their fee entitlement. As a result, each NOP's profit is at risk but not the direct costs. This risk/reward regime will create a 'win-win' or 'lose-lose' situation for the participants as they align with decision-making incentives. (Hayford, Collaborative Contracting, 2018)

3.6 Alliancing Value for Money Debate

One of the major concerns for the clients while choosing alliancing as a project delivery method is value for money. For instance, the public sector owners may argue on the value generated by alliancing for the money spent as project alliances lack the competition in bidding. It is also a concern that the alliance participants are chosen even before the target cost is set. Even after the target cost is set, the cost outcomes will remain uncertain. However, traditional contracts with competitive bidding do not provide any guarantee on outcome costs. Generally, the project owners choose a contract with the lowest bidding. However, it ends up in legal conflicts as the risks are transferred. The significant benefit of alliancing is that it promotes the participants to work together and share risks. Thus, this type of contract performs better than traditional contracts in complex and dynamic projects dealing with time and cost constraints. (Sakal, 2005)

Alliancing Association of Australasia (Walker, Harley, & Mills, 2008-2013) published a report showing the outcomes of 30 finished alliance projects in Australia. Figure 17 shows the actual versus target outcomes for cost and time based on these projects.

		Under Planned				Over Planned			
Parameter	**No.**	**#**	**%**	**Mean**	**Range**	**#**	**%**	**Mean**	**Range**
TOC	30	25	83.3	8.3%	1-29%	5	16.7	4.4%	3-5%
Duration (months)*	30	11	37	4.7m	½-18m	6	20	2.5m	½-6m

* 43% were deemed to be 'on-time'

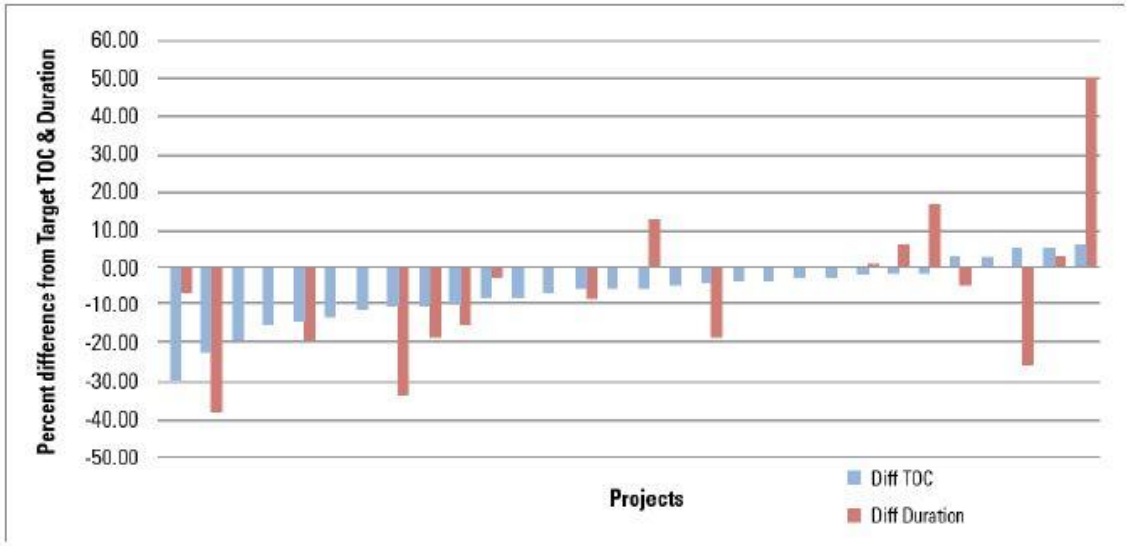

Figure 17: Cost/time performance of alliance projects Source: AAA 2008 Report (Ross, 2009)

The report shows that majority of the projects performed better than expected in terms of time and cost targets. Further, the report reveals that the alliance approach was crucial to achieving this success. It would be difficult for these projects to thrive under the traditional approach. However, as per Ross (2009), in the present situation, the comparison between alliancing and traditional contracts are difficult to conclude as the report consists of old data.

3.7 Success Factors of Alliancing

Even though alliancing provides unique features to deliver a project to achieve targets, it depends on several factors to work well. Following are the factors that the project participants should consider in order to implement alliancing:

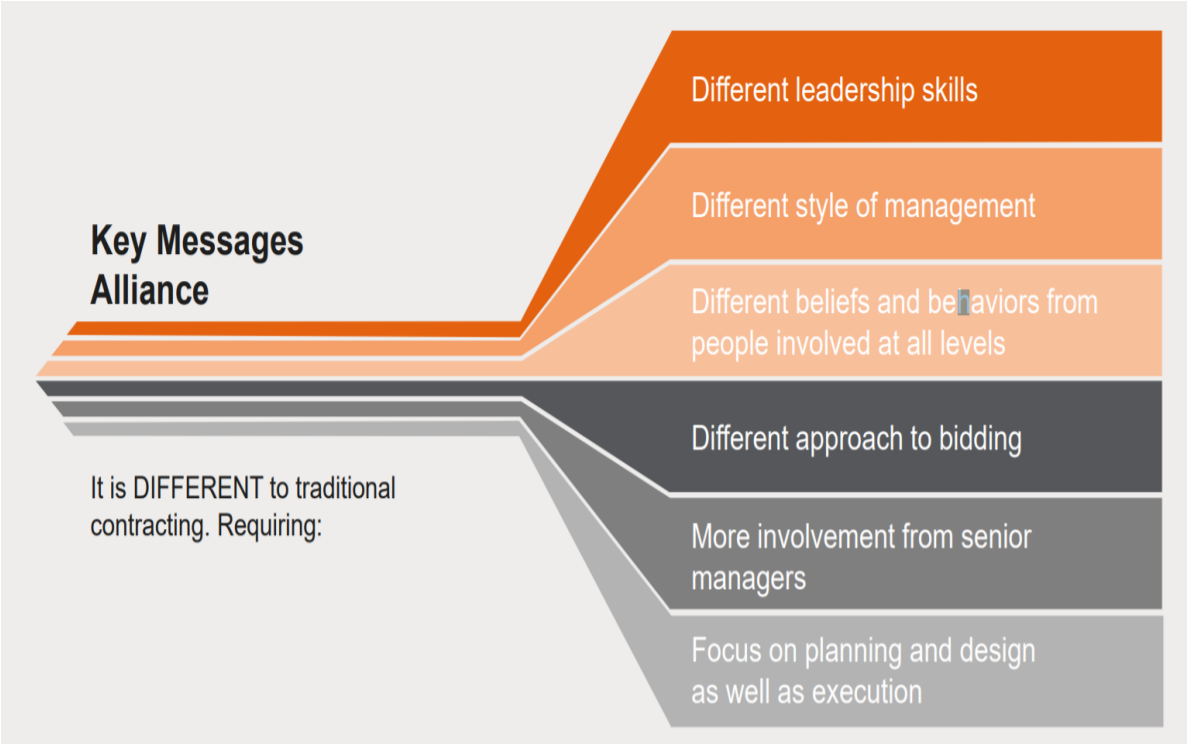

Figure 18: Critical factors of alliancing Source: (Bartz, 2019)

Vision and Committment

An alliance works well when all the participants share their interests to work for a common goal. They need to engage in mutual and creative ways so that the project's objectives can be delivered. The most effective way to accomplish this is by setting a vision in the interest of each participant. The senior members of the management team must be committed to this approach. They play an essential role to motivate the other participants to understand and sell the concept. These participants must understand their goals and obligations. They stay committed to "best for a project". (Scott, 2000)

Open Communication

Open communication improves participants' behaviour and encourages them to face challenges together and solve them from every participant's perspective, which eventually helps prevent disputes. The information shared between participants must be related to the concept of an alliance so that there will be a clear understanding between them. This information should be shared as an open book so that every member has access to information such as financial forecasts, costs, expenses and profits. The flow of this information should be easy and should be updated regularly to ensure maximum accuracy. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

Early Involvements of Key Participants

As per Scott (2000), the early stages of the project's development significantly impact the outcomes. Therefore, the involvement of the key participants of the project in the early stages can be crucial. The final result of the project can be improved with their expertise and knowledge. As Figure 19 shows, the influence of key participants should be more decisive at earlier stages to achieve a higher quality of the project.

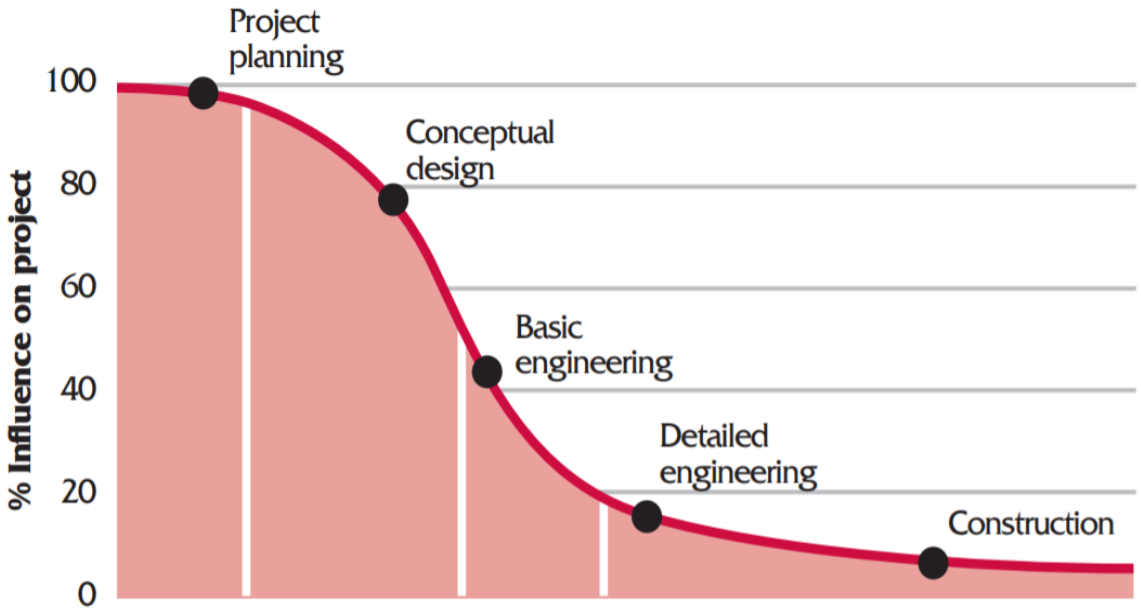

Figure 19: Influence of key participants on the project Source: (Scott, 2000)

Furthermore, Scott (2000) recommends involving alliance participants at early stages, but it depends on the nature of the project. Suppose these participants are familiar with cost estimation and schedules of execution from the beginning. In that case, it will help the owner make decisions regarding the project.

Equatable Relationships

The relationship between participants should be developed based on a "win-win" culture. The culture helps to develop a mutual understanding between them and act to deliver their obligations collaboratively. Apart from this, "no blame - no claim" is key to form an alliance relationship. With such an environment, there is no space for participants for claims in case of delay, errors in designs or work, and this eventually prevents disputes. However, intentional errors, rejection to work and breach of contract are exceptions to this. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

Commercial Alignment

In the traditional approach of contracts, the owner and contractors may share different commercial interests, resulting in poor performance. Because of this, there will be a commercial misalignment. Whereas with alliance approach provides commercial alignment between the owner and non-owner participants as their interests are aligned. The participants work for the project's best interests that improve the quality and decrease the time duration and cost of the project. With the alliance, since the contractors are responsible for risks, they add 'risk value', increasing the overall cost. To tackle this issue, the alliance works on an incentive-based framework of pain share and gain share. Under this, the members share the reward. However, this structure leads to higher initial investment as it requires developing a team by providing training to the participants. (Walsh, 2015)

Lastly, Walsh (2015) argues that the alliance will provide value for money room for further improvement with time, which helps the construction sector progress.

Integrated Team

As mentioned earlier, the key to the success of an alliance is that the owner and other participants should work as a single entity, and their liabilities should be shared together. As an integrated team, the project decisions are taken in the project's best interests and not for the benefit of a single party.

The outcome of an alliance depends on how effective is the organization structure. The organization structure must represent the accountabilities and the positions of the participants. There should be a leader for each functional area such as construction, HVAC, health, and safety. However, the repetitions of duties should be eliminated as such repetitions happen in areas such as cost estimation, planning, procurement and audits. In order to avoid this, the participants should take appropriate measures in a way that organizational demands are also met. Figure 20 indicates the typical integrated team structure along with the positions of the key participants. (Scott, 2000)

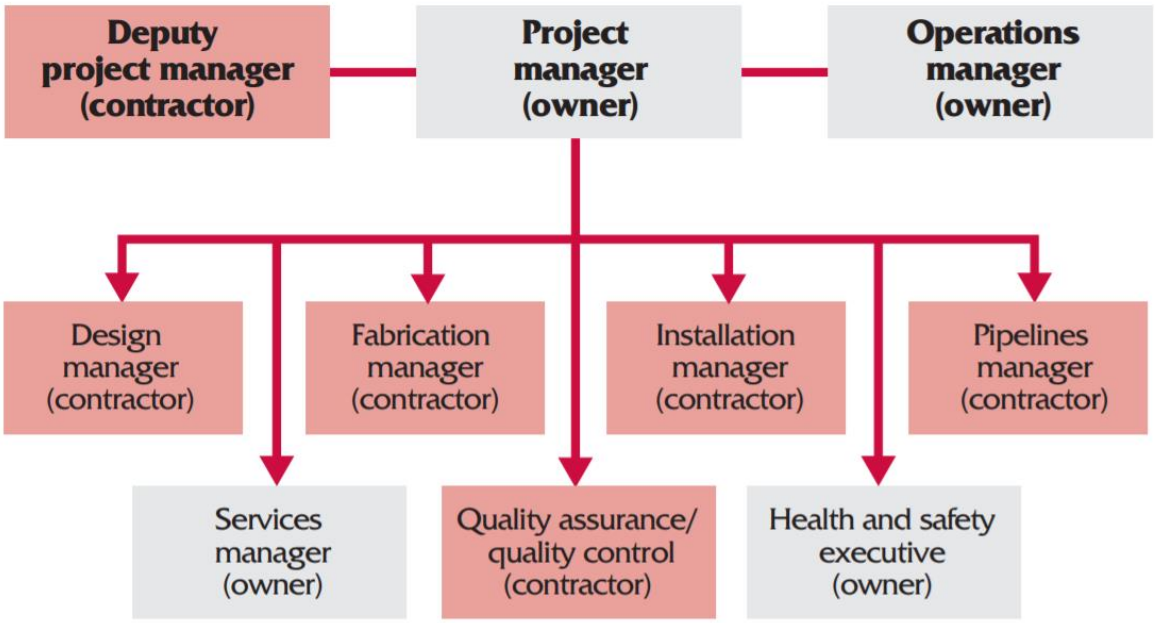

Figure 20: Typical Integrated Project Team Source: (Scott, 2000)

By forming an integrated team, the personnel resources will be decreased significantly and bring immediate benefits to the project. Other than that, the integrated team provides transparency in processes that increases the productivity of the participants.

Trust

The alliance participants must build trust between themselves in order to share their strengths and weaknesses so that any threats to the project can be anticipated prior. Nonetheless, in reality, trust can be developed with time as the participants work together and adopt the concept of alliancing. Even though the trust is not developed at the beginning of the project, the participants must have a "leap of faith" to be committed to working together. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

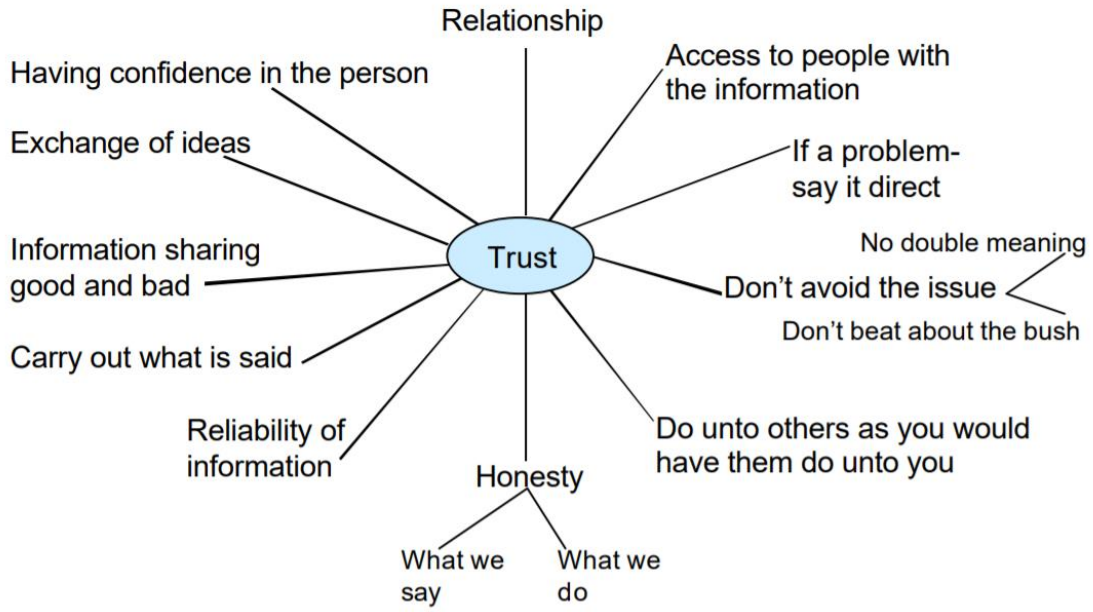

Figure 21: Elements of Trust Source: (Walker, Hampson, & Peters)

Innovation

The introduction of innovative techniques to the different levels of the project, such as engineering or technical, enhances the project's overall performance. Thus, such innovative efforts should be encouraged and promoted throughout different stages of the project. Usually, any automatic adjustments during the execution phase lead to poor performance. Therefore, with a framework where new ideas and methods are taken into considerations and priorities are given to the project's best interests. The outcome will be reversed to positive. (Scott, 2000)

Dispute Resolution

One of the ideas of choosing an alliance approach is to mitigate disputes between participants by identifying and establishing mutual interests. The participants are motivated to analyze and resolve the issues. As mentioned earlier, the interests of participants are aligned in a manner that they share the risks and rewards equally, which helps to maximize the profit. Thus in case of disputes, their mutual interests are taken into consideration and resolve the conflicts with constructive efforts. Although the risk-reward policy is not enough to collaborate between the participants, supporting policies such as open communication or open book must maintain and encourage collaboration. Also, it is decisive to test the performance of the integrated team before signing the alliance contract. (Koolwijk, 2006)

Further, in the research paper, Koolwijk (2006) states that a web-based system can help to enhance the communication between the participants and boost the enthusiasm in the alliance. Another solution to improve the communication could be facilitating a temporary office where all the participants can work together until the end of the project. Besides, the author believes that disputes during a project are more or less inevitable between the participants. These disputes should be dealt with appropriate way to maintain the spirit of alliance between the participants. In the research paper, Koolwijk (2006) gives an insight into the construction sector in the Netherlands, where disputes are resolved through council or arbitration, which acts as a legal entity to solve the conflicts.

