

Implementation of Lean Construction Method Depending on Generation Gap

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Abstract — *The research project focuses on the implementation of Lean Construction in two construction companies where each owner belongs to a different generation. Company A belongs to the Baby Boomer generation while Company B the owner belongs to generation "X" and I, the assistant project manager, belonging to generation "y". So this project studies the generational shock and the different visions that each generation has with reference to work ethics and how this affects the management of a company when applying new methodologies to improve its efficiency. Using the principles of Lean Construction and knowing the characteristics of each generation, I will develop an implementation guide for the construction and management processes involved in a construction company and that it be more efficient in terms of profits, process identification, definition of roles, reports and above all the constant communication between owner, employee and client.*

Key Terms — *Construction process, Generation, Lean, RACI.*

INTRODUCTION

As the years go by the construction industry continues to grow and innovate by applying the new technologies and products created. Where the initial objective of each construction company should be to execute each project perfectly and without loss acquiring the estimated profit; but we know that this is not always the case given that during a construction project changes occur at the last minute or variables beyond the control of the contractor. But how to prevent or anticipate it? One of the most accurate methods to meet these objectives is the

Lean Construction Methodology; It helps to restructure the production management system of a company to eliminate losses in the production process.

This research project will be focused in the implementation of Lean Construction methodology based on the generation gap in construction companies.

PROBLEM STATEMENT

The construction industry has existed since before the Roman Empire, where it has evolved according to technological advances and the needs of the human being. With the purpose of improving the quality of life and improving the efficiency of construction processes. Composed of three essential elements: the architect, the engineer and finally the contractor who work hand in hand to be able to carry out the construction work.

Some of the factors for a construction project to be successful and have profits are documentation, efficiency and organization. Some small construction companies lack these factors either due to lack of employees, lack of knowledge or generation gap. But what happens when the generation gap affects the growth of a construction company?

RESEARCH DESCRIPTION

This research studies the behavior of the last three generations in the field of construction. The difference between a leader who refuses to implement new methods for an efficient project with profits versus a leader willing to implement new construction methods without losses.

RESEARCH OBJECTIVES

The objective of this research is to create a lean construction guide depending on the type of generation a leader belongs to.

RESEARCH CONTRIBUTIONS

Knowing and /or understanding the behavior of each generation we could improve the efficiency of a construction company by implementing the Lean Construction Method.

LITERATURE REVIEW

In order to apply the methodology of "Lean Construction" in a construction company we must consider the type of generation that directs it. We must ask ourselves this question; Is the multigenerational shock affects the work environment? Several studies have revealed that this situation mostly affects the operation of a company. With this data in mind, we investigate the characteristics of the last three generations (Baby Boomers, Generation X & Generation Y) in the world of work. What characterizes them? What is your work ethic? What defines you as a person? & What is your learning method? In order to apply the Lean construction method in a company.

Lean Construction Overview

Lean Construction has existed for more than fifteen years. At the same time the five lean principles as outlined by Womack and Jones [1] have gained a firm foothold in the manufacturing & construction industries [2].

The practical stream started with Howell and Ballard [3] observations that typically only half of the tasks in a weekly plan get realized as planned on site. In a series of experimental work, a new approach to production control, called the Last Planner™ System, was developed by Glenn Ballard [4]. Whilst Last Planner covers production control and improvement, methods for production system design have also been developed by [5].

Lean Production was coined by [6] to describe the implementation of the ideas inherent in the Toyota Production System. It was based upon their studies of the car manufacturing industry in Japan and other countries. Womack and Jones [7] moved from the automotive industry to look at manufacturing in general and established the five principles for Lean Production; this theoretical foundation is called Lean Thinking by them:

1. Precisely specify value by specific product.
2. Identify value stream for each product.
3. Make value flow without interruptions.
4. Let the customer pull value from the producer.
5. Pursue perfection.

Construction is obviously a production, and [8] establishes a theory for production and demonstrates its use in construction. The basic idea is that construction should not be transformation only but understood as a flow of work and a creation of value as well.

Construction as Production

Lauri Koskela in 2000 [8] introduces three basic conceptualizations of production: transformation, flow and value generation. Bertelsen and Koskela [9] consider these three aspects from a management point of view as outlined in the following.