Nonetheless, Koolwijk (2006) does not recommend solving disputes with arbitration or other legal ways. It can jeopardize the relationship between the participants and harm the spirit of alliance; ultimately, it will harm the project's outcomes. The author suggests using Alteration Dispute Resolution (ADR) methods to help solve the disputes between participants by respecting each other's views. Eventually, the outcome of the project can be protected.

Flexibility

In a project alliance, the integrated project team provides flexibility. All the participants can analyze any spontaneous change in the delivery. For participants, it can be easy to acknowledge and adopt new changes. This flexible nature of alliance benefits large scale and multi-disciplinary projects where the project's design is too complex, and construction or environmental problems are not foreseeable at the beginning of the project. In this regard, the alliance contracts have the edge over traditional contracts, as any changes in the conventional form lead to a delay. Additionally, this flexible nature also helps negotiations as the relationship between the participants is meant for the long term. Lastly, the "open book" culture of alliancing provides control over time duration and project costs that improves the quality of the outcome. (Portes, 2016)

3.8 Suitability of Alliancing

In a traditional approach, the owners intend to transfer the maximum risk to other participants such as contractors, designers, and insurance agencies. In some cases, confrontational contract behaviour emerges when the owner attempts to transfer risks

to parties who are not in the most excellent position to handle those risks. Therefore, it is widely agreed that the competent party should manage those risks under the contract. It is also necessary to choose a suitable project delivery method based on threshold issues such as project value and resourcing. If these issues are considered, the following are the circumstances where alliance delivery method is suitable: (Department of Infrastructure and Regional Development, Australia, 2015)

Project Risks that can not be dimensioned

Typically, alliancing is suitable in complex projects where significant risks are involved that can not be dimensioned in a feasibility study. In such circumstances, it is beneficial to have an alliance with the collaborative decision-making concept. The participants would be able to deal with the risks and complexities that may arise during a project. However, this reason can not justify implementing an alliance; instead, the owners will need to demonstrate that the traditional approach cannot deliver a particular project.

The cost of transferring risk is prohibitive

When the cost of shifting risk to non-owner participants is prohibitively high for the owner, alliancing may be a viable option. However, this decision requires an analysis of present market conditions. Since the risks are shared collectively between the participants, the alliance approach should deliver a project at a reduced price. In a unique situation where the risks are unforeseen, or the stakeholder management process is complex, the owner with a greater risk profile may choose a traditional approach. Still, the owner is required to pay a premium to transfer the risks. As a result, the owner may find it beneficial to use an alternative delivery method such as alliancing.

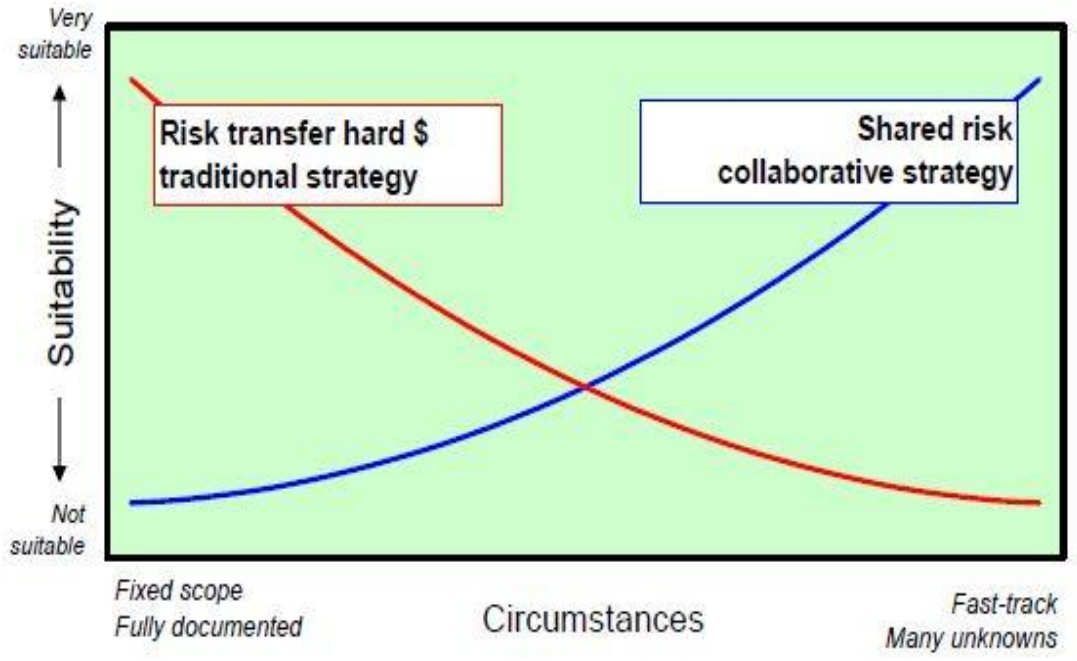

Figure 22: Suitability of alliancing as a delivery method Source: (Ross, 2009)

Even if the intention is well, allocating the risks among the project participants may threaten the project's success. As per Figure 22, the key participants must take collective responsibility under an agreement where they all win or lose together to achieve the project outcomes. However, this depends on the agreed targets. In simple words, the owners choose alliance when they believe that it has the highest possibility to accomplish the project goals. (2009)

Urgent Project start is required

In some cases, the public sector demands and early project completion under extreme time constraints. It requires the constructor to start construction as soon as possible basis. Under these circumstances, an alliance method could be suitable. However, several drawbacks while choosing an alliance, such as the time constraint, can lead to a higher cost or negative Value for Money (VfM).

The owner has valuable knowledge, skills and capacities

The owner's active participation in the project management processes is crucial for particular projects since they have valuable experience, insights, and competencies. Other than that, the owner requires special skills to form an alliance management team. It is quite challenging to ensure that the participants' interests are aligned.

Need for a collective approach to managing risk and opportunities

For some high-risk projects, the best VfM outcome may be attained by gradually refining and defining the project solution to address new risks. Most of the time, these risks are related to stakeholders or legal issues. In the owner's interest, the participants work collaboratively to solve such issues, thus creating a better VfM. Also, The owner is most likely to get the intended objectives with a collective approach without taking a significant risk earlier.

Innovation is needed

Traditional project delivery approaches with adequate planning and execution can also generate innovations and remarkable results. However, an alliance approach can be considered since its a unique project delivery method where the owner is involved with other participants to encourage them. Also, an alliance is a continuous team development with a room full of innovative solutions to accomplish desired outcomes.

To deliver new or emerging technology

Under an alliance agreement, the participants are tempted to use new technologies in order to improve the project performance so that they all can gain profit at the end of the project. However, the owner should be concerned while choosing a new technology to bring potential risks to the alliance. Since the participants are working under the risk-sharing method, these potential risks from new technologies may lead to a higher cost.

No litigation over contractual disputes

One of the main attractive features of alliancing is that there is no threat of litigation. The participants are required to commit that they will not sue each other in case of disputes. The no-fault–no–blame attitude is beneficial to both owners and non-owners. However, there is a good chance that there may be some differences among the participants. In a way, the threat of litigation is not entirely removed.

Additional reasons for using an alliance

Other than mentioned above, these are the numerous circumstance where an alliance is likely to prove most effective: (Department of Infrastructure and Regional Development, Australia, 2015)

- Uncertainty in the scope of work
- Larger and long-term projects

- A single participant is not able to provide the required resources or capacity
- Complex external threats
- A change or performance improvement is a business requirement
- Cultural and behavioural change is required

Consequently, it can be said that alliancing provides flexibility to the owner and non-owner participants. They can modify and adjust to problems as quickly as possible.

3.9 Barriers and Constraints in Alliancing

Even though the alliancing concept has significant benefits over the traditional approach, it also has several barriers and constraints. It is pretty challenging to adapt its principles. Ross (2006) has mentioned that the number of alliance projects is reducing although proven beneficial. The owners opt for alternative delivery methods over alliancing. (Department of Treasury and Finance, Victoria, Australia, 2009) Following are the barriers the participants face while choosing alliancing:

Cost to Establish and Operate Alliancing

The establishment of alliancing is expensive. It demands a significant level of commitment from project participants, particularly senior-level decision-makers who can tender, establish, and deliver throughout the project lifecycle. The training of the participants results in an overhead cost. Therefore, it is most likely that only a sufficiently large project can justify such an investment amount. (WSP Global, 2021)

The Incompetence of Alliance Participants

The competence of alliance participants is critical to the alliance's success. The owner's lack of knowledge and the non-owner participants' lack of capacity and poor planning will lead to a failure in an alliance project. The client's lack of knowledge means he is not motivated enough to spend resources on the project's development. Also, he has a wrong perception of the alliance concept. These concerns will lead to adverse outcomes for the project. The wrong perception could be challenging to handle since there will not be any efforts to analyse and improve the alliance principles. In other words, it will discourage the participants from exploring the potential benefits of the alliance. Not only that, but management skills are also crucial for smooth processes and effective communication. (Rahat, 2014)

In some situations, the incompetencies of an organization can also lead to improper planning even when the owner has enough knowledge of the alliance. As a result, it will be challenging to develop a feasible plan and ensure the organization will gain the desired results.

Commitment to Alliance Principles

Not all participants can commit the time and effort required to ensure the success of a project. It takes time to build relationships and gain commitments from the participants. De Man and Roijakkers (2009) mentioned that alliances have a more considerable risk of failure since they focus on shared innovation projects with uncertainties. Ross (2006) has also noted that a lack of commitment to underlying alliance projects could cause a failure. Fundamentally, the quality of participants, commercial interests, and the spirit of the alliance team are the most critical factors that ensure the success of a project. As a result, early in the project, the owner and non-owner participants must decide on alliance guidelines and work within those standards. (Vilasini, 2014)

Top Management Support

The concept of alliancing relies on the principle of collective management. It requires more involvement of senior staff in comparison with the traditional type of arrangements. Also, top management support is crucial to develop new processes as per the organization's criteria. Wittmann, Hunt, and Arnett (2009) identified a significant relationship between top organizational support and alliance participants' skills. The alliance team face an increase in workload while monitoring and measuring the performance of a project. The top management officials fail to provide adequate support because sometimes they are unaware of the entire scope and severity of the problem that requires assistance, or sometimes they do not prioritise issues. A proper alliance structure and member selection can help to mitigate these issues.

Focus on Operation Level and Process Management Techniques

Even though alliance projects have several guidelines on a contractual and organizational level, a slight emphasis is made on increasing innovation and efficiency. (Vilasini, 2014). The success of a project is determined not only by the adoption of the project delivery method but also by handling the resources and activities strategically. Mitropoulos and Tatum (2000) stated that in order to achieve excellent performance, the project participants use an integration mechanism in the contractual,

organizational, and operation levels. Alarcon, Christian, and Tommelein (2011) mentioned that a project must focus on these three domains for successful project delivery. The alliance model only focuses on organizational and contractual aspects and lacks specific workflows at the operational level.

Participant Resistance and Partial Collaboration

As mentioned before, every member of the alliance management team has a right to vote in the decision-making process. The members of the alliance team partially give up their authority to some extent on the project. As a result, the project participants may have doubts about choosing an alliance.

One of the alliance principles is that all the parties, owners and non-owners, work collectively and share a joint responsibility of risks to achieve the desired result. In practice, it is challenging to develop such an environment. Consequently, the alliance may fail. Furthermore, the majority of the alliance projects rely on the owner, designer, and contractor. In contrast, the sub-contractors are not in the alliance loop. As a result, it is not sure that the projects will have the desired outcome until the integration of the sub-contractor to the alliance team. (Vilasini, 2014)

Appropriate Cultural Shift

The concept of collaborative culture in alliancing is appealing, but the situation is quite different in reality. Most project participants are used to their old habits and behaviours coming from the traditional approach. Therefore, adapting to collaborative approach and communication systems can be difficult due to cultural shock. Consequently, the participants get negative feelings and feel a threat of thriving in a new environment. (Helen & M, 2012)

Figure 23 shows the cultural difference between traditional and alliance contracts.

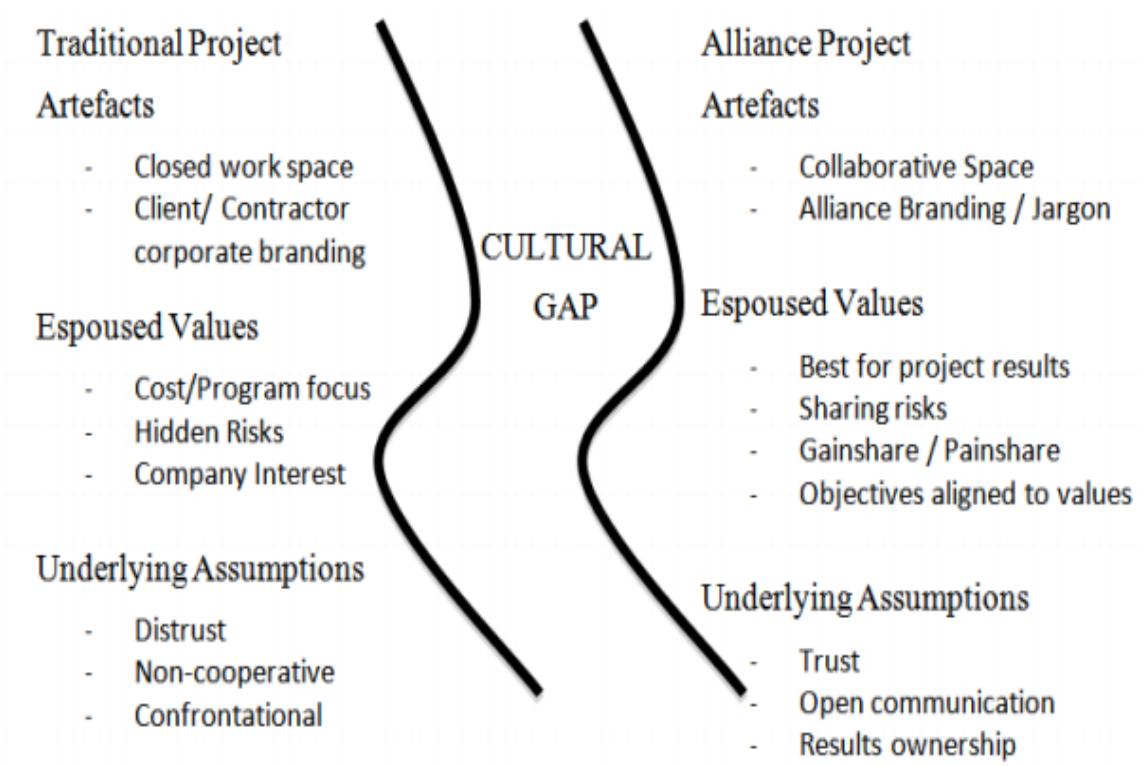

Figure 23: Cultural difference between traditional and alliance contracts Source: (Helen & M, 2012)

Xue, Shen, and Ren (2010) state that a significant cultural shift is required to create an effective and efficient collaborative model. However, it is not very easy to achieve such a cultural shift in such a short amount of time. The effectiveness of the alliance model is highly dependable on the trust and personal relationships between the participants. In order to improve the project performance, alliance management must be able to manage and guide the participants in the right direction. (Vilasini, 2014)

Lack of Price Competition

Ross (2006) stated that the value for money could not be guaranteed in the absence of price competition. They are making it more difficult to reassure the project owner of its financial feasibility. In order to tackle this challenge, a price competition approach is necessary, which will create competition between participants as only one of them will remain in the alliance. Moreover, the lack of price competition may result in an artificial increase in target cost and time (Green, 2002). Other than that, it is also vital that incentive terms are adequately set. Otherwise, in some cases, these terms will encourage the participants to compromise the performance for their self-interests. Eventually, this will lead to a project failure.