Managing flow in the construction industry introduces several new management activities. One should be to establish a closer cooperation along the supply chain – Supply Chain Management has this been coined in the manufacturing industry. This kind of cooperation should not only comprise cooperation between main contractor and trade contractors but should comprise the manufacturers and suppliers of construction materials as well.

Generally, project management understands the project as an ordered and simple – and thus predictable – phenomenon which can be divided into contracts, phases, activities, work packages, assignments etc. to be executed independently. The project is also seen as a mainly sequential, assembly-like, linear process, which can be planned in any degree of detail through an adequate effort and executed in accordance with the plans.

Project management must perceive the project as a complex, dynamic phenomenon in a complex and non-linear setting. Most systems in the world are complex.

Very often the results of this complexity of the design process overflow to the next stage, construction, in the form of delays, deficient information and poorly constructible design solutions. However, the same kind of wickedness is often found in the construction phase, which is characterized by the close succession of:

- ✓ production system design
- ✓ production system realization
- ✓ operation of the production system
- ✓ dismantling of the production system

Table 1 summarizes the fundamental differences between lossless production and conventional production.

Table 1
Conventional Production vs. Lean Production [10]

Table 1. Conventional Production vs. Lean Production [10]		
Phases	Conventional Production	Lean Production
Object	Affects products and services	Affects all the activities of the company
Scope	Control	Management, advice and control
Application Mode	Impose by the address	By conviction and participation
Methodology	Detect and correct	To prevent
Responsibility	Quality Department	Commitment of all members of the company
Customers	Outside the company	Internal and external
Conceptualization of Production	Production consists of conversion (activities) all activities add value to the product that does not add value to the product	Production consists of conversions and flows, there are activities that add value and activities
Control	Cost of activities	Directed towards the cost, time and value of flows.
Improvements	Implementation of new technology	Reduction of flow task, and increase process efficiency with continuous improvements and technology

The basic principles and tools used by the lossless production system have been widely disseminated in the manufacturing industry, especially following the publication of the book "Lean thinking" [11].

Lean Project Delivery

The integral philosophy of lossless construction is specified in the LPD ("lean project delivery") model, whose mission is to develop the best possible way to design and build infrastructure [10]. The

general framework of the model is defined by the intersection between projects and production systems; This domain is usually designated as that of project-based production systems (or projects). The fundamental characteristics of the LPD model are [12]:

- ✓ The project is organized and managed as a value generating process.
- ✓ The agents that intervene afterwards are also involved in initial planning and design through multi-functional teams.
- ✓ The control of the project has an executive function, as opposed to the classic a posteriori detection.
- ✓ The optimization of efforts focuses on achieving a reliable workflow, in contrast to the increase in productivity.
- ✓ "Pull" techniques are used to manage the flow of information and materials through specialist networks.
- ✓ Capacity and storage guards are used to absorb variations.
- ✓ Feedback cycles are incorporated into each level, so that they can make quick adjustments.

The LPD model is organized in five phases (definition, design, supply, assembly and use) that accommodate eleven modules or stages: objectives, design criteria, design concepts, process design, product design, detail engineering, manufacturing and logistics, installation, commissioning, operation and maintenance and end of life [13].

Last Planner System

The implementation of the Last Planner System (LPS) is one of the most popular practices that illustrate the introduction of "lean construction" in the execution phase, mainly in construction companies.

The LPS is not a methodology that replaces or competes with the methods of networks and critical path, but it complements and enriches them.

The LPS is specially designed to improve the control of uncertainty in projects, increasing the reliability of the plans. In the weekly planning, only the work that we know can be done to "protect" the

productive units from uncertainty and variability must be committed [13].

Weekly work plans are effective when assignments meet five quality criteria [13]:

- ✓ adequate definition
- ✓ consistency or legitimacy
- ✓ adequate sequence
- ✓ optimal size
- ✓ feedback or learning

According to [13] these criteria are applied to select, sequence and size the work that will be included in the weekly work plan. The LPS needs to measure the performance of each weekly work plan to estimate its quality. This measurement, which is the first step to learn from mistakes and implement improvements, is done through the percentage of assignments completed; This percentage is the number of achievements divided by the number of assignments for a given week. The percentage of completed assignments assesses how far the system of the last planner can anticipate the work that will be done in the following week.