Lack of Acceptance by Investors

There can be an of building confidence with investors or political bodies that alliances delivery project successfully. In order to overcome this obstacle, effective communication is required. It is also essential to highlight the shortcomings of traditional models and provide case studies that demonstrate successful project delivery. It is usually simpler to use what has already been done. However, this might result in the same disappointing outcomes for all the parties involved. (WSP Global, 2021)

'No Blame/No Dispute' Principle

The ‘No blame/No dispute’ principle has certain limitations. It will not prevent the participants from being held liable for any damages, even if no blame clause is included in the contract. This clause only applies to the participants. It can not stop any third parties to bring a claim on one of the participants. According to alliance principles, the owner must reimburse such claims from third parties as it is recognized as a direct cost (Hayford, 2020). These matters are complicated, and it is unclear how the operation under an alliance agreement with no apparent risk allocation conditions was carried out. (Department of Treasury and Finance, Victoria, Australia, 2009)

Construction Market Readiness

The construction sector has relied on alternative project delivery methods such as Public-Private Partnerships (PPP) and Design-Builds (DB) for years. These models are functional with extended commercial agreements. However, they lack transparency, which can be a determinative factor for the success of the participants. Therefore, an alliance can only be effective when there is transparency and trust. Other than that, the success of an alliance massively relies on a cultural shift that could take time and money. As a result, it is quite challenging to choose an alliance over other models. (WSP Global, 2021)

3.10 Status Quo of Alliancing

Globally, the use and development of alliancing are at various stages. Alliance contracts are widespread in some countries, whereas in other countries, they are not well comprehended. In some countries, the construction sector still takes alliancing as

a learning opportunity. As a result, pilot projects are underway in various countries. In this section, the current status of alliancing is discussed.

3.10.1 Alliancing in Australia

In the mid-1990s, the construction sector in Australia was facing a rising dissatisfaction. The construction firms were dissatisfied with the amount of time on resolving the issues. Nevertheless, the project performance and productivity were below the standards of feasibility. As a result, a new project delivery method of collaborative concept was introduced. The Australian Constructors Association (ACA) proposed a new approach that was based on relationship contracting. The idea of this approach was to develop relationships between participants and allow them to achieve success together. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

Since introducing the collaborative model, the construction industry and the public sector have been using and developing project alliancing as a technique on mega projects. The first alliance projects in Australia were Wandoo Project and East Spar Project. Following the success of these two projects, the construction and designing firms started to implement alliancing. Since then, the Australian government has used alliancing to accomplish several significant infrastructure projects. Alliance is used in the Australian construction sector as a cost-effective and efficient way to collaborate on projects with uncertainties. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

In Australia, alliancing has been implemented in over 200 major infrastructure projects to address several drawbacks that the owners face with a traditional approach. However, there has been a long-running dispute on the performance of alliance contracts over a traditional type of arrangement (Frame, Picarel-Pechdimaldjian, & Bartz, 2019). However, a study conducted by RMIT University (Walker, Harley, & Mills, 2008-2013) indicates that only a few alliance projects failed to meet their time and cost targets. At the same time, a majority of alliance projects delivered highly successful outcomes. The project participants identified that the trust and the attitude to work on “best for the project” were the keys to success. The number of alliance projects has dropped down in recent years due to a slowdown in the construction sector; Australia is still a world leader in alliancing. The Australian experience of alliancing has

encouraged other countries such as Finland, The Netherlands, and the UK to choose alliancing. (Walker, Harley, & Mills, 2008-2013)

3.10.2 Alliancing in Finland

Finland’s construction industry faced problems in the early 2000s. The project results consistently fell short of expectations, and projects exceeded time and cost limits. The Finnish authorities were under considerable pressure to find a suitable solution. As a result, the construction sector moved towards a unique approach of collaboration between participants. To increase productivity, the company's culture needed to alter to be more open and trustworthy. The foundation of Finnish Lean Construction played a central role to make a change in this regard. The first pilot project (Leikki Project and Tampere Tunnel) were launched in 2012. The alliance agreement was established between the Finnish construction industry and the Finnish Transport Authority. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

The development of construction projects methods is experiencing a massive transformation. Ever since the introduction of alliancing in Finland, the adoption of this unique model has been used in about 70 construction and real estate projects. These projects are valued at around €4.9 Billion. Figure 24 shows the growth of alliance projects in Finland over time. (Saarinen, Koskelo, & Fuss, 2020)

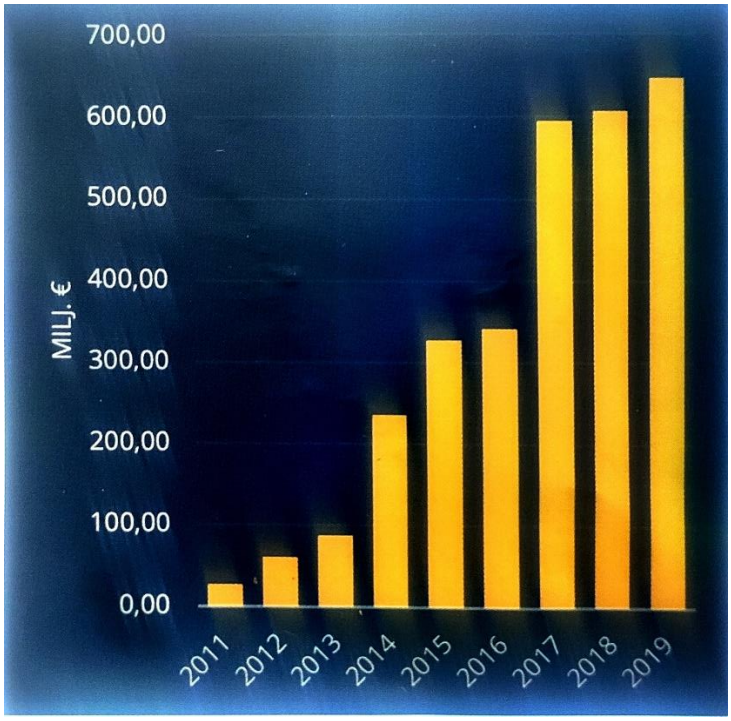

Figure 24: Volume of growth of alliance projects in Finland Source: (Saarinen, Koskelo, & Fuss, 2020)

The basic principles of the alliance model are also used in project management contracts and traditional contracts. In other words, these are the Integrated Project Delivery (IPD) models. The adoption of IPD models has changed the culture of the construction sector as the participants are shifted towards cooperation and continuous improvement. Also, the joint management idea has benefited in better planning and accurate budget estimation and better commitment from parties. Other than that, the risk-reward concept has motivated the participants to execute the project within time and budget. As a consequence, all the IPD projects have met the desired targets. (Saarinen, Koskelo, & Fuss, 2020)

3.10.3 Alliancing in Other Countries

- Austria:

There is limited use of multi-party contract arrangements in Austria. However, the topic of the risk-sharing concept is on-trend in the Austrian construction industry. The risk-sharing concept is widely used in multiple projects under the Public-Private Partnerships arrangement. The risks are partially transferred to the sub-contractors and not managed jointly. The Austrian construction industry has recently implemented alliancing in a major project (a hydropower plant, “Gemeinschaftskraftwerk Inn GKI”).

The participants decided to adopt alliancing after the traditional contract was terminated due to unsatisfactory performance. The participants were managed to save the cost by 6-9%. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

- Germany

The concept of relational or multi-party agreement is new in the German construction industry. Despite that, collaborative models such as alliance contracts are underway. Since 2018, early contract models have also been adopted in the German market. It is anticipated that relation-based multi-party agreements will play a vital role in the German construction sector. Real estate owners and investors tend to adopt collaborative agreements. Besides, some of the alliance principles are already taking place in the German market, for instance, risk-sharing, good faith, and collaboration. Other models such as Guaranteed Maximum Price (GMP) is used to encourage commitment from the participants. Additionally, the first alliancing pilot projects are underway. However, it is remained to see whether these alliancing projects thrive under German statutory procurement laws and, if so, under what conditions. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

- The Netherlands

Pure collaborative contracts such as alliancing or partnering are not commonly used in the Netherlands, but they are gaining popularity. The contract sum in the alliance is not fixed; therefore, the Dutch owners consider it considerable risk. The most commonly used contract in the Netherlands is a “building team” contract. During the design process, the contractor contributes his cost expertise. All construction team members are responsible for team decisions that fall within their area of expertise. In the case of alliancing, it will likely become widespread if and when the Dutch owners recognize the extra benefits of alliancing and get a better experience with such projects. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

- New Zealand

The public sector of New Zealand has adopted alliancing in infrastructure projects, particularly highway contracts. The multi-party agreements were formed under alliance concepts to improve Auckland's northern highway corridor and the Auckland Motorway Alliance. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

- Singapore

Similar to the Netherlands, alliancing is still gaining popularity in the construction sector in Singapore. The first pilot alliance project for the public project was planned by the Singapore Building and Construction Association (BCA) which was due to start by early 2020. In order to increase productivity in the construction sector, the BCA has encouraged the implementation of a collaborative approach. Further, a Working Committee on Collaborative Contracting (WCCC) was formed to promote the use of alliancing. The Singapore construction sector is targetting the public projects to use alliancing. The government of Singapore has determined that alliancing could be beneficial in involving the participants such as engineers and contractors in early phases to provide their expert opinions. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

- United Kingdom

In the 1980s, most of the UK's infrastructure development fall under the private sector. A competitive tendering mechanism was used to procure a contractor to bid the lowest price while taking the highest risk. As a result, the projects were facing issues such as cost overrun and late project delivery. Consequently, the concept of alliance emerged in the 1990s. A collaborative partnership was used in the Honda Cars Plant construction project in Swindon, based on "one team, one goal". The outcome of the project was significant as there was a 40% improvement in cost. The complex Heathrow Airport Terminal expansion was the first major alliance concept in the UK. In recent times, the alliancing has evolved in the UK. The Infrastructure Client Group (ICG) and the Institute of Civil Engineers (ICE) formed an alliance in 2018. They introduced the industry-wide "Project 13". Project 13 provides the guidelines on the implementation of alliancing principles. Since the introduction of project 13, many projects have been using these guidelines to adopt the alliancing. (Frame, Picarel-Pechdimaldjian, & Bartz, 2019)

4. Introduction of Lean Philosophy to Construction

This chapter presents the background of lean philosophy in the construction industry. The chapter is divided into seven sections, followed by the introductory section. Section 4.1 discusses the history of lean philosophy in brief. Section 4.2 introduces lean philosophy in the construction industry. The following section (4.3) provides multiple definitions of lean. Section 4.4 explains the principles of lean philosophy. Further, the next section (4.5) highlights the critical factors for the success of lean principles. The following section (4.6) analyses the impact of lean tools in construction projects. Lastly, the final section (4.7) analyses the existence of lean philosophy in various project delivery methods.

4.1 A Brief History of Lean Philosophy

The idea of lean was conceptualized by a research team working in a production industry. The engineer and leader of this team, Ohno, presented a concept of waste reduction in the Toyota car production company. He broadened his perspective from the narrow focus of craft production on worker productivity and mass manufacturing on the machine to the entire production system. Later, he reduced the waste by developing several objectives for the new production system, such as manufacturing cars according to the demand and the customer's requirements, reducing delivery time, and minimizing extra costs from intermediate stores. (Howell, 1999)

Further, Howell (1999) has identified waste in terms of the production platform's performance metric. Inability to meet the customer's needs is also considered waste and unnecessary delays in delivering the product. Approaching zero waste diverts the focus of improvement from operation to the delivery system. Ohno saw the threat of the waste of overproduction as the pressure to maximize the production meant defects in the cars and eventually time loss for reproduction. Ohno's approach required tight coordination in reproduction work. Therefore, it was essential to eliminate rework. As a result, he implemented the idea of production based on demand. (Howell, 1999)

Moreover, Ohno structured the production line management so that all the employees could access the information of the production system. With such transparency, the employees were able to make decisions that were beneficial for achieving the objectives. Later, new contracting concepts were developed where the contractors were

provided with an incentive to reduce the waste, which eventually turned out to be an overall improvement of the delivery process. The underlying foundation of lean is apparent, even though the concept is continually changing. Develop a supply chain that can deliver a product promptly based on specifications while avoiding the need for intermediate inventories. (Howell, 1999)

4.2 Introduction of Lean Construction

The application of lean has substantial benefits in various industries, especially the construction sector. As per Ballard and Howell (1998), the researchers are concerned about implementing lean manufacturing principles in the construction industry. Picchi and Granja (2004) state that it is feasible to integrate lean concepts into construction projects. The researchers discovered that lean construction encompasses more than just using lean manufacturing ideas primarily due to the unique characteristics of construction projects (Vilasini, 2014). Moreover, there are several obstacles such as insufficient investment in research and development, deeply embedded project culture, lack of knowledge about lean construction, and lack of motivation in project participants. (Vilasini, 2014)

The concept of lean construction is based on two main perspectives. The first perspective attempts to implement lean manufacturing principles to construction where alterations are also possible. In contrast, the second point of view attempts to implement only lean thinking principles to construction. This way of practice is a unique approach in construction. Both perspectives have enhanced the performance in the construction industry. (Vilasini, 2014)

4.3 Definition

There is no clear definition of lean construction. Some authors identified lean construction as a concept, tool, method, philosophy, or a set of ideas for construction management. Because of this invariably, lean construction has different techniques, methods, and implementation strategies. Lean construction is a philosophy that provides continuous improvement through the management process to fulfil customers' needs. These improvements are the results of waste elimination in the manufacturing processes (Mossman, 2009). Dauber (2003) stated that there is no universally accepted

definition of lean construction. Leong, ward, and Koskela (2015) noted that each project participant has their version of the explanation for lean construction. Lean construction is a new approach based on the principles of production management and project management. Still, this definition lacks clear guidance for lean construction philosophy (Vilasini, 2014). Even though there is no specific definition for lean construction, the concept is still evolving continuously.

According to Egan (1998), lean construction is a technique for reducing waste, increasing efficiency, and improving quality in construction. In Ballard and Howell's (1998)opinion, lean construction is a tool that controls production. Whereas Koskela, Howell, Ballard, and Tommelein (2002) stated that lean construction also helps to reduce waste and generate the maximum value for the project. The definitions of lean construction are based on two perspectives; either on a theoretical point of view which includes goals and principles, or on a practical point of view which includes tools or methods. All these definitions present a generic approach while the concept of lean construction is expanding with time. The following definition of lean construction covers the basic principles of lean:

"*Lean construction is the continuous process of elimination waste, meeting or exceeding all customer requirements, focusing on the entire value stream and pursuing perfection in the execution of a constructed project.*" (Diekmann, Krewedl, Balonick, & Stewart, 2004)

Howell (1999) pointed the difference between lean construction and traditional construction by following points:

"*Lean Construction: has a clear set of objectives for the delivery process, is aimed at maximizing performance for the customer at the project level, designs concurrently product and process, and applies production control throughout the life of the project.*"

4.4 Lean Principles

This section compiles an overview of lean construction principles based on various articles and research papers. Note that the authors of these articles and research papers do not always use the same terminology when describing lean principles. Koskela (1992) stated that construction should bring an innovative philosophy that brings competitiveness by identifying and eliminating waste; in other words, removing non-value-

adding activities. In order to put this idea into practice, Koskela (1992) presented multiple principles of lean construction. These principles include reducing non-value-adding activities, increasing output value through systematic consideration of customer requirements, reducing variability and the cycle time; simplifying the process by minimizing the number of steps, parts, and linkages, increasing output flexibility and process transparency, focus control on the complete process, build continuous improvement into the process, balance flow improvement with conversion improvement, and benchmarking.

Lean Construction Principles	Authors/Sources
• Minimize the share of non-value adding activities • Increase output value by considering customer requirements • Reduce Variability • Reduce the cycle time • Adopt simplicity by minimizing the number of steps, parts, and linkages • Increase transparency and output flexibility • Focus control on the complete process • Build continuous improvement in the process • Balance flow improvement with conversion improvement • Set up a benchmark	(Koskela, 1992)
• Identify value • Map the value stream • Create flow • Establish pull • Seek Perfection	(Lean Enterprise Institute, 2009)
• Establishing integrated teams • Combining project design with process design • Stopping production rather than releasing a faulty assignment • Decentralizing decision making • Requiring a simple, direct hand-off between tasks in the workstream	(Pinch, 2005)
• Collaborate, improve networks of commitments • Optimize the project, not the pieces • Tightly couple learning with action • Increase relatedness	(Lichtig, 2005)

Table 2: Lean Principles Source: Adopted from (Vilasini, 2014)

Further, the Lean Enterprise Institute (2009) noted five principles for supporting lean technique implementation. These principles identify value, map the value stream, create flow, establish pull, and seek perfection. In addition, Pinch (2005) also identified five principles of lean construction. These principles follow as; creating integrated teams comprised of owners, architects, contractors, suppliers, and end-users, combining project and process design and at the same time designing the facility and its manufacturing process, assuring the quality of the production by stopping the production of faulty assignments, decentralized decision-making, empowering project participants, and making the process transparent, and requiring a simple, direct hand-off with a straightforward way to request action and receive a response in order to remove blockages (Pinch, 2005). Other than that, Lichtig (2005) has presented five big ideas to support lean project delivery. These ideas are mentioned in Table 2.

In order to implement the best practice in construction, Cain (2004) outlined six lean principles. These principles are mentioned in Table 3.

Lean Construction Principles in Construction	Authors/Sources
• Delighted end users • End users benefitting from the lowest optimum cost • Elimination of inefficiency and waste • The involvement of suppliers to achieve integration and buildability • A single point of contact for the most effective coordination and clarity of responsibility • Establishment of current performance and improvement achievements by measurement	(Cain, 2004)
• Customer focus • Culture/people • Workplace standardization • Waste elimination • Continuous improvement/built-in quality	(Salem & Zimmer, 2005)

Table 3: Lean Construction Principles Source: Adopted from (Vilasini, 2014)

Meanwhile, Salem and Zimmer (2005) applied the principles of lean manufacturing to construction. The principles are customer focus, culture/people, workplace standardization, waste elimination, and continuous improvement with built-in quality. In comparison, Womack and Jones (2003) presented lean thinking principles as an antidote to

waste. The principles specify a value, identify the value stream, flow, pull, and pursue perfection (see Figure 25). These principles are explained below:

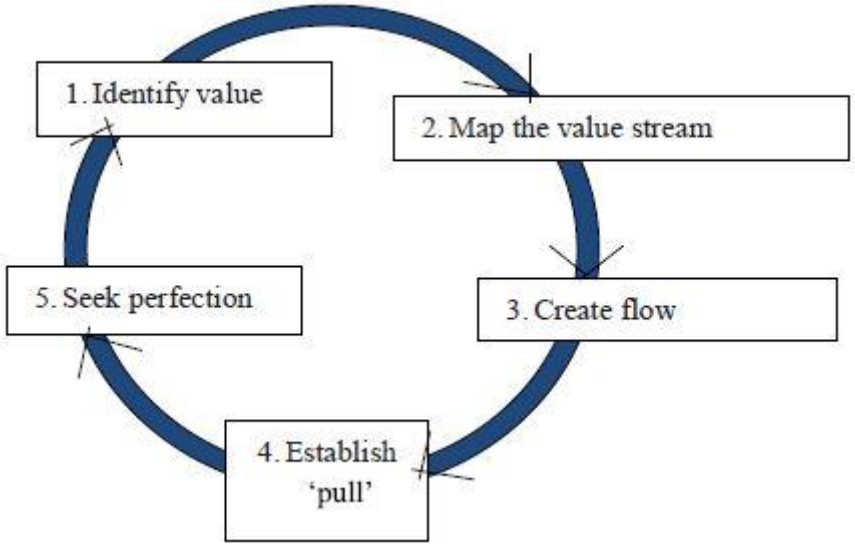

Figure 25: Lean principles Source: (Lean Enterprise Institute, 2009)

4.4.1 Specify value

In the traditional approach of construction, the project specifications mainly focus on what the customer wants. On the other hand, the lean approach promotes the focus on what customer values. In order to define these values, tools such as value management, quality function deployment, and simulation are used. Eventually, it will define characteristics that are keys to the customer's satisfaction. Moreover, the owner desires that all the project participants come together and understand the customer's point of view in the early stages of the project. When the communication between the owner and other participants is clear, the owner will use their ideas and expertise to fulfil the customer's requirements. (Hill, 2020)

4.4.2 Identify and Map the Value Stream

This step identifies the steps to create a process that delivers a project. Identifying the value stream also involves a task on when and what decisions should be made. Process mapping is the crucial technique to understand how the value of a project is built

from the client's perspective. In order to map out this process, all the aspects are considered, from materials to machines. Any aspect that is not a value-adding step is eliminated. (Dulaimi & Tanamas, 2008)

From the strategic point of view, this principle provides a different approach to organizing the construction. It identifies the value streams on how building envelope and structure are to be designed and constructed. Whereas from a tactical point of view, the value stream map can identify non-value adding activities, or in other words, waste activities. (Dulaimi & Tanamas, 2008)

4.4.3 Flows

The main attributes of flows are time, cost, and value. In order to analyze the flows, resources and information are considered in lean construction. Further, the flows are categorized into controllable (i.e., materials management) and uncontrollable flows (i.e., supplies from vendors or information from design firms). (Dulaimi & Tanamas, 2008)

One of the main features of Lean is that it eliminates activities or barriers that interrupt value-adding activities. Following are the areas where non-value adding activities usually occur: (Hill, 2020)

- Transportation: Sometimes, resources are moved to a construction site during a project even before they are needed. This results in transportation waste. Therefore, it is necessary to eliminate this cost that does not add any value to the project.
- Wait time: The most typical situation on a construction site is because the manpower must wait for the materials to arrive to perform the work.
- Inventory: Due to poor inventory management, sometimes the raw materials are stored on-site in more quantity than needed on time. This takes up unnecessary storage space and adds up cost.
- Movement: The waste of movement is created by the unnecessary movements of resources across the construction site.
- Resource Utilization: The knowledge and the skills of site workers go to waste if the right person is not utilizing the right resource.

- Excess Processing: This happens when additional activities are added that are not according to schedule. These activities are added as precautions to avoid any other wastes, but ultimately, they lead to over-processing.
- Over Production: Overproduction occurs when an activity is finished ahead of the scheduled time. The schedule of the succeeding activities will be changed.

The negligence of flow causes issues on a construction site, as mentioned above. Each process in construction can be controlled and improved by lean philosophy. For instance, redesigning the planning system in the early stages by minimizing uncertainties will ensure a smooth workflow. (Dulaimi & Tanamas, 2008)

4.4.4 Pull

The concept of pull states that no activity should produce goods or services until the next customer downstream requests it. Therefore, developing a reliable workflow relies on the execution works as per the downstream demand. The pull principle of the lean concept provides the workflow by ensuring that the project participants work collaboratively to finish the execution works. However, they are required to specify a target date and execute the work on schedule. (Hill, 2020)

In other words, with the pull concept, a project completion timeline is created, which includes tasks on a downstream schedule. For instance, after one task is finished, the next task in the process begins. It improves the workflow by establishing clear expectations for responsibilities and more opportunities for communication between project participants. (BigRentz, Inc, 2021)

4.4.5 Perfection

Regardless of implementing the first four principles, it is a never-ending process for the participants to minimize efforts, time, space, cost, errors, and other sorts of wastes while still providing the owners what they want. The interaction between these principles will create a cycle that reveals the hidden waste in the value stream. As the cycle proceeds further, more obstacles/wastes will be revealed which need to be eliminated. Sometimes, it requires new tools or concepts or technologies to eliminate these obstacles. Therefore, in order to implement lean principles successfully, it requires continuous monitoring and effort. Also, pursuing this level of perfection demands transparency

between the project participants to present better ideas to create value. In short, pursuing perfection is a concept of continuous improvement on applying and reapplying of first four principles. (Marzouk, Bakry, & El-Said, 2011)

4.5 Success Factors of Lean

While transitioning to a lean construction delivery method, lean tools and techniques are not enough to succeed. These tools and techniques must be supported with the factors that are described below:

4.5.1 Contracts

In order to enhance the performance of a project with lean initiative, the contractual arrangements should support the collaborative environment between the participants. The Collaborative feature of an agreement plays a crucial role in implementing the lean concept successfully. The owner can engage with the participants directly, which can be beneficial to develop trust. Also, the participants feel that they are being treated fairly. The contractual arrangements should also include several attributes that promote lean such as target costs, shared rewards, and activity schedules. Traditional arrangements focus on assigning blame rather than promoting early solutions. Therefore, the contract must promote a risk-sharing environment where the participants can work together to mitigate risks early and cost-effectively. Risk management that is not appropriately handled leads to waste in the construction sector. Therefore, the contract must encourage the idea that the party which can manage the risk should bear it. (Chick, 2013)

4.5.2 Behaviour and Culture

The most critical feature in the success of a lean project is the adoption of cultural change. The top management requires to provide support and genuine commitment to achieving long-term improvement. The owner must spend time with the participants to understand their goals. Consequently, the project outcomes will be improved. All the participants should get an induction covering both the culture and techniques they may encounter to achieve better lean results. Since this is the only lean training, there must

be enough training duration to be effective. Choosing the Lean training champions is also a best practice as they are likely to deliver better performance than consultants. However, this induction program must be continuous for the new participants. Otherwise, there will be cultural and technical issues. The owner must take the initiatives to demonstrate the appropriate behaviour necessary to create a collaborative environment. Lastly, the owner and his representatives must encourage informed risk-sharing, “best for the project” thinking, creativity, and innovation. (Chick, 2013)

4.5.3 Commercial Considerations

The open book culture should not be limited to cost-related matters. It should also include complete openness regarding defects, time spent, environmental and social impacts, and health and safety statistics. The objective is not to expose any participant but to have a clear picture of all costs so that waste can be found and avoided. For an owner who commissions a similar sort of work on a regular basis, he must understand the cost at a basic level to analyze the savings opportunities. Regardless of how risks are organized in the contract, the owner and his organization should demand a detailed level of cost information at the tender stage. Moreover, the owner must establish targets on costs, quality, and the delivery time as contractual obligations. However, these targets should be realistic and mutually agreed upon. (Chick, 2013)

4.5.4 Appropriate Tools and Techniques

Much of the importance is given to the tools and techniques in the construction industry rather than their implementation and necessary culture and behaviour to support them. When these tools are used without making the necessary adjustments to an organization’s culture to encourage adopting lean tools techniques, the results will surely be less than ideal. The best outcomes will come from using the most straightforward tools that require the slightest degree of adaption. One of the examples of a simple technique is thorough observation. This technique aims to help build the ability to observe what is actually happening rather than what is believed to be happening. This technique can be beneficial to identify waste from the construction processes. The best outcomes can be achieved by involving the participants who have extensive experience with such techniques. (Chick, 2013)

4.6 Lean Construction Tools and Techniques

A well-established culture of lean principles relies on tools and techniques to facilitate the process. These tools lead to enhance the value of the project. Ansah, Sorooshian, and Bin Mustafa (2016) stated that lean tools aim to optimize delivery systems and processes by reducing waste, boosting productivity, improving safety standards, and meeting client's needs. Several lean tools have been analyzed and implemented in the construction sector. Ansah, Sorooshian, Bin Mustafa, and Duvvuru (2016) identified 30 lean tools that are effective and suitable for the construction industry (Appendix B). The following are some of the most common lean tools:

4.6.1 Last Planner System (LPS)

Glenn Ballard developed the approach of the Last Planner System (LPS). This concept is based on the lean principle of waste elimination in processes through planning, controlling, and scheduling (Ballard H. G., 2000). LPS technique aims to improve productivity and to create a reliable workflow by eliminating barriers. This technique also identifies worker's abilities, which may be used for risk management and better decision-making. (Bashir, Suresh, Proverbs, & Gameson, 2011)

Last Planners are usually the authorized site foremen or other experts who are in direct contact with work to plan and decide what work is to be done the following day. The traditional approach of planning defines periods but fails to define the tasks required for project completion adequately. The decentralized decision-making feature of the Last Planner allows him to match resources to complete tasks based on future demands. (Kumar & Ramasamy, 2016)

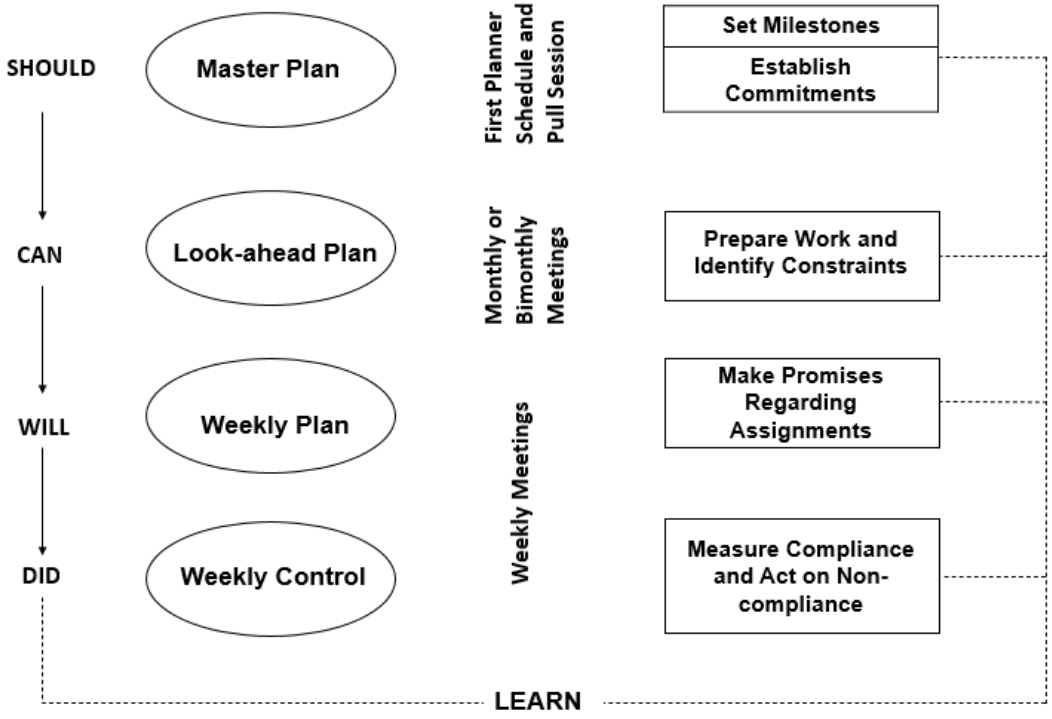

Figure 26: Summary of the Last Planner System Source: Adapted from (Pellicer, Cerveró, Lozano, & Ponz-Tienda, 2015)

As shown in Figure 26, the concept of the Last Planner System is based on five levels, Should, Can, Will, Did, and Learn. These levels are explained below: (Ebbs, 2017)

- **Should;** this level is a set of tasks that needs to be executed in the master plan. This level consists of overall project milestone planning and phase planning to establish a shared knowledge of the scope, main constraints, and workflows.
- **Can;** this level entails a look-ahead plan of a few weeks and identifying constraints that may keep the work from starting on schedule. Generally, the plans are reviewed for the next six weeks.
- **Will;** involves Weekly Work Planning (WWP). At this level, planners commit to performing work that is unconstrained and ready to start. Last Planners are embedded in phase planning through daily coordination.
- **Did;** this level tracks the status of activities by monitoring the actual progress. Thus, the potential reworks will be reduced.
- **Learn;** this level evaluates the success and failures of the previous plans and develops strategies for putting the lessons learnt into practice.

Furthermore, specific characteristics of the Last Planner System technique are associated with improvement in safety standards. Accidents induced by onsite variables

such as time pressure, organizational pressure, and extreme stress could be reduced by allowing workers to finish specific tasks over a more extended period. Also, providing flexibility to the workers to choose construction methods that could match their potential could minimize physical accidents and excessive stress. (Bashir, Suresh, Proverbs, & Gameson, 2011)

4.6.2 TAKT-Time Planning

The German word ‘takt’ means ‘beat’, and it relates to the precision with which something is performed. Takt time is a unit of time it takes the supply rate to match the demand rate (Frandson, Berghede, & Tommelein, 2013). Takt time planning is a work scheduling strategy that optimizes the supply rate by pacing work through a design process, efficient handoffs, and improve the system constantly. Takt time planning aims to create a more supportive environment for the Last Planner System by actively developing a continuous workflow of activities. (Frandson, 2019) Takt time planning utilizes the workplace environment by creating a continuous workflow while LPS stabilizes this workflow (Liker & Meier, 2006).

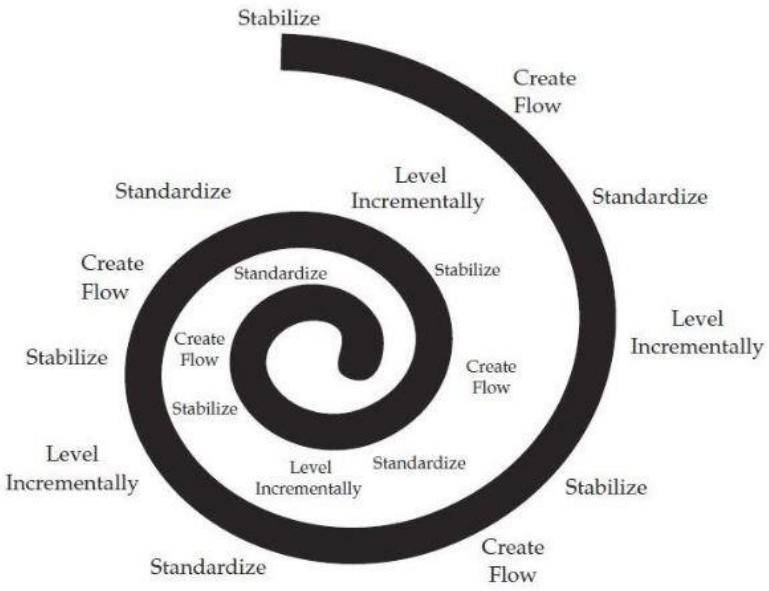

Figure 27: Continuous improvement spiral Source: (Liker & Meier, 2006)

The construction projects consist of many activities that progress at a different paces. Therefore, the workplace environment becomes hectic. In order to overcome this problem, a construction project requires a systematic way of improving the workflows.

Figure 27 shows how continuous improvement occurs through establishing stability, pacing work, and standardizing. (Liker & Meier, 2006)

Frandson, Berghede, and Tommelein (2013) Identified six phases used in production planning. These phases are explained below:

- **Collect Information:** The Last Planner is usually in charge of determining how, by whom, and in what order every activity should be carried out.
- **Define Zones:** Each workstation is divided into zones. Each zone consists of locations with the same supply rate for a specific task.
- **Understanding the Trade Sequence:** Coordination meetings are held between the participants to obtain a more detailed information sequence that helps develop a reliable Takt time.
- **Balance the Workflow:** Identify the tasks that create barriers, improve their production rate, and identify those activities that need to slow down.
- **Time Required for each Trade:** First-run studies to create accurate time duration of each task for future improvement.
- **Planning according to Takt time:** Taking control of over-improved processes to take action in the event of deviations from each task's defined takt time.

As shown in Figure 28, the main benefits of Takt Time Planning have reduced project cost and time duration.