The Impact of Planning on Project Performance

The LPS has been successfully applied in multiple projects in numerous countries. Prior to its implementation, in most projects, compliance with planning showed erratic behavior and low average compliance with weekly planning, even less than 50% in some cases. By introducing some very basic aspects of the LPS, such as holding weekly meetings, controlling the percentage of assignments completed and monitoring the productivity of the activities, positive changes were recorded in the percentage of activities completed. Furthermore, even in the latest measurements, the degree of implementation observed was still limited, which made it possible to assert that the potential for improvement was still much greater. (Alarcon, L.F. & Pellicer, E., 2009)

When asked about their perception of impacts, project managers mentioned numerous positive impacts described below:

- ✓ Improvement in the management and control of the project; Managers appreciate the order and

systematization of the project management process that gives them a feeling of better project control.

- ✓ Greater involvement of middle managers thanks to a more active role in project management and their greater commitment to planning.
- ✓ Reduction of urgent and unforeseen orders, which in most projects initially represents very high percentages of total orders; The decrease in these orders alone can mean a significant reduction in project costs.
- ✓ Perception, by administrators, of greater process productivity although in some cases it cannot be measured directly.
- ✓ Shorter deadlines for the execution of the works.

Generation Gap

As every generation is unique in its way, it can bring problems in the advance of the company. Sometimes the lack of knowledge or fear of the unknown can hold back leader when the time comes for the implementation of new methods in the awakening of technologies. This can be a challenge when it comes to managing three generations at work. Lieber [14] states the generational diversity brings an array of experiences and perspectives to the workplace. Yet, managing and working with members of different generations can also create workplace challenges because of different generations' needs, approaches, and expectations. Certain attitudes are common to each generation, and distinct from those held by members of other generations. In part, these differences exist because the values and motivations of each generation are shaped by the unique historical events, settings, and innovations of the time [14].

Baby Boomers [14] - Baby boomers are currently 52–70 years old and are one of the most talked about, studied, and analyzed generations. Members of this age group are characterized as rebels who were forced to conform. While their parents tended to follow rules, this generational group is known for challenging the rules. Baby boomers' value personal satisfaction, pursue high achievements, and crave external recognition [14].

This generation was shaped by the Civil Rights Movement, women's liberation, the Cuban Missile Crisis, the Vietnam War, the Trudeau era of multiculturalism, Woodstock, the Cold War, the U.S. landing on the moon, the rise of television, and the Kennedy assassination. Boomers tend to have difficulty sharing praise or rewards. Many are also concerned that technology is phasing out face-to-face human interaction in the business world [14].

Generation X [14] - The Generation X group is currently 37–51 years old. This group was stereotyped as “slackers” but is also thought of as growing up quickly. Rather than following rules or challenging them, this generational group often elects to change the rules entirely. Generation X has been shaped by the rise of MTV, the emergence of personal computers, the AIDS crisis, the Challenger disaster, massive corporate downsizing, Reagan conservatism, the fall of the Berlin Wall, Operation Desert Storm, the Los Angeles riots, and the beginning of the video game era. Lieber [14] said Generation X employees change jobs frequently; many believe organizations are more loyal to the bottom line than to the employees who invested a lifetime's commitment to a single employer. Members of Generation X also butt heads with managers and organizations that operate according to rigid, hierarchical organizational structures [14].

Generation Y (Millennial) [14] - Currently age 22-36, this group goes by many names, including nesters, millennial, echo boomers, net generation, and the recession generation. This group's identity is actively evolving. Compared with those who came before them, Generation Y members prefer to create the rules for themselves. Generation Y is also seen as being overconfident and relatively self-absorbed. Generation Y has a more difficult time than previous generations distinguishing between or separating their professional and personal lives. Generation Y employees' lives have been shaped by the Oklahoma City bombing, the Waco Massacre, incidents of school violence, the digital age, Enron and other

corporate scandals, reality TV, 9/11, the U.S.-led war on terror, and Web-based social networking.

PROJECT METHODOLOGY

Occupying a position as assistant project manager for two small construction companies in Puerto Rico I have been able to observe the lack of organization and structure to establish a safe and successful process when managing a construction project. Given that the owners of each company belong to different generations, each one has different methods of how to manage their company. According to [8] it is important to visualize a construction company as a production where the project must be managed as a product and it must be completed to perfection.