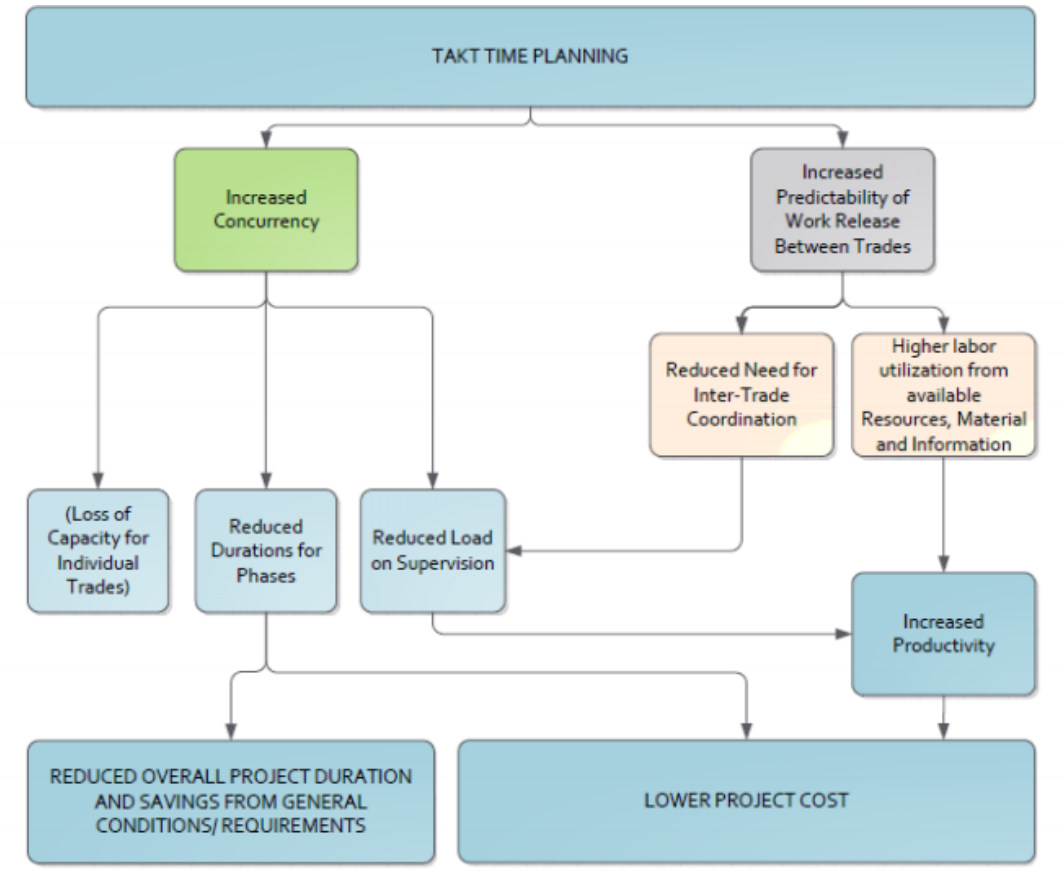

Figure 28: Takt time planning benefits Source: (Linnik, MBerghede, & Ballard , 2013)

4.6.3 Target Value Design (TVD)

Target Value Design (TVD) can be defined as a management technique that maximizes value within the constraints of a pre-determined cost target. Ballard (2012) identified TVD as a method that steers design and construction towards project constraints while maximizing customer value. The concept of TVD was adopted in the construction industry from Target Costing. The basic principle of TVD is to turn the client's value into a design driver, reducing waste and the client's expectations. (Zimina, Ballard, & Pasquire, 2012)

Macomber and Barberio (2007) stated that TVD transforms the current design practice upside down since, in this method, the costs determine the design rather than the design deciding the cost. In this technique, the design is prepared on what is constructible rather than evaluating a design's constructability.

Figure 29: Components of Target Value Design Source: (Kaushik, Keraminiyage, Koskela, Tzortzopoulos, & Hope)

Figure 29 reflects the components of the Target Value design. Based on these components, the following are the practices that deliver target value from the design process: (Macomber & Barberio, 2007)

- Engaging the client with the designers to define target value throughout the design process.
- Developing a practice of learning through innovations. Expecting that the participants will grow and generate something unexpected.
- Designing a detailed estimation based on the budget and target value.
- In order to avoid delays and reworks, plan collaboratively.
- Developing details in small quantities in collaboration with the project participants.
- Design and detail according to the order in which the customer will use it.
- Distributing work in small and diverse groups to encourage productivity and innovations.
- Promote collaboration through working in a Big Room environment.
- Developing a habit of completing the design cycle with retrospectives from the participants.

4.6.4 The 5S Technique

5s is a systematic lean technique developed from five Japanese words: Seiso (shine), Seiton (straighten), Seiri (sort), Seiketsu (Standardize), and Shitsuke (sustain). This technique promotes continuous improvement by efficiently organizing a workplace, reducing waste, and maximizing quality and productivity. The main feature of this technique is to standardize the site work systematically. (Kumar & Ramasamy, 2016)

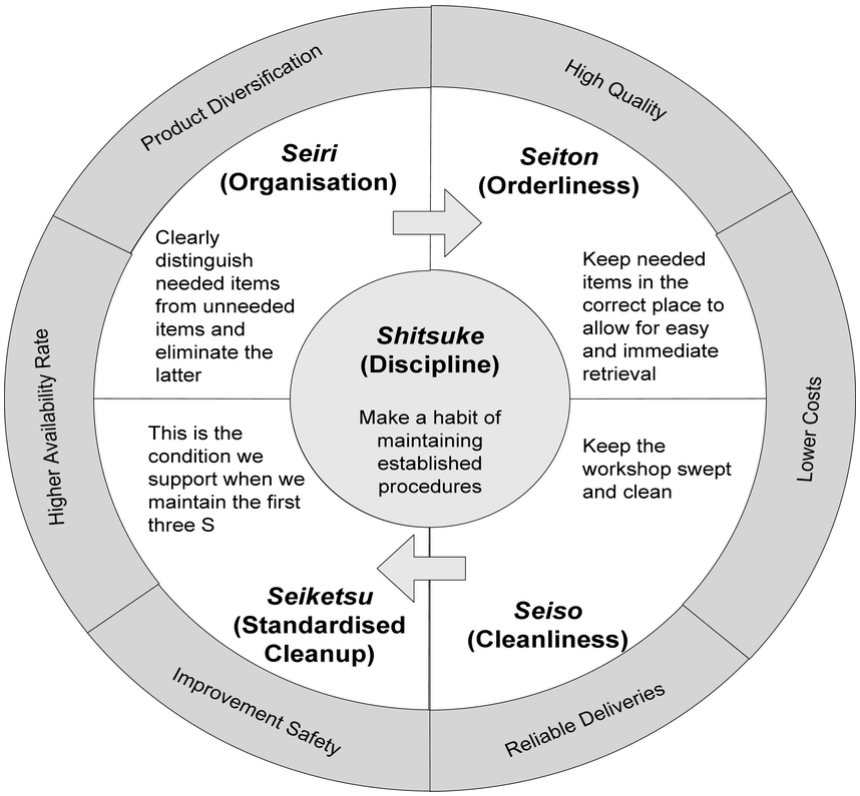

Figure 30: The elements of the 5S technique Source: (Kobayashi, Fisher, & Gapp, 2008)

Figure 30 reflects the elements of the 5S technique. These elements are explained below: (Bashir, Suresh, Proverbs, & Gameson, 2011)

- **Seiri (sorting);** involves the removal of all unwanted tools and parts and reorganizing them. This method discusses keeping the number of relevant items in the workplace to a bare minimum to maximize productivity and safety. The unwanted materials could be disposed of or removed from the place to improve cleanliness. As a result, the site congestion will be reduced, which will lead to better movement and site circulation.

- **Seiton (straighten);** reflects putting all items and equipment in the most convenient place to facilitate their identification and improve the site cleanliness. As a result, the workflow will be smooth and free from inefficient activities.
- **Seiso (shine);** includes the removal of all materials and equipment from unwanted places. This feature also indicates that materials that are not required to be used during that time should be removed. Their presence could cause site congestion and raise the risk of accidents.
- **Seiketsu (standardization);** ensures workplace standardization. A lack of safety culture among the workers could be a major cause of accidents. This element promotes the maintenance of with high level of cleanliness, which will ensure the safety and productivity of the workers.
- **Shitsuke (sustain);** reflects the continuous improvement of workplace culture by maintaining procedures and rules that have been established. It would enable the workers to develop a permanent habit on site.

4.7 Lean and Common Delivery Methods

According to Naoum (2003), selecting a delivery method for the project is one of the most critical decisions a project owner takes as the productivity and delivery of the project relies on the contractual arrangement. This section compares common delivery methods and lean principles to identify which delivery method is suitable for lean principles.

Table 4 shows the comparison of common delivery methods in the context of lean principles. Design Bid Build is the most common delivery method used in the construction industry because of its simplicity and flexibility (Vilasini, 2014). Other methods consist of complex management and design processes. As discussed before, the relational type of methods such as alliancing lack price competition. Thus, the project owners could prefer alternative arrangements as relational methods do not add value in this manner. However, relational contracts include value addition from incentives and waste elimination processes which does not exist in other methods. Based on the literature review, relational agreements such as alliancing is based on a collaborative environment that supports continuous improvement throughout the project timeline.

The lean principle of continuous improvement is non-existent in other methods. (Vilasini, 2014)

Lean Construction Principles	Common Delivery Methods					
	Design Bid Build	Design and Build	Design, Build and Manage	Construction Management	Management Contracting	Relational Contracts
Customer Focus	No	No	No	Yes	No	Yes
System Thinking	No	No	No	No	No	Yes
Collaboration	No	Yes	Yes	No	No	Yes
Culture and Behaviour	No	No	No	No	No	Yes
Workflow Management	No	No	No	No	No	Yes
Simplicity and Flexibility	Yes	No	No	No	No	No
Decentralized Decision Making	No	Yes	Yes	No	No	Yes
Transparency	No	Yes	Yes	No	No	Yes
Performance Measurement	No	No	No	No	No	Yes
Continuous Improvement	No	No	No	No	No	Yes

Table 4: Comparison of Common Delivery Methods with Lean Principles Source: Adapted from (Vilasini, 2014)

As mentioned in the literature review, in the construction management multi-prime method, the contractor acts as a general contractor representing the owners' interests. The general contractors are responsible for addressing the customer's needs. However, the other project participants are not included in this process. There are no incentive-based concepts to encourage them to improve the project's outcomes. On the other hand, management contracts promote risk transferring to the contractors, which may end up in disputes and not focus on customer's demands. In relational contracts, the interests of the participants are aligned. Also, since the beginning of the project, the owner has been embedded in the team, encouraging the non-owner participants to focus on customer needs.

To conclude, traditional contracts make it challenging to implement lean ideas in the workplace. Relational contracts make it easier. They provide an environment where

the project is delivered collaboratively, which correlates with lean philosophy. However, such an environment is insufficient to deliver desired outcomes as it requires proper operational processes. Thus, Lean tools and techniques are required to be integrated with relational contracts. (Vilasini, 2014)

5. Findings: Case Studies & Questionnaire

This section highlights the summary of two cases studies where the concept of the alliancing model was used. Both of these projects were part of pilot alliance projects in Finland.

- Case Study 1: Liekki Railway Renovation Project Lielahti – Kokemäki (2011 – 2015)
- Case Study 2: Rantatunneli Alliance Project (2011 – 2017)

5.1 Case Study 1: Liekki Railway Renovation Project Lielahti – Kokemäki (2011 – 2015)

Project Scope

The Lielahti – Kokemäki line is a part of Tampere – Pori line. The renovation project of Liekki Railway was the first public sector project in Europe that adopted alliancing approach. The budget was €106.4 million for an 89.6 km long railway renovation project. The main objective of the project was to improve safety for the railway section and reduce maintenance costs. The project also included other improvement works, such as changes in bench width and removal of railway grade crossings. Figure 31 reflects the locations of the crossings. (Heiskanen & Nyhä, 2013)

Figure 31: The locations of the crossings Source: (Heiskanen, Lielahti–Kokemäki project alliance, 2015)

Alliance Participants

The alliance was formed between Finnish Transport Agency (owner) and VR Track (non-owner). These two participants' total budget would be shared as the owner's share was €20.6 million. The non-owners share was €85.6 million. (Heiskanen & Nyhä, 2013)

Project Objectives

In this alliance project, a joint team was formed by the owner and non-owner participants. The team was responsible for establishing project objectives by defining Key Result Areas (see Table 5).

Key Result Areas	Description
Cost-effectiveness	Cost-effective implementation of the project through innovative solutions and operating techniques
Schedule	Achieve all the predefined goals; the project should be implemented as agreed
Quality	The design and construction of the project should be of the highest quality possible
Safety	The project should be managed excellently in terms of safety
Track Availability	The entire section of the line should be available for train traffic as agreed
Uninterrupted Train Traffic	Train traffic runs smoothly

Table 5: Key Research Areas of the project Source: Adapted from (Finnish Transport Agency, 2015)

Challenges

The project was to be implemented on a busy section of a single-track. It was challenging to minimize the disruptions caused by power outages and traffic. The owner found challenges in the alliance's ability to provide sufficient added value to the client through the cost-effectiveness and innovations and the success of setting a strict target cost. Also, the scope of the project was changed multiple times. Moreover, there was a risk of implementing the new model due to unclear responsibilities and organizational problems. The team was also facing a potential risk of unforeseen circumstances causing a delay in the project. (Finnish Transport Agency, 2015)

Ideas and Innovations

One of the most important policies of alliancing for this project was to use lean construction tools and techniques. Multiple lean tools such as the Big Room, the Last Planner System, and the lean principle of continuous improvement were used throughout the project in order to reduce waste. The Big Room helped bring people from different cultures to work in a shared workplace where the flow of information was efficient. Moreover, remote connections were also used in collaborative events. A cooperative environment was created where a group of experts from different positions worked together to solve problems. As a result, the participants developed a working practice that was very helpful in risk management. For scheduling, the implementation of the Last Planner System provided flexibility and efficiency in the management of the project schedule. Consequently, schedule updating became very simple, and the completed tasks were easy to track. (Finnish Transport Agency, 2015)

Success Factors

Following are the factors that enabled the project to achieve all the predefined targets: (Finnish Transport Agency, 2015)

- Involving the Finnish Transportation Agency in the planning process of crossing arrangements was crucial to solving the problems of traffic
- “Open book“ culture led to developing trust between participants
- Precision indicators were developed during the development phase. As a result, it was easier to measure the impact of the project on accuracy.
- For the decision-making process, prioritization and impacts have been accurately recorded. Therefore, the prepared alternatives could be implemented without delaying the project.
- The cooperation between the participants provided certainty about the schedule, which prevented any additional costs.
- The collaborative culture between the participants achieved flexibility in implementation. For instance, it was easier for the designer to monitor the site execution works and make any changes if needed.
- Joint events such as workshops provided a practice of solving problems together.
- With the alliance approach, the project could be taken forward as a whole.

Outcomes

Following the implementation of the alliance concept and lean tools, Liekki Railway Renovation Project achieved success in all the key research areas. The project was completed three months ahead of schedule. The actual outturn cost was €10 million under the target. Despite being the pilot alliance project, it achieved success due to innovative solutions and key result areas. The project won the title of "Construction site of the year 2012" in Finland. (Heiskanen & Nyhä, 2013)

Key Result Area	Outcome
Schedule	Finished three months earlier
Cost-efficiency	Actual outturn cost €10 million under target
Safety	Good level
Uninterrupted Train Traffic (target punctuality 90%)	Punctuality of railway traffic 99.7%

Table 6: Outcomes of the project Source: the author

5.2 Case Study 2: Rantatunneli Alliance Project (2011 – 2017)

Project Scope

The Rantatunneli Alliance Project is based in Finland's second-largest city and an important industrial centre, Tampere. The city of Tampere is facing major issues such as increasing traffic, congestion, and bottlenecks. Therefore, the Rantatunneli project would improve the connections and safety of traffic throughout the city. The project's main idea was to relocate Highway 12 and construct a tunnel for a length of 2.3 km between Santalahti and Naistenlahti. The project was complex as it also included the required road and street patterns, equipment relocations, and interchange preparations throughout the 4.2 km stretch of highway. (Tampere City, Finnish Transport Agency, Lemminkäinen Infra Oy, Saanio & Riekkola Oy, A-Insinöörit Suunnittelu Oy, 2014)

Figure 32: Rantatunneli (The tunnel) Source: (Frame, Picarel-Pechdimaldjian, & Bartz)

The project's scope was specified by the Highway 12 road plan, specifically the section between Santalahti and Naistenlahti and the repercussions of its implementation. The project's initial budget was estimated to be over €185 million, with a final TOC of around €180.3 million. It was agreed that the estimated cost of the project would be shared between the City of Tampere and the Finnish Transport Agency by 67% and 33%, respectively. Following the budget of 2016, the total cost was raised to €200 million. However, this sum included new works due to zoning changes, increased contaminated soil treatment costs, and transport distances. (Finnish Transport Agency, 2018)

Alliance Participants

The alliance model for the Rantatunneli project was formed between Tampere City, Finnish Transport Agency (FTA), Lemminkäinen Infra Oy, Saanio & Riekkola Oy, and A-Insinöörit Suunnittelu Oy. The City of Tampere and FTA acted as owner participants while other parties acted as non-owner participants. (Tampere City, Finnish Transport Agency, Lemminkäinen Infra Oy, Saanio & Riekkola Oy, A-Insinöörit Suunnittelu Oy, 2013)

Project Objectives

The owner participants of the alliance have established the project's objectives in the development phase to ensure that the project is cost-effective and of better quality. The objectives are presented in the table below.

Key objectives	Description
Cost effectiveness	The project is implemented cost effectively using innovative solutions and operational and work methods. The Alliance will produce value for money for the subscriber.
Schedule	The project is deployed successfully according to the schedule where the tender phase duration is optimised.
Environment	The environmental impact of the project's end product and construction phase is minor.
Quality	The quality of planning and construction is excellent.
Safety	The project is managed in an excellent fashion in terms of safety.
Traffic	Traffic during the construction must be as unhindered as possible and the tunnel must remain in constant use after opening.
Public image	The public image of the project must be positive.

Table 7: Key Objectives of Rantatunneli Alliance Project Source: (Tampere City, Finnish Transport Agency, Lemminkäinen Infra Oy, Saanio & Riekkola Oy, A-Insinöörit Suunnittelu Oy, 2013)

Further, the objectives of the projects are refined into Key Research Areas (KRAs). The alliance must develop a work culture that supports innovation, collaboration, continuous development, efficiency, and effectiveness in order to meet these KRAs. As a result, the alliance partners would achieve better outcomes. The KRAs are listed in Table 8.

Key result area	Indicator
Schedule	The deployment of the tunnel in both directions takes place as planned according to the set schedules. Opening and deployment of other traffic systems takes place according the set schedules.
Safety	Accidents caused by the project are of minor magnitude and effect, e.g., absences from work due to accidents are few.
Usability	Traffic capacity and flow remain at an appropriate level.
Public image	The public image of the project improves and the acceptance of the project can be clearly ascertained.

,

Table 8: Key Result Areas set by the Alliance Team Source: (Tampere City, Finnish Transport Agency, Lemminkäinen Infra Oy, Saanio & Riekkola Oy, A-Insinöörit Suunnittelu Oy, 2013)

Challenges

During the implementation of the project, the participants faced many uncertainties and challenges. As a result, the interest of subcontractors was significantly reduced. Following are the uncertainties and technical challenges that occurred during the project: (Tampere City, Finnish Transport Agency, Lemminkäinen Infra Oy, Saanio & Riekkola Oy, A-Insinöörit Suunnittelu Oy, 2014)

- The processing time of the road plans and water permits
- The project's impact on public perception
- Demonstrating the value for money of the alliance model
- Risks occurred by the contamination of soil in Santalahti
- Traffic arrangements near the sites in Naistenlahti
- The quality of rocks
- Groundwater and air quality management at the tunnel heads

Ideas and Innovations

In order to complete the project more cost-effectively, a structured process was developed to generate ideas that were best for the project. The participants were provided with the training and explained the importance of ideas. In addition, the process was

also improved by identifying and removing barriers to innovation (Finnish Transport Agency, 2018). Table 9 presents the process of gathering ideas and innovations.

Innovation process	Description
Principles	A coordinator was elected to develop a structured process to identify ideas and innovations. The alliance participants were given training on this process and encouraged to present their ideas. A reward system was created to motivate the participants.
Promises	All the ideas were considered and documented regardless of their feasibility. Ideas that have been rejected were not taken off the list. All the ideas were passed on to the coordinator.
Exploration of ideas	A coordinator was assigned for each idea that was on the list. The coordinators were authorized to seek assistance from any alliance participant to explore the idea.
Deciding on ideas	As soon as the ideas were explored, a quick decision was made to accept, reject, or continue exploring. While making the decision, the impact of the ideas was considered.
Assessment of value for money	Technical feasibility, quality parameters, cost, safety, and life-cycle impact were considered when evaluating ideas.
Follow-up and reporting of ideas	The Alliance Leadership Team, the Alliance Project Team, and the Design Management Team assessed ideas and innovations.
Incentivization	The participants were rewarded for their ideas and given feedback.

Table 9: Key principles of the ideas and innovation process Source: (Finnish Transport Agency, 2018)

Success Factors

Following are the significant factors that defined the success of the Rantatunneli Alliance Project: (Finnish Transport Agency, 2018)

- The first crucial factor was implementing the procurement process. As a result of this process, the participants developed trust amongst each other.
- Collaboration in work coordination resulted in a more efficient working environment.
- The project adopted new techniques and tools such as the Big Room concept and the Target Value Design (TVD) from the beginning of the project. Also, the target outturn cost was set below the budget without compromising the project's scope due to ideas and innovations.

- The alliancing concept developed a positive team spirit within the participants. Though the project performed significant preparation and consultation in the planning phase, the cooperation between the participants was smooth.
- The ALT adopted a systematic process to approach risks throughout the project. All the decisions taken by management staff were “best for the project”.
- During the development phase, the participants were provided alliancing and lean construction training. Multiple events were organized to boost team spirit and develop a culture of continuous improvement.

Outcomes

The project of Rantatunneli succeeded to meet targets through alliancing concepts and lean tools. The project was completed six months before. The achieved quality was higher than the target. The level of safety was excellent, and the overall public image was improved. The owners were able to reduce the target cost from the budget. Following the success of the alliance approach, the Rantatunneli project won multiple awards such as the 2016 RIL award (Construction Engineers Association), 2017 project of the year (Project Association), and 2018 IPMA Global Project Excellence Award Gold Winner (IPMA International Project Management Association) (Mäkiaho, 2019).

Key Result Area	Outcome
Schedule	Finished six months earlier
Cost-efficiency	The cost saved was around €20 million
Quality	Higher than the target
Safety	Excellent
Public Image	Improved all the time

Table 10: Project Outcomes Source: the author

Room for Improvements

Even though all the key research areas were exceeded, a few areas could be improved for future alliance projects. (Dzwonnik, Lehtimäki, Okoro, Adriaans, & Hizebry, 2018)

- More visual communication
- Data updating more frequently and make it visual for the participants
- Using the right tools and techniques
- Defining and monitoring the operation processes
- Guidance to the participants
- Continuous improvement on the workflow

5.3 Findings from Case Studies

The author analyzes that the primary aim to adopt alliancing was to improve productivity and customer satisfaction. The construction industry in Finland must adopt a culture of trust and openness to provide a faster, cheaper, and better quality of construction projects. The positive impact on the people from the outcomes of these projects can be considered a significant success. However, several aspects should be kept in mind while choosing the alliance approach. The author identifies the following points as lessons learned from the case studies:

- The most capable team should be chosen to adopt a new model.
- All the participants must understand why the alliance approach has been chosen.
- A change of culture is a big concern; therefore, the participants require enough time to develop trust.
- The communication between the participants should be open, honest, fair, and straightforward to establish a collaborative environment.
- The participants should be given training in the form of team building events.
- In order to simplify the workflow, the alliance management team should adopt lean tools such as the Big Room, the Last Planner System, and the Takt-time planning technique.

5.4 Findings from the Questionnaire

In addition to case studies, a web-based questionnaire (See Appendix A) is conducted to analyse the current practice of alliancing. Based on responses, mutual understanding and effective communication between the participants are the most crucial features in alliancing. The alliance models lack the continuous involvement of the client throughout the construction processes. Also, the alliance members require to focus on customer's needs adequately. The majority of the survey participants agreed that the alliance members need training and coaching to improve the relationship. Other than that, equal importance should be given to eliminating repetitive works, improving safety standards, and sharing information.

As per the majority, one of the primary concerns in alliance models is that involved parties have to shift their cultural behaviours while adopting this new approach. There was not enough evidence found that the alliance agreements involve subcontractors. This could be a setback as the subcontractors are directly involved with day-to-day works. Additionally, similar to traditional methods, the alliance models still rely on standard project management tools on an operational level. The participants agreed that the lean principles could improve the alliance model on an operational level by standardizing the workplace. However, it could be a major challenge for the project entities to select capable alliance members who know and understand alliance and lean principles.

6. Discussion: Lean Thinking in Alliancing

In the previous chapters, the principles of alliancing and lean philosophy are discussed. Based on the literature review, the concept of alliancing and lean correlates to some extent. The lean goals focus on time, cost, quality and waste elimination, resource management, and customer requirements. On the other hand, alliancing focuses on a collaborative environment, risk-sharing, transparency, and dispute resolution. Section 4.5.1 outlines that to improve the project performance, a contractual agreement between the participants must support various attributes such as a collaborative environment, risk-sharing, and transparency. Therefore, the concept of alliancing is suitable for lean principles. The unification of lean construction and alliancing can be beneficial to maximize the efficiency of construction projects.

6.1 Correlation between Project Alliancing and Lean Principles

This section will analyze the correspondence between alliancing concepts and lean principles. This analysis aims to identify the areas in alliancing where it could be beneficial to implement lean tools and techniques. For this analysis, five lean principles identified by Salem and Zimmer (2005) are used (See Table 3). The principles are Customer focus, culture/people, workspace standardization, waste elimination, and continuous improvement.

Principles	**Lean Philosophy**	**Alliance Models**
Customer Focus	Customer-driven value	All stakeholder focus
Culture/People	Team environment	Team environment
Workplace Standardization	Operational	Contractual/organizational
Waste Elimination	Learn tools and techniques	Integrated decision making
Improvement	Continuous improvement	Innovations

Table 11: Overview of alliancing and lean principles Source: adapted from (Vilasini, 2014)

Customer Focus

As discussed before, the lean principle emphasises understanding and addressing customer's requirements. The concept of the alliancing also focuses on customer value. In an alliance model, the owner is also a part of the management team through-

out the project duration. Therefore, he influences the management team. The engagement of the owner leads to the elimination of reworks. Other than this, the open book culture of alliancing provides transparency between the owner and non-owner participants. As a result, the owner and non-owner participants understand each other's points of view. Ballard (2008) pointed that the continuous communication between the participants generated value. Eventually, it leads to the satisfaction of the customer. Even though establishing an alliance agreement is expensive, it can deliver better value for money than traditional contracts. However, the client must commit skilled and capable resources to achieve desired outcomes. (Young, Tadayon, & Lædre, 2016)

Culture/People

As discussed earlier, the most crucial factor for lean success is developing an organizational culture where the participants have mutual respect. Similarly, the alliance concept shares the same value as it is based on a shared culture where participants are dedicated to developing trust and work on common goals. Thus, it can be said that the characteristics of alliancing and lean philosophy are aligned.

Alliancing follows a strict process of selection of alliance members. The selection criteria are based on the best for the project. The members must be capable of executing their duties and understanding the alliance's concept. According to Locatelli, Mancini, Gastaldo, and Mazza (2013), training the alliance members is an essential investment when contemplating lean philosophy. As discussed in the case studies, many efforts were made into forming a unified alliance team culture from the beginning of the project. Since the primary importance is given to team culture, team building events are held continuously throughout the project.

Workplace Standardization

The author could not find sufficient evidence from the alliance concept on workplace standardization based on the literature review. Lahdenperä (2012) noted that alliance projects include an internal training program or consulting services for guidance. However, it depends on the alliance management team. On the other hand, Lean adopts a comprehensive approach that includes strategic, tactical, and operational levels to create value for the participants. Figure 33 reflects that the concept of the alliance is concerned with management and governance. In contrast, lean principles are concerned with implementation. (Vilasini, 2014)

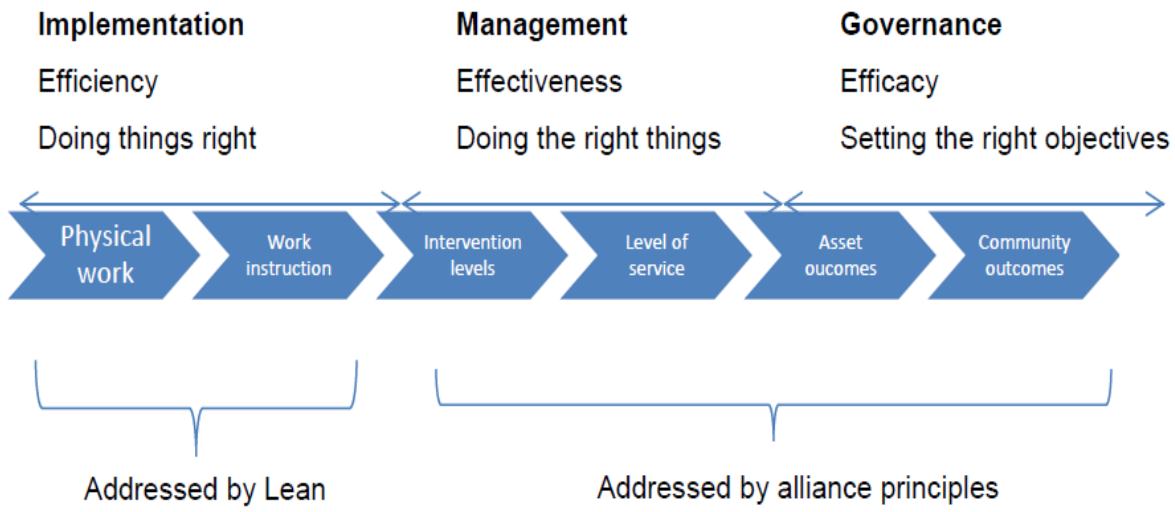

Figure 33: Value chain of alliance projects Source: (Vilasini, 2014)

The outcomes of the case studies resemble that with the integration of lean techniques and tools to alliancing, it was possible to provide a well-defined set of processes and procedures. As a result, the participants were able to achieve the desired outcome on an operational level.

Waste Elimination

As discussed in the literature review, lean principles improve performance by removing non-value adding activities. One of the fundamental principles of lean philosophy is to identify and eliminate waste. Lean promotes simplicity in organizations to eliminate wastes. The alliance models have similar features in this manner.

The author noted that waste removal processes are performed in alliance projects, such as eliminating repetitive works and minimizing unnecessary resource movements from the questionnaire's responses. As mentioned earlier, the alliance aims to achieve higher performance and quality. Consequently, the defects and extra processing are minimized. Since the alliance team is formed of the most suitable people for their roles and responsibilities, the threat of doubling up the resources is eliminated. Every participant is a part of the design and decision-making processes. Therefore, any variations that may arise are eliminated by the owner at the beginning. Other than that, the contractors and the designers can provide their skills and expertise on resources, construction methods, and scheduling to remove needless activities that may cause the delay in the project.

Continuous Improvement

The bottom-up approach of lean principles promotes continuous improvement in the organization. It demands the involvement of top management to achieve this. Also, it provides setting Key Performance Indicators (KPIs) to encourage continuous measurement of the progress by aligning all the stakeholders. Whereas alliancing provides a pain share – gain share model to monitor the progress continuously. In addition, in order to improve the workflow, innovations play a significant role in the alliance.

As mentioned in the literature review, all the alliance participants must conduct open discussions to make the best decisions for the project. Although the participants follow the guidelines, there can be changes if needed. For instance, in case study 1, the scope of the project was changed. However, the participants dealt with the changes due to the flexibility of the alliancing model. The participants are trained to challenge the schedule of the project continues to make it better. Lastly, the no-blame culture encourages the participants to work together if problems arise and share the lessons learned throughout the project regularly.

6.2 Best Practice to Use Alliancing

Lean Construction Institute (2015) emphasize the three domains (organizational, commercial, and operational) for successful project delivery. Figure 34 indicates that the concept of the alliance model corresponds to lean principles on the organizational and commercial domains of a project. Alliance models share similar characteristics with lean principles of culture/people, waste elimination, and continuous improvement on organizational level and with customer focus on the commercial level.

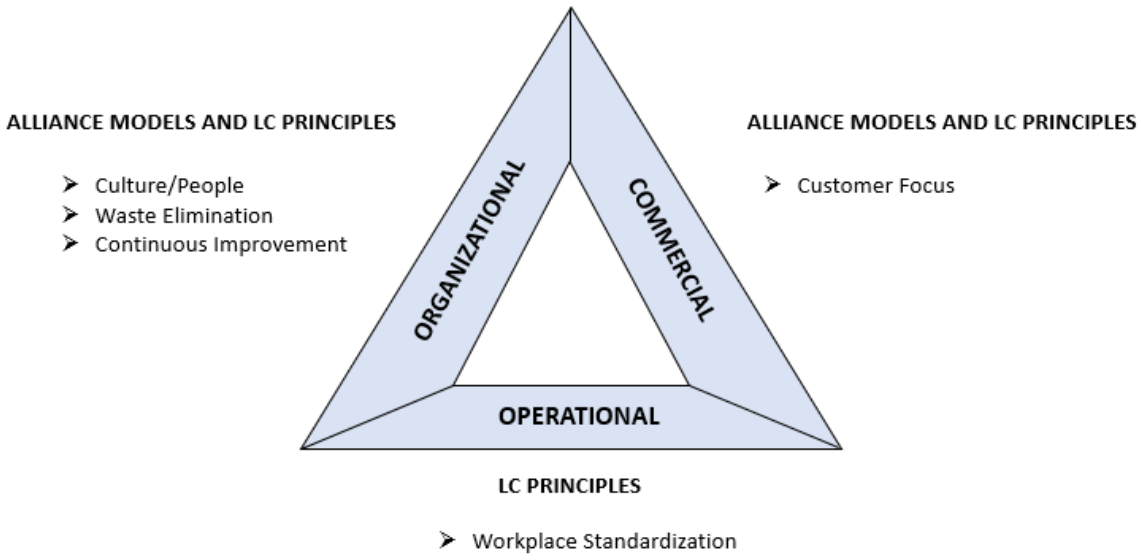

Figure 34: Lean construction institute triangle Source: (Lean Construction Institute, 2015)

Since project alliancing and lean principles correlate with each other, it can be ideal for integrating them. The alliance models could be facilitated by lean tools and techniques, making it a best practice. However, alliancing could learn and adapt from lean principles, particularly in the operational system. As per Young, Brenda, Tadayon, and Lædre (2016), in order to adopt lean principles, alliance models do not require any significant change in their structure and concept.

In order to improve the operational system, the alliance requires a new type of schedule planning and production control. One of the lean tools an alliance project can adopt is the Last Planner System (LPS). LPS is effective in overall planning and phase schedule. This tool can help the designers not to combine or harmonize various tasks. Moreover, the Last Planner System also provides a planning system based on social interaction and a unique way of cooperation between the participants. It allows to plan and combine the various tasks simply and efficiently.