To carry out this research I will be dividing the process into five phases, which will begin with the existing definition of each company, the study of functions assigned to the personnel and the processes to carry out the management of a project. The second phase will consist of the comparison of both companies; from the personnel with whom it counts, the structure of the company, processes of management, documentation, proposals and finally form of collection. In the third phase the process of implementation of the methodology of Lean Construction will be discussed. While in the fourth phase it will be defined what distinguishes each leader according to the generation to which each one belongs. Finally, in the fifth phase, a guide will be developed according to the need of how to guide each generation for the implementation of the Lean Construction methodology in a construction company and that it obtains positive results by increasing its profits.

RESULTS AND DISCUSSION

The results obtained through the five phases of the implementation of Lean Construction methodology follows.

Phase 1: Companies Review

Company A description: Is a company run by an entity belonging to the "Baby Boomer" generation which has more than thirty years of experience in general construction. The same company was established in 2013 and has 3 superintendents, 20 labor employees and an accountant. The company specializes in construction of residences, restaurants, shopping malls, gyms, and electrical and mechanical work.

Company B description: Is a company run by an entity belonging to the "x" generation which has more than fifteen years of experience in general construction. The same company was established in 2009 and has 2 superintendents, 8 labor employees and an accountant. The company specializes in construction of residences, restaurants, shopping malls, structural repairs, design & build, project management and real state.

Phase 2: Company A vs. Company B

In order to compare both companies, I prepared a table of the most significant activities in a construction project where I could see which activities were carried out by each contractor and which were not. It should be noted that both companies are run by contractors and that neither has an engineer's license; therefore none of the companies are of design but of general construction.

Table 2
Company A vs. Company B General Construction Activities

ACTIVITY	COMPANY A		COMPANY B	
	YES	NO	YES	NO
A	GENERAL CONSTRUCTION			
A.1	CONTRACTOR MAKES FIRST SITE INSPECTION	X		X
A.2	CONTRACTOR PREPARES TAKE-OFF		X	X
A.3	CONTRACTOR PREPARES COST ESTIMATES		X	X
A.4	CONTRACTOR PREPARES BID-PROPOSAL	X		X
A.5	CONTRACTOR PREPARES CONTRACT		X	X
A.6	EMPLOYEES ARE SKILLED IN STRUCTURAL STEEL		X	
A.7	EMPLOYEES ARE SKILLED WITH CONCRETE	X		X
A.8	EMPLOYEES ARE SKILLED WITH MASONRY	X		X
A.9	EMPLOYEES ARE SKILLED WITH ELECTRICAL WORK	X		X
A.10	EMPLOYEES ARE SKILLED WITH PLUMBING WORK	X		X
A.11	EMPLOYEES ARE SKILLED WITH GYPSUM WORK	X		X
B	DESIGN & BUILD			
B.1	STRUCTURAL DESIGN		X	X
B.2	ARCHITECTURAL DESIGN		X	X
B.3	ELECTRICAL DESIGN		X	X
B.4	MECHANICAL DESIGN		X	X
B.5	PLUMBING DESIGN		X	X
B.5	SITE DESIGN		X	X
C	PROJECT MANAGEMENT			
C.1	CONTRACTOR SUBMITS PERMITS	X		X
C.2	CONTRACTOR PREPARES WEEKLY PROJECT REPORTS		X	X
C.3	CONTRACTOR DEVELOP PROJECT SCHEDULE		X	X
C.4	CONTRACTOR PREPARES BUDGET REPORTS		X	X
C.5	CONTRACTOR PREPARES PAYROLL		X	X
C.6	CONTRACTOR MAKES DAILY SITE INSPECTION		X	X
C.7	CONTRACTOR MAKES PAYMENT CERTIFICATION		X	X
C.8	CONTRACTOR PREPARES INVOICE	X		X
C.9	CONTRACTOR SUBMITS INVOICE	X		X