The Last Planner System technique could be supported by another technique, Target Value Design (TVD). The basic idea of TVD is that the project owners set the targets of cost and time through planning and not the other way around. Cost estimation should be viewed as a tool for planning rather than the result (Saarinen, Koskelo, & Fuss, 2020). The other tools an alliance could adopt are the 5S technique and Takt time

production. The 5S technique promotes continuous improvement by efficiently organizing a workplace, reducing waste, and maximizing quality and productivity. Thus, the 5S tool could provide a solution to the operational system of alliancing. On the other hand, the takt time planning system could improve the productivity in alliancing. This system facilitates the conditions of improving the lead time, productive work, and eliminating wastes. Also, it makes sure that all the involved parties are on the same page on the present situation of the project by focusing on preplanning, continuous instructions, and daily communication.

In Liekki Railway Renovation Project (Case Study 1), the project participants implemented tools such as the Big Room and the Last Planner System. The Big Room environment helped bring people from different cultures to work together and adapt to the cultural shift. Also, the LPS provided flexibility and efficiency in the management of the project schedule. Similarly, in Rantatunneli Alliance Project, the project owners achieved significant success by integrating alliancing and lean tools such as the Big Room and Target Value Design.

7. Conclusions

The construction sector required a unique approach to delivering complex projects. The project entities needed to find drivers and processes that are compatible with the complexity of construction projects. Project alliancing provides solutions to the complexity, time, and cost constraints of construction projects. The alliance participants are involved in the decision-making process together as an integrated team. As a result, the collaborative approach of alliance adds value to the construction projects. Similarly, the integration of lean principles to construction enhances the project's performance by minimizing waste, time, and effort. Therefore, the implementation of lean principles into project alliancing will generate the maximum value of the project.

The cost of a construction project depends on many factors, particularly selecting a suitable contractual agreement. The owner could save cost by taking a strategic approach to choose an agreement. There are different types of construction contracts available to meet all parties' requirements. The selection of a construction contract should be based on the project's scope, budget, and owner's goals. The traditional types of contracts are simple to adapt. However, they do not thrive under complex projects where cost transferring risks are high. As a result, the concept of alliancing is gaining popularity as a feasible project delivery method in the construction sector.

Alliancing concept was originated in the UK in the oil and gas industry. This framework was based on special features like trust, integrity, risk-sharing, and faith. Since then, the adoption of alliancing has emerged in large-scale projects in the Australian construction industry. The success of the Australian experience encouraged other countries like Finland, Austria, Germany, New Zealand, Singapore, the Netherlands, and the UK.

The framework of alliancing consists of integrated teams to operate and govern the projects. These integrated teams formed by the owner and non-owner participants are structured at different levels. The first level includes Alliance Leadership Team, which is responsible for defining goals and objectives. The next level includes the Alliance Management team that is responsible for managing day-to-day activities and processes. Lastly, the Wider Project Team includes service providers such as designers, contractors, and vendors. The members of the integrated teams are selected based on their capabilities and determination to work best for the project. The primary benefit

of alliancing is flexibility, as it handles uncertainties and changes throughout the project life cycle. The compensation framework of alliancing encourages the participants to exploit their abilities and improve the performance of a project. However, alliancing requires the right circumstances to implement it. Otherwise, choosing it for the wrong reasons could lead to failure. Other than that, the project owner could face a range of barriers and constraints for successful implementation of alliancing. The primary issue is a cultural change for the participants. An alliance project's success depends on the participants' abilities to remain committed to the concept. Also, clear communication from the top management is required for the smooth flow of information and the decision-making process.

On the other hand, lean philosophy shares similar values as alliancing. The main focus of lean construction is to improve quality, increase efficiency, and reduce waste. The lean construction concept is based on five principles. These principles include focusing on customer requirements, improving culture and behaviour, standardising the workplace, eliminating waste, and continuous improvement.

The basic concept of alliancing correlates with lean principles. Both approaches aim to generate maximum value for the client. However, a successful construction project requires improvement on three domains: organizational, commercial, and operational. Considering these domains, project alliancing lacks improvement on the operational level as it relies on standard project management tools. In contrast, lean construction improves the operating system through lean tools such as the 5S technique, the Last Planner System, and the Target Value Design. The alliancing could adopt these tools and techniques to enhance productivity in the workplace. The findings from the case studies have shown that the alliance project can achieve significant success through lean tools. Therefore, the best practice to use alliancing is to adopt lean construction principles throughout the project life cycle.

7.1 Limitations

The research into lean integration in alliancing in this study was based on only two case studies. Both of the case studies include projects from Finland. Future research could eliminate this limitation by including case studies from different countries to an-

alyse the global experience in alliancing and lean construction. Also, these case studies are based on infrastructure projects as the author faced difficulties finding case studies where both alliancing and lean principles were implemented. The research could be improved with a broader perspective if one of the case studies included alliancing experience from a commercial or residential project.

Moreover, a web-based questionnaire was structured to get insights into alliancing experiences. The intended population for the questionnaire were top and middle-level participants who have been part of the alliance projects. However, the author did not get enough responses from experienced persons. Future research could also consider the interviews from top management to analyse the current practice.

Based on the questionnaire, the construction industry relies on traditional operating systems; it could be challenging to recruit people in alliance models who know lean techniques. Moreover, it can be said that the alliance participants form a partial alliance as some of the key stakeholders, such as subcontractors, are not considered in the loop.

7.2 Recommendations and Future Work

Even though the integration of alliance models and lean provides outstanding results, the idea of their integration is far from perfect. The alliancing and lean concepts have the full potential to evolve continuously. Future research could focus on developing a combined framework to put the theory into practice. This framework could be developed from practices and analysing if any significant changes in the alliance are required. The framework should include key stakeholders such as subcontractors to optimize the workflow with their skills and expertise. The research in future could also identify the cause of wastes in alliancing and potential lean techniques for the solution. Lastly, the possible barriers while integrating lean with alliance should be studied.

Declaration of Authorship

I hereby declare that the attached Master's thesis was completed independently and without the prohibited assistance of third parties, and that no sources or assistance were used other than those listed. All passages whose content or wording originates from another publication have been marked as such. Neither this thesis nor any variant of it has previously been submitted to an examining authority or published.

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Appendix

Appendix A

Web-Based Questionnaire

Project Alliancing and Lean Principles

The construction industry is shifting towards relational type agreements such as Project Alliancing. The concept of alliancing focuses not only on traditional goals such as time, cost and quality but also on the environment, work-life balance and community developments. However, it can be pretty challenging to adapt the alliance approach.

On the other hand, the lean philosophy is also gaining popularity in the construction industry. The concept of alliancing align with lean principles to some extent. The following five lean principles are related to construction projects.

Customer Focus :
This principle puts a strong emphasis on understanding and addressing customer's requirements. It promotes the focus on what customer values. Understanding the customer's value requires a different level of trust. Lean demands that all the participants should come together to deliver the client's demands.

Culture/People:
This principle states that the organization should develop a culture that improves mutual respect between the participants. The relationships between the participants should be long-term, trust-based, and mutually beneficial. Lean states that training of the participants is the most important investment.

Workplace Standardization:
Lean implies that an organization should maintain a clean and organized workplace as it increases safety standards. Lean encourages using several techniques such as providing visual management devices, 5S (sort, straighten, sweep, standardize, and systemize), creating defined work processes for repetitive tasks, etc.

Waste Elimination:
One of the main features of Lean is that it eliminates activities or barriers that interrupt value-adding activities or wastes. Lean not only focuses on physical waste but also on cultural and behavioral wastes. (I.e. waiting, unnecessary movements, not utilizing talents, etc.)

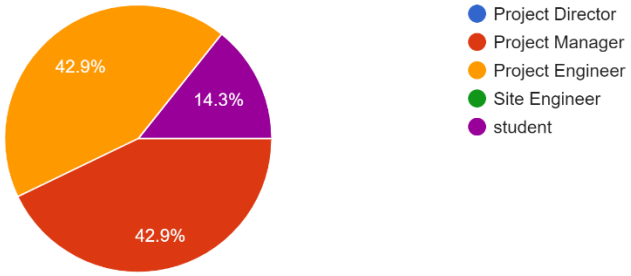
Continuous Improvement:
Lean principles demand a mindset of continuous improvement to eliminate waste. Other than that, lean promotes a level of perfection. There is transparency between project participants to share ideas to create a better value.

The survey is created based on these principles. This survey aims to analyze how alliancing can learn from lean construction principles. Completion of this survey shows your consent to participate. However, all responses will be held anonymous and will be used only for my thesis research. The data will be deleted as soon as the research is completed. The survey should take 10 minutes.

*Obligatory

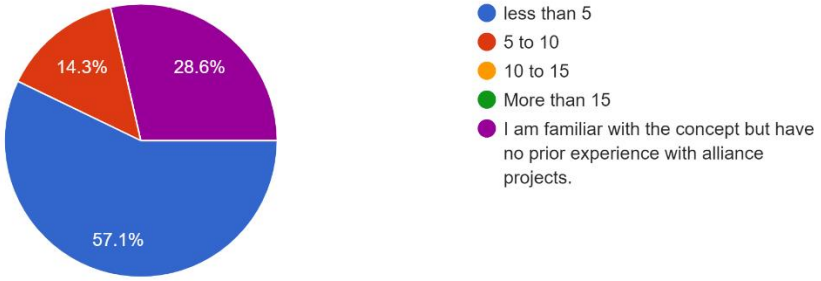
Question 1:

Your job title:
7 responses



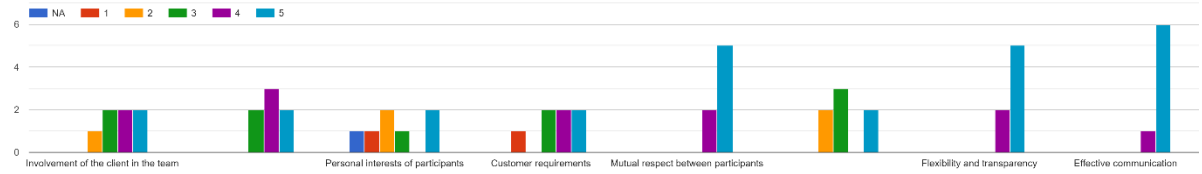
Question 2:

The average number of years of experience in alliancing:
7 responses



Question 3:

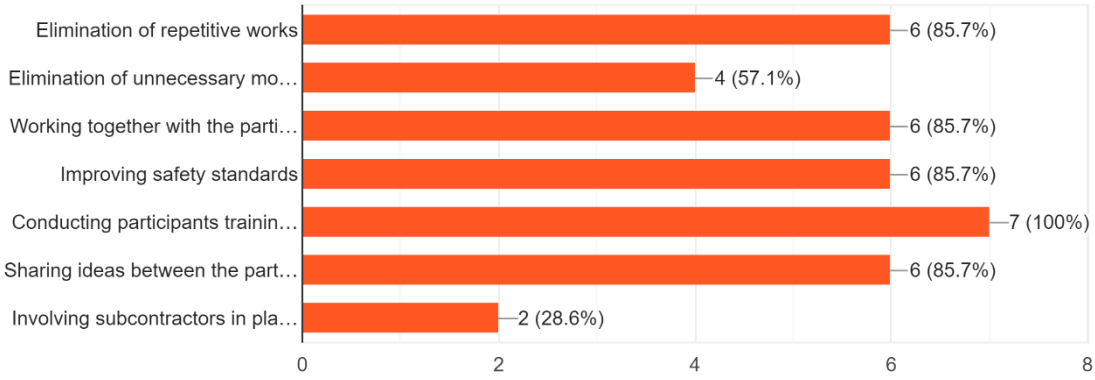
This question is designed to identify if the core principles of alliancing correspondence with lean philosophy. Based on your experience in alliancing, select the relative importance of the following factors. (NA- Not applicable, 1- Not at all important, 2- Slightly important, 3- Moderately important, 4- Very important, 5- Extremely important)



Question 4:

Which of the following initiatives were taken during an alliance project to improve efficiency and quality?

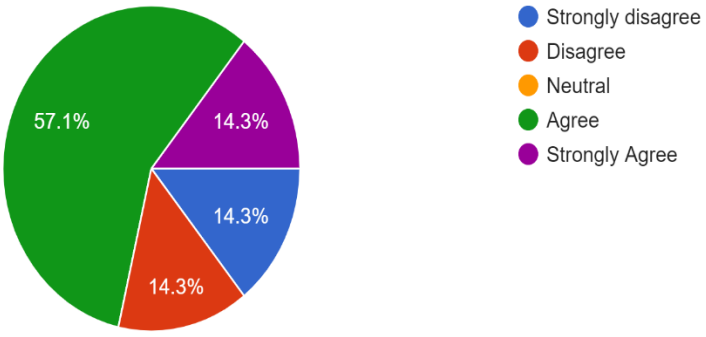
7 responses



Question 5:

Since most participants are used to their old habits and behaviors from the traditional approach, it can be challenging to adopt a collaborative culture such as alliancing due to culture shock.

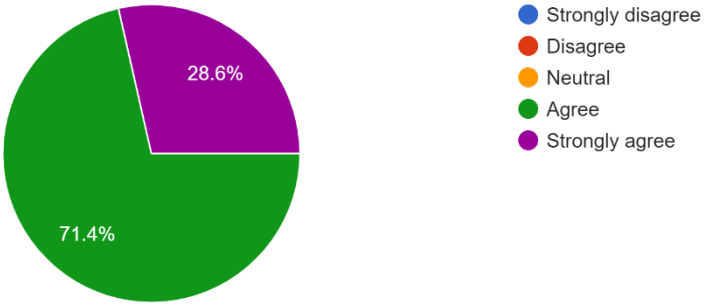
7 responses



Question 6:

The integration of a lean principle "Culture/People" to alliancing could be beneficial to develop a collaborative environment.

7 responses



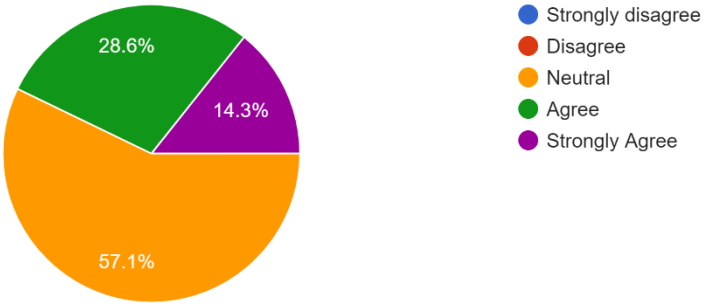
Question 7:

In order to improve the performance of an alliance project, the following initiatives are necessary. How strongly do you agree?

Question 8:

In order to handle daily operations, alliancing relies on common project management tools such as Critical Path Method (CPM), Gantt Chart, Program ...itional projects that would use common PM tools.

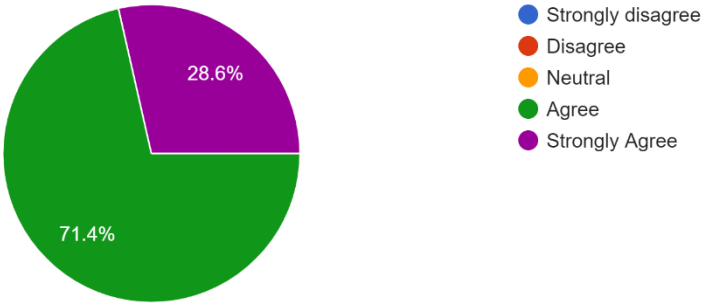
7 responses



Question 9:

On an operation level, lean construction encourages to use of specific tools such as last-planner and 5S (sort, straighten, sweep, standardize, and sys...ting tools in alliancing can deliver better results?

7 responses



Question 10:

What are your views on integrating lean principles to alliancing? Could there be any barriers?

7 responses

good when it is practiced right

Lean construction works on the principle- collaboration of work by reducing the RFI's. It has directly a relationship with the alliancing. To what extent, it can be applied will vary widely globally due to the building and contractural laws.

Could be beneficial to improve the workflow

There might be time shortages and lack of time management die to support the lean; the potential of lean also might not be understood by all the parties involved; and implementing lean requires sufficient workforce that might not be possible for an alliancing to make it.

I don't think there could be any barriers in the implementation of lean principles to alliancing

The idea seems feasible and innovative for project solutions. However, finding workforce who has experience in alliance and lean construction could be challenging.

results can be maximized

Question 11:

Are there any suggestions you would like to share to improve alliance projects?

2 responses

By the removing of waste in the planning process and calculation of costs realistically as well as planing the schedule effectively.

The less the costs will get escalated and claims emerged, the better will be the chances of the project stakeholders to consider the alliancing on further projects.

Culture and mutual understanding in alliancing projects play a key role; therefore, the parties involved must have a mutual understanding of their culture and expectations in a professional working environment.

Appendix B

Lean Tools

No.	Lean Tool
1	Last Planner System (LPS)
2	Concurrent Engineering
3	Daily Huddle Meetings
4	5S
5	First Run Studies
6	Visual Management
7	Fail Safe for Quality
8	Construction Process Analysis
9	Kanban (Pull System)
10	Just-In-Time
11	Work Standardization
12	Value Stream Mapping
13	Statistical Process Control (SPC)
14	Work Structuring
15	Pareto Analysis
16	Poka-Yoke (Error Proofing)
17	Continuous Flow
18	Six Sigma
19	Failure Mode and Effects Analysis (FMEA)
20	Bottleneck Analysis
21	Kaizen
22	PDCA (Plan, Do, Check, Act)
23	5 Whys
24	Muda Walk
25	Root Cause Analysis
26	Check Sheet
27	Synchronize/Line Balancing
28	Jidoka/Autonomation
29	FIFO line (First In, First Out)
30	Team Preparation

Table: Suitable lean tools Source: (Ansah, Sorooshian, Bin Mustafa, & Duvvuru, 2016)

List of Literature

Abrahams, A., & Cullen, A. (n.d.). *Project Alliances In The Construction Industry.* KPMG Legal.

Accent Estimating. (n.d.). *COST-PLUS CONTRACTS VS. FIXED-PRICE CONTRACTS*. Retrieved from Accent Estimating: https://aestimating.com.au/blog/cost-plus-contracts-vs-fixed-price-contracts/

Akintoye, A., Beck, M., & Kumaraswamy, M. (2016). Public Private Partnerships A global review. In A. Akintoye, M. Beck, & M. Kumaraswamy, *Public Private Partnerships A global review.* Abingdon: Routledge.

Alarcon, I., Christian, D., & Tommelein, I. D. (2011). Collaborating with a Permitting Agency to Deliver a Healthcare Project: Case Study of the Sutter Medical Center Castro Valley (SMCCV). *19th Annual Conference of the International Group for Lean Construction*, (pp. 402-415). Lima, Peru.

Ansah, R. H., Sorooshian, S., & Bin Mustafa, S. (2016). LEAN CONSTRUCTION: AN EFFECTIVE APPROACH FOR PROJECT MANAGEMENT. *ARPN Journal of Engineering and Applied Sciences*.

Ansah, R. H., Sorooshian, S., Bin Mustafa, S., & Duvvuru, G. (2016). © IEOM Society International. *International Conference on Industrial Engineering and Operations Management.* Detroit, Michigan, USA.

Ballard, G. (2008). The Lean Project Delivery System: An Update. *Lean Construction Journal*, 19.

Ballard, G. (2012). *Target Value Design.*

Ballard, G., & Howell, G. (1998). WHAT KIND OF PRODUCTION IS CONSTRUCTION? *International Group of Lean Construction* (pp. 1-7). Guaruja, Brazil: Lean Construction Institute.

Ballard, H. G. (2000). *The last planner system of production control.*

Bartz, O. (2019). *Alliancing 101.*

Bashir, A. M., Suresh, S., Proverbs, D., & Gameson, R. (2011). A critical, theoretical, review of the impacts of lean construction tools in reducing accidents on

construction sites. *Annual ARCOM Conference* (pp. 249-258). Bristol, UK: Association of Researchers in Construction Management.

Benarroche, A. (2019, 02 21). *How Does a Guaranteed Maximum Price (GMP) Contract Work?* Retrieved from levelset: https://www.levelset.com/blog/guaranteed-maximum-price-gmp-contract/

BigRentz, Inc. (2021, 01 22). *Lean Construction: Principles Shaping the Future of Construction*. Retrieved from bigrentz: https://www.bigrentz.com/blog/lean-construction

Bowmans. (n.d.). *A guide to construction contracts.* Bowmans.

Cain, C. T. (2004). *Profitable Partnering for Lean Construction.* Willy-Blackwell.

Chew, A. (2004). *ALLIANCING IN DELIVERY OF MAJOR INFRASTRUCTURE PROJECTS AND OUTSOURCING SERVICES IN AUSTRALIA - AN OVERVIEW OF LEGAL ISSUES.*

Chick, G. (2013). *Implementing Lean in Construction.* London: CIRIA.

Cicero, J. T., & Gallo, R. (2019, 03 28). *4 POWERFUL APPROACHES TO COLLABORATIVE PROJECT DELIVERY*. Retrieved from karpinskieng: https://karpinskieng.com/insights/4-powerful-approaches-to-collaborative-project-delivery

Darwish, D. M. (2017). *Construction Project Delivery Methods.*

Dauber, V. (2003). *Measuring and minimising waste in construction by applying lean thinking.* Dundee: PhD Thesis. University of Dundee.

de Man, A.-P., & Roijakkers, N. (2009). Alliance Governance: Balancing Control and Trust in Dealing with Risk. *Long Range Planning 42*, 75-95.

Department of Infrastructure and Regional Development, Australia. (2015). *National Alliancing Contracting Guidelines - Guide to Alliance Contracting.* Canberra: Department of Infrastructre and Regional Development.

Department of Infrastructure, Regional Development and Communications Australia. (2015, September). *https://www.infrastructure.gov.au/.* Retrieved August 5, 2020, from

https://www.infrastructure.gov.au/infrastructure/ngpd/files/National_Guide_to_Alliance_Contracting.pdf

Department of Treasury and Finance. (2006). *The Project Alliancing Practitioners' Guide.* Melbourne: Department of Treasury and Finance, Australia.

Department of Treasury and Finance, Victoria, Australia. (2009). *In Pursuit of Aditional Value - A Benchmarking Study into alliancing in the Australian Public Sector.* Melbourne: Department of Treasury and Finance.

Diekmann, J. E., Krewedl, M., Balonick, J., & Stewart, T. (2004). *Application of lean manufacturing principles to construction.*

Drawert, S. (2020). *CONTRACT, CHANGE AND CLAIM MANAGEMENT.* Arcadis.

Dulaimi, M. F., & Tanamas, C. (2008). *The principles and applications of lean construction in Singapore.*

Dzwonnik, G., Lehtimäki, T., Okoro, T. V., Adriaans, M., & Hizebry, Y. (2018). *IPMA Global Project IPMA Global Project Feedback report.* IPMA.

Ebbs, P. (2017, 08 30). *5 Levels of the Last Planner® System "Should, Can, Will, Did and Learn"*. Retrieved from leanconstructionblog: https://leanconstructionblog.com/5-Levels-of-the-Last-Planner-System-Should-Can-Will-Did-and-Learn.html

Egan, S. J. (1998). *Rethinking Construction: The report of the construction task force.* London, UK: The construction task force.

Elbeltagi, D. E. (2009). *Construction Project Management.*

Ellis, G. (2021, 01 04). *8 Main types of construction contracts*. Retrieved from digital builder: constructionblog.autodesk.com/construction-contracts-types/

Finity, J. (2020, 02 12). *Construction Contracts: Understanding The 5 Main Contract Types*. Retrieved from levelset: https://www.levelset.com/blog/construction-contracts-5-main-types/

Finnish Transport Agency. (2015). *Lielahti – Kokemäki allianssihanke Arvoa Rahalle Raportti.* FTA.

Finnish Transport Agency. (2018). *Rantatunneli Value for money report.* Helsinki: FTA.

Frame, S., Picarel-Pechdimaldjian, J., & Bartz, O. (2019). *Guide to Contract Alliancing in Construction.* Arcadis.

Frame, S., Picarel-Pechdimaldjian, J., & Bartz, O. (n.d.). *Contract Alliancing in Construction.* CMS.

Frandson, A. (2019). *Takt time planning as a work structuring method to improve construction workflow.*

Frandson, A., Berghede, K., & Tommelein, I. D. (2013). Takt time planning for construction of exterior cladding. *IGCL-21.* Fortaleza, Brazil.

Green, S. D. (2002). The human resource management implications of lean construction: critical perspectives and conceptual chasms. *Journal of Construction Research 3(1)*, 147-165.

Hayford, O. (2018). *Collaborative Contracting.*

Hayford, O. (2020). *Collaborative contracting and procurement.* DLA Piper.

Heiskanen, M. A. (2015). *Lielahti–Kokemäki project alliance.* FTA.

Heiskanen, M. A., & Nyhä, M. (2013). *NETLIPSE Network Meeting Helsinki Pilot Railwat renovation project.*

Helen, R., & M, L. (2012). *CULTURE SHOCK OF ALLIANCE PROJECTS .*

Hill, K. (2020, 02 02). *The Guide To Implementing Lean Principles In Construction*. Retrieved from industry europe: https://industryeurope.com/sectors/construction-engineering/the-guide-to-implementing-lean-principles-in-construction/

Howell, G. A. (1999). *What is Lean Construction - 1999.*

Jain, V. (n.d.). *Types of construction contracts and their comparison*. Retrieved from The Constructor: theconstructor.org/construction/types-of-construction-contracts-comparision/14268/

Jin, H., & Rial, I. (2017). Regulating local government financing vehicles and public–private partnerships in China. *Journal of Infrastructure, Policy and Development*, 26.

Kaushik, A., Keraminiyage, K., Koskela, L., Tzortzopoulos, P., & Hope, G. (n.d.). *Knowledge Transfer Partnership: Implementation of Target Value Design in the UK construction Industry.*

Killough, D. (2018, 08 02). *Common Construction Project Delivery Methods: A Breakdown*. Retrieved from levelset: levelset.com/blog/construction-project-delivery-methods/

Klee, L. (2018). *International Construction Contract Law.* John Wiley & Sons.

Kobayashi, K., Fisher, R., & Gapp, R. (2008). Business improvement strategy or useful tool? Analysis of the application of the 5S concept in Japan, the UK and the US. *Taylor and Francis Online*.

Koolwijk, J. S. (2006). *Alternative Dispute Resolution Methods Used in Alliance Contracts.*

Koskela, L. (1992). *Application of the new production philosophy to construction.*

Koskela, L., Howell, G., Ballard, G., & Tommelein, I. (2002). *The foundations of lean construction.*

Kumar, U. V., & Ramasamy, G. (2016). *A critical study of various lean techniques in practice and developing a framework for different construction building projects.* Sadguru Publications.

Lahdenperä, P. (2012, 02 06). Making sense of the multi-party contractual arrangements of project partnering, project alliancing and integrated project delivery. Tampere.

Lahdenperä, P. (2012). Making sense of the multi-party contractual arrangements of project partnering, project alliancing and integrated project delivery. *Construction Management and Economics, 30(1)*, 57-79.

Lean Construction Institute. (2015). *TRANSFORMING DESIGN AND CONSTRUCTION: A Framework for Change.* Lean Construction Institute.

Lean Enterprise Institute. (2009). *Principles of lean*. Retrieved from lean.org: https://www.lean.org/whatslean/principles.cfm

Leong, M. S., Ward, S., & koskela, L. (2015). Towards an Operational Definition of Lean Construction Onsite. *23rd Annual Conference of the International Group for Lean Construction*, (pp. 507-516). Perth, Australia.

Lichtig, W. A. (2005). *Sutter Health: Developing a contracting model to support lean project delivery.*

Liker, J. K., & Meier, D. (2006). *The Toyota Way Fieldbook.* McGraw-Hills.

Linnik, M., MBerghede, K., & Ballard , G. (2013). “An Experiment in Takt Time Planning Applied to Non-Repetitive Work. *Proceedings 21st Annual Conference of the International Group for Lean Construction*, (pp. 609-618). Fortaleza, Brazil.

Locatelli, G., Mancini, M., Gastaldo, G., & Mazza, F. (2013). Improving Projects Performance With Lean Construction: State Of The Art, Applicability And Impacts. *organization, technology and management in construction · an international journal · 6(2)*, 775-783.

Macomber, H., & Barberio, J. (2007). *Target-Value design: nine foundational practices for delivering surprising client value.* Lean Project Consulting.

Mäkiaho, M. (2019). *IPMA Award, Tampere Tunnel 2018.* FTIA.

Mark Saunders, P. L. (2009). *Research methods for business students* (5 ed.). Harlow, England: Pearson Education Limited.

Marzouk, M., Bakry, I., & El-Said, M. (2011). *APPLICATION OF LEAN PRINCIPLES TO DESIGN PROCESSES IN CONSTRUCTION CONSULTANCY FIRMS.*

McInnis, A. (2003). *Relational contracting under the new engineering contract: A model, framework and analysis.*

Mitropoulos, P., & Tatum, C. (2000). Management-Driven Integration. *Journal of Management in Engineering 16(1)*, 48-58.

Morwood, R., Scott, D., & Pitcher, I. (2008). *Alliancing - A participant's guide.* Brisbane: AECOM.

Mossman, A. (2009). Why isn’t the UK construction industry going lean with gusto? *Lean Construction Journal*, 24-36.

Mossman, A. (2018). WHAT IS LEAN CONSTRUCTION: ANOTHER LOOK. *Annual Conference of the International. Group for Lean Construction* (pp. 1240-1250). Chennai, India: IGLC.

Naoum, S. (2003). An overview into the concept of partnering. *International Journal of Project Management 21*, 71-76.

Pellicer, E., Cerveró, F., Lozano, A., & Ponz-Tienda2, J. L. (2015). THE LAST PLANNER SYSTEM OF CONSTRUCTION PLANNING ANDCONTROL AS A TEACHING AND LEARNING TOOL. *INTED2015 Conference.* Madrid, Spain.

Picchi, F., & Granja, A. D. (2004). Construction Sites: Using Lean Principles to Seek Broader Implementations. *12th Annual Conference of the International Group for Lean Construction*, (pp. 3-5). Helsingor, Denmark.

Pinch, L. (2005). *Lean Construction - Eliminating the Waste.*

Portes, F. J. (2016). *intechopen*. Retrieved 08 05, 2020, from https://www.intechopen.com/books/case-study-of-innovative-projects-successful-real-cases/alliances-an-innovative-management-model-for-public-and-private-investments

Rahat, A. (2014). *Organizational barriers for adopting project alliancing.*

Raisbeck, P., Millie, R., & Maher, A. (2010). Assessing integrated project delivery: A comparative analysis of IPD and alliance contracting procurement routes. *ARCOM Conference* (pp. 1019-1028). Leeds, UK: Association of Researchers in Construction Management.

Raisbeck, P., Millie, R., & Maher, A. (2010). *ASSESSING INTEGRATED PROJECT DELIVERY: A COMPARATIVE ANALYSIS OF IPD AND ALLIANCE CONTRACTING PROCUREMENT ROUTES.*

Riediger, D.-I. N. (2019). *Project Management in Civil Engineering.* Berlin: HTW Berlin.

Ross, J. (2006). *The Project Alliancing Practitioners' Guide.* Melbourne: Department of Treasury and Finance, Australia.

Ross, J. (2009). *Alliance Contracting: lessons from the Australian experience.*

Saarinen, J. (2014). *Project Alliancing – New Platform for Efficient Solutions; Finland's experience.* Vison Alliance Partners Oy.

Saarinen, J., Koskelo, S., & Fuss, P. (2020). *Alliance report - Making Finland the world leader in integrated construction.* Vison Oy.

Sakal, M. W. (2005). *Project Alliancing: A Relational Contracting Mechanism for Dynamic Projects.*

Salem, O., & Zimmer, E. (2005). Application of lean manufacturing principles to construction. *Lean construction journal*, 59.

Schlabach, C. (2013). *Untersuchungen zum Transfer der australischen Projektabwicklungsform, Project Alliancing auf den deutschen Hochbaumarkt.* Kassel University Press.

Scott, B. (2000). *Partnering in Europe - Incentive Based Alliancing for Projects.* Thomas Telford Ltd.

Smith & Howard. (2017, 04). *What Are Public-Private Partnerships?* Retrieved from smith-howard: https://www.smith-howard.com/what-are-public-private-partnerships/

Tampere City, Finnish Transport Agency, Lemminkäinen Infra Oy, Saanio & Riekkola Oy, A-Insinöörit Suunnittelu Oy. (2013). *Rantatunneli Alliance Project Project Plan.* Tampere.

Tampere City, Finnish Transport Agency, Lemminkäinen Infra Oy, Saanio & Riekkola Oy, A-Insinöörit Suunnittelu Oy. (2014). *Rantatunneli Alliance Value for Money Report.* Tampere.

The Construction Management Association of America. (2012). *An owner's guide to project delivery methods.*

The State of Queensland. (2015). *Project Assessment Framework - Alliance Establishment and Management.* Queensland Treasury.

Umstot, D. (2016). *Target Value Design (Delivery) An Overview.* Umstot Project & Facilities Solutions, LLC.

Vilasini, N. (2014). *Generating value in alliance contracts through the lean concept.*

Vilasini, N. (2014). *Generating value in alliance contracts through the lean concept.*

Walker, D. H., Hampson, K. D., & Peters, R. (n.d.). *Relationship-Based Procurement Strategies for the 21st Century.* Canberra: AusInfo.

Walker, P. D., Harley, D., & Mills, P. (2008-2013). *Longitudinal Study of Performance in Large Australasian Public Sector Infrastructure Alliances.* RMIT University.

Walsh, P. (2015). *Construction Blog*. Retrieved 08 04, 2020, from http://constructionblog.practicallaw.com/alliance-contracting-the-way-forward/

Weatherall, M. (2013). *Best Value Contracting – From Collaboration?* Simpson Grierson.

Wittmann, C. M., Hunt, S. D., & Arnett, D. B. (2009). Explaining alliance success: Competences, resources, relational factors, and resource-advantage theory. *Industrial Marketing Management 38*, 743-756.

Womack, J. P., & Jones, D. T. (2003). *Lean thinking - Banish waste and create wealth in your corporation.*

Woodruff, J. (2020, 08 25). *What Is a Cost-Plus Contract in Construction?* Retrieved from smallbusiness.chron.com: https://smallbusiness.chron.com/costplus-contract-construction-66735.html

WSP Global. (2021). *Leveraging project procurement & delivery approaches for positive outcomes - How and when to use alliance contracting.*

Xue, X., Shen, Q., & Ren, Z. (2010). Critical Review of Collaborative Working in Construction Projects: Business Environment and Human Behaviors. *Journal of Management in Engineering 26(4)*, 196.

Young, B. K., Tadayon, A., & Lædre, O. (2016). Project Alliances And Lean Construction Principles. *24th Ann. Conf. of the Int'l. Group for Lean Construction*, (pp. 33-42). Boston, MA, USA.

Zimina, D., Ballard, G., & Pasquire, C. (2012). target value design: using collaboration and lean approach to reduce construction cost. *Construction management and econmics*, 383-398.

Zuber, S. Z., Bahaudin, A. Y., & Nawi, M. N. (2018). *An overview of project delivery methods in construction industry.*