As provided in table 2 we can see that in the general construction part both contractors carry out the initial inspection of the projects, that contractor A does not carry out the take-offs but rather subcontracts an employee to do the same while the contractor B performs them until using programs like plan swift to account for them. In the proposal preparation part, contractor A numbers the general items without details of them and makes a total sum while contractor B details each item notifying the unit price and the total sum of each one. In the employee skills, both companies subcontract employees with steel skills. Company A has skilled employees in concrete, masonry, electrical, plumbing, and gypsum work; While Company B and its employees are also skilled in these skills previously mention with the exception of gypsum jobs and these are outsourced. In the design heading, Contractor A is a general contractor and has no design knowledge, while Contractor B is a Civil Engineer and he is affiliated with a design company and he performs the structural blueprints and his partner verifies and signs the blueprints. Finally we can observe in project management that Contractor A does not make reports of any kind or itineraries for projects given that in this company it is the superintendent who dictates the order in which the activities will be carried out, on the other hand it is the contractor who submits construction permits and prepares invoices and submits them. On the other hand, Contractor B, like Contractor A, does not make project reports, but prepares the names and makes daily inspections of the project; Contractor B also submits construction permits and prepares invoices and submits them.

Phase 3: Lean Construction Methodology Implementation

Using the methodology of Lean Construction and following the principles established by Womack and Jones [11] precisely specify value by specific product, identify value stream for each product, make value flow without interruptions, let the customer pull value from the producer & finally pursue perfection.

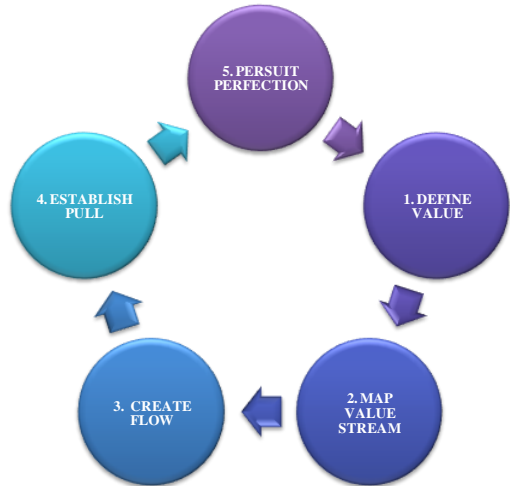


Figure 1
Lean Construction Principles

First, we must visualize our construction company as a production and sale of products. Thus, one must first of all prepare a profile of the company since we are selling our services as a product, after that we proceed to make the tables that will help us to have a better management of all the information of the projects passed by minus the last five years and the projects that are currently being worked on. As shown in Figure 2 we can see the process which the contractor from company A follows in a general construction project as discussed in phase 1.

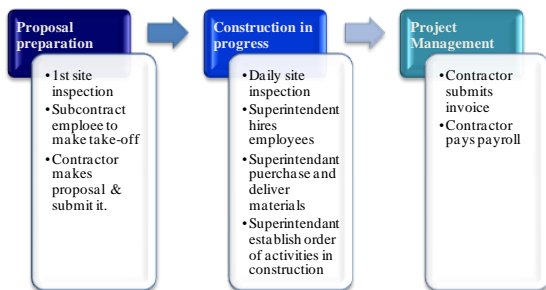
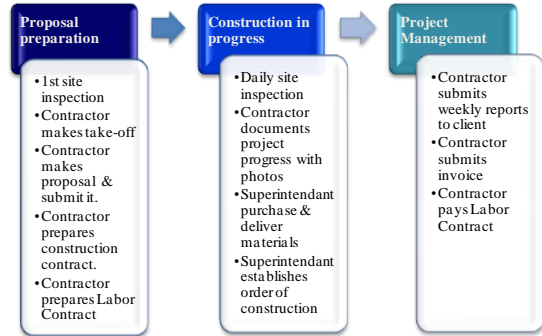


Figure 2
Company A General Construction Process



As shown in Figures 3 & 4 we can see the process which the contractor from company B follows in a general construction project and in a design and build process as discussed un phase 1.

Figure 3
Company B General Construction Process

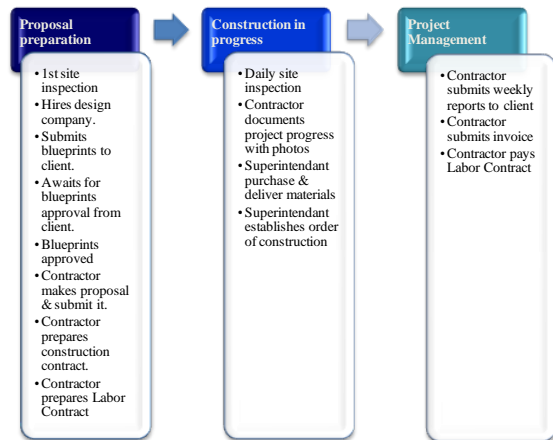


Figure 4
Company B Design & Build Process

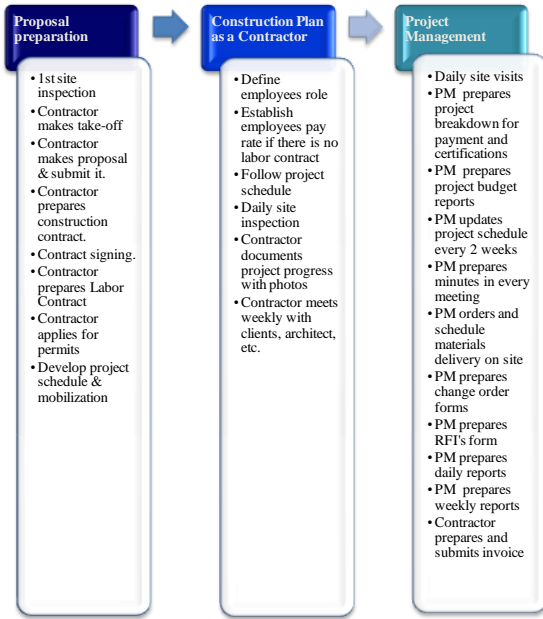


Figure 5
New Process Applying Lean Construction

Figure 5 explains the new process and roles description for the company employees. After analyzing the company's profiles and project process I established the new process to be follow in a general construction applying the lean construction principles (shown in figure 1).

In the fiscal year 2019 company A had five (projects) of general construction; some of them were residential construction or renovation and other were of commercial use. Company A distribute the project budget as: 40% for labor, 45-50% for material, 5-10% for overhead and only a 5% of profit.

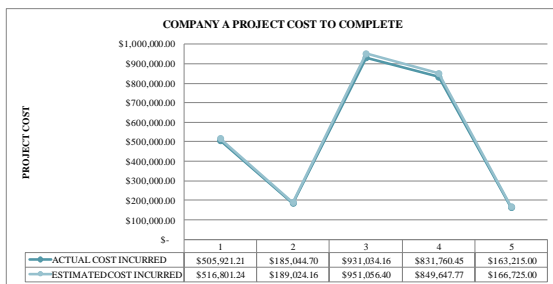


Figure 6
Company A Project Cost to Complete

Trying to adjust the percentages of both expenses and profits, with materials being 30%, labor 45%, overhead 5% and profits 20%; I could only increase 2% of the original 5% that it had.

Given that the contractor refused to use the lean construction principles, he only generated 7% of the profit versus 20% which was the goal.

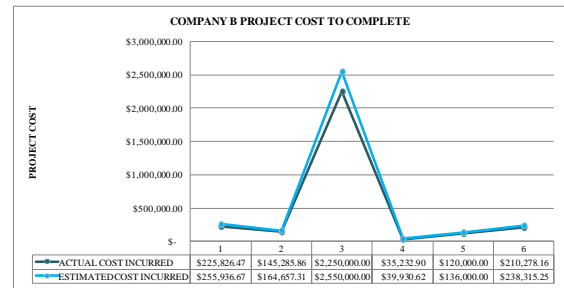


Figure 7
Company B Project Cost to Complete

On the other hand company B had five (projects) of general construction and one design and build; some of them were residential construction or renovation and other were of commercial use. Company B distribute the project budget as: 34% for labor, 46% for material, 5% for overhead and 15% of profit. Using the percent adjustment and applying the lean construction principles accepted by the contractor, it was possible to observe a 5% increase in profits, generating 20% instead of 15%.

Phase 4: Distinguish Traits of Each Generation

By analyzing phase 3 of implementation I can defined what distinguishes each leader according to the generation to which each one belongs. Knowing their work ethics, believes and characteristic I can define what distinguishes a leader for a Baby Boomer generation (Company A) versus a Generation X (Company B).

Work Ethic: Table 3 shows the different ways of thinking, both of an employee and a boss in the work environment. The ethics by which they are governed and their personal motto depending on the generation to which they belong.

Table 3
Work Ethic Based on Each Generation

Generation	Baby Boomers	Generation "X"	Generation "Y"
How generations view their relationship with the organizations?	Tend to be more loyal to their team than to the organization. They believe in adding value by going the extra mile and can have a "live-to-work" mentality. "Fight-your-way-up-the-corporate ladder" mentality.	Are primarily loyal to their supervisors. They can exceed expectations and deliver results. "Work-to live" attitude. Focus on their own professional career ladder.	More likely to feel loyalty to their peers than to management or the organization itself. Want to ensure equitable treatment of all. They are more likely to have a "work-to-contribute" philosophy.
How they relate to authority?	Tend to challenge authority, desiring "flat" organizations that are more democratic. "Let me show what I can do for you."	Unimpressed with authority. Their attitude toward management can be more in line with "Tell me what you can do for me." They prefer informal relationships with their supervisors and value competence and skills over tenure.	Evaluated at an individual level rather than according to a predetermined policy. Tend to have high expectations of employers in terms of benefits, flexibility, and compensation.
What work style defines them?	Work best in structured environments but are willing to challenge the rules when they feel it is necessary. They equate change with caution and are people-focused, preferring to work as a team.	Flexible, rule-changing, and results-focused. They prefer to work independently, with little supervision. Sees change as opportunity.	Has a unique, flexible work style that many managers may find challenging. They value fluidity in the workplace.
What are the management styles based on each generation?	Are participative managers. Always aware of workplace politics. Making management decisions based on consensus. Tend to follow the latest management trends, books, and theories.	Collaborators Tend to favor performance-based management. Their attitude is often "Do what we need to do to get the results."	Tends to be hyper-collaborative as managers. Using a personal approach and encouraging team members to do what they are best at. They are proponents of just-in-time management and do not like to interfere. They prefer to let employees have free rein.

Phase 5: Guide Development

By collecting the data from the previous phases, I was able to develop a Lean Construction implementation guide, adjusting the needs according to each generation so that the construction company generates profits and that it is efficient in its processes. The guide divided it into 4 phases:

1. Product Introduction (Lean Construction Methodology) - Each generation has different ways of learning. The easiest and safest to apply would be the formal methodology (written presentation or power point describing the product, its advantages, disadvantages and use of it) where it is presented to the pillars of a construction company being the owner, the manager of project, superintendent and labor employees. For the owner of a company the product will be presented in its entirety explaining the product and the advantages that it will give to improve the efficiency of the company. For the project manager, this methodology will help to establish processes and project management in order to obtain a successful project. For the superintendent, his

tasks will be defined and how to establish communication with the project manager to make it more bearable. Finally, for labor employees, the construction process will be defined in order to comply with the construction itinerary and to comply with the delivery date.

2. RACI matrix - implementation of the RACI methodology (it is a tool that identifies the roles and responsibility in relation to the tasks to be carried out) which, by its abbreviations, means: responsible, accountable, consulted and informed. Within the RACI methodology are the following processes:
 - Identify the roles of the project.
 - Identify project tasks and delivery dates.
 - Assign RACI to each function and task.
 - Notify and agree this with your team.
 - Notify and agree this with stakeholders of the main project.
 - Make it useful throughout the life of the project.
3. Implementation of Lean Construction
 - Define value
 - Map Value Stream
 - Create Flow
 - Establish Pull
 - Pursuit Perfection
4. Continuing education- It is important to continue implementing new processes, both methodological and in the use of new tools. Given that new processes arise every day due to technological advances, it is important that companies implement them in order to achieve better efficiency in the company using the benefits that technology offers us.

CONCLUSION

The implementation of Lean Construction in both companies was carried out for a period of one year where it was observed that company A led by a Baby Boomer increased 2% of the original profits for each project given that the same owner of the company resisted the implementation of this methodology. On the other hand, company B led by

generation "x" increased 5% in the production of profits, obtaining in the end 20% of profits in each project; given the availability of implementing this methodology. Where it helps to establish the processes and identifies in advance the possible problems that could happen throughout a project using itineraries and reporting formats in a project.

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