AN INVESTIGATION INTO THE USAGE OF LEAN CONSTRUCTION TECHNIQUES IN NIGERIA

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ABSTRACT

Inadequate implementation of lean construction techniques poses a serious problem to the Nigerian construction process. The usage of lean techniques at the early stage of construction projects results in enhanced environmental performance, waste reduction, an increase in profits, and sustainable construction, among other things. This study focuses on the implementation of lean techniques, with a view to enhancing their usage, thereby improving the performance of construction projects. It examines the lean construction techniques that are used, as well as the extent of their usage, the implementation processes that are used, the benefits of improving usage of lean construction techniques in the study area, and the measures used to improve implementation of such techniques. In achieving these objectives, construction professionals from 10 organisations in Lagos State, Nigeria, were interviewed on 12 selected lean techniques. The data were analysed using descriptive statistics tools, namely means, frequencies, percentages, and modes. The findings reveal that fail-safe quality and safety, daily huddle meetings, increased visualisation, and the 5S process are poorly used, while the other eight techniques, namely Last Planner® System (LPS®), first-run studies, just-in-time (JIT), total production maintenance, concurrent design, kaizen, design for buildability, and supply chain management, are not used at all. Nevertheless, application of the aforementioned first four techniques has contributed to improved workflow on sites, maintenance of good site organisation, and increased job satisfaction among employees. It is recommended that top management, professional bodies, and institutions of higher learning make it a priority to offer education and training programmes on the concept of lean for workers on construction projects. Government should promote the concept of lean techniques, so as to encourage a culture of safety and improve productivity and performance on construction projects.

Keywords: lean, Nigeria, projects, techniques, usage

INTRODUCTION

There is emerging awareness of the concept of lean construction in the Nigerian construction industry compared to how it was about a decade ago (Adamu and Hamid, 2012). Olamilokun (2014) suggests that there is increasing readiness on the part of consulting firms in Nigeria to adopt lean techniques. This is also true of contracting organisations, and it could be due to growing awareness of such techniques. This is probably the industry's response to the objectives of projects and clients, as well as the imperatives of satisfying users, reducing waste, maximising value, and ensuring sustainability, among other things. However, there seems to be no direct proportionality between the industry's awareness of the multidimensional techniques of lean construction and its usage of such techniques, for

various reasons. One of the reasons that has been suggested is that the benefits of lean construction are visibly absent in most projects, and are generally limited to multinational medium and large construction organisations. The benefits of lean construction include increased focus on customer value, shorter project completion time, fewer faults and omissions, and greater customer satisfaction (Bertelsen, 2001). In this regard, Oladiran (2008) highlights the factors that could be germane to the non-extensive usage of lean construction in Nigeria. The factors highlighted are related to skills and knowledge, management, government, attitude, resources, and logistics, among other things. This study therefore investigates the extent of usage of 12 lean construction techniques in selected projects in Nigeria. The objectives are to examine the extent of usage of the techniques, the implementation processes used, the benefits of improving the usage of such techniques, and the measures used to improve implementation of such techniques. The significance of this study is in revealing the state of usage of lean techniques, which should hopefully stimulate efforts to improve the implementation and the benefits of such techniques.

LITERATURE REVIEW

There are several lean construction techniques that can be used to manage construction production effectively and efficiently. These include the Last Planner® System (LPS®), increased visualisation, the 5S process, just-in-time, and lean supply chain management (LSCM). The Last Planner® involves the supervisor or the foreman that is responsible for the site work, who plans and executes the work with the site team (Ballard et al., 2002). LPS® initiates communication among the workers, ensuring that the team understands and complies with the requirements of the Master Schedule, that it is involved in joint preparation of the Phase Pull Plan, and that it employs this Pull Plan to reveal the obstacles in carrying out their task (Engineers Australia, 2012). LPS® consists of three components, namely lookahead planning, work planning, and learning (Ballard et al., 2002). Lookahead planning is about arranging workflow sequence and rate, matching workflow and capacity, establishing a backlog of ready work (a workable backlog), and developing full plans on how to carry out the work. Work planning is the Last Planner®'s methodology for defining criteria to achieve good work. The criteria could comprise definitions, soundness, sequence, size, and learning. Previous plans are reviewed and analysed in the learning, so as to establish the causes for not meeting targets, and the relevant actions that need to be taken to prevent recurrence of the problem.

Increased visualisation fosters delivery of the most important information effectively to the workforce, via posting of various signs, such as schedules, safety signs, and quality signs. It reminds workers of elements such as workflow, performance, and specific actions (Moser and Dos Santos, 2003). Visual workplaces are built on the 5S process, which is a method for achieving a self-sustaining culture that results in neat, clean, and efficient workplaces. It eliminates excess materials and tools, and provides and maintains required resources. It makes available what one needs to do one's task, without more or less. It comprises five processes, namely "sort", "set in order", "shine", "standardise", and "sustain". "Sort" means getting rid of all materials or things from the workplace that are not needed for the current job. "Set in order" means arrangement of needed items in such a way that they are neatly arranged and easily identifiable. "Shine" means cleaning off all dirt from the workplace. "Standardise" means doing the right things always, including "sorting", "setting in order", and "shining". "Sustain" means engraving the 5S process in the mentality of all team members. 5S is applied in lean construction for materials storage and site areas of work (O'Connor and Swain, 2013). Just-in-time (JIT) focuses on reduction or elimination of inventories, resulting in minimisation of waste, through continuous improvement of

operations, equipment, and processes (Koskela, 1992). It takes into consideration other inventory less techniques, such as lot size reduction, layout reconfiguration, supplier cooperation, and set-up time reduction. Salem et al. (2005) assert that JIT views inventories as waste, and that materials and components should be made available only when required. Abdullah (2003) posits that JIT consists of three elements, namely JIT production, JIT distribution, and JIT purchasing. JIT production is having the exact amount of raw materials, work in process, or products required for production. JIT distribution is providing prompt delivery to customers or distributors. It prevents overproduction from occurring, because units are produced based on customers' requests and needs (Howell and Ballard, 1998). JIT purchasing is procuring or delivering the exact quantity of materials to the site as and when needed. JIT purchasing is practised on construction sites. JIT advocates continuous improvement, and it can help in value enhancement (Ajiboye et al., 2012). It is synonymous with lean material management functions (Engineers Australia, 2012). Lean supply chain management (LSCM) is a new network of suppliers enacted through cooperative relationships, while balancing cooperation and competition (Nightingale, 2005).

Implementation of LPS® in an industrial project in Egypt reduced the effect of risk factors on the time objective of the project (Issa, 2013). It significantly reduced the Percent Expected Time-overrun values and improved the Percent Plan Complete values on the project. Nine of the 13 risk factors were also minimised on the project by implementing lean techniques, as measured by a fuzzy model for time-overrun quantification. The nine factors were contractor problems and inadequate experience, unskilled workers and poor labour productivity, inefficient use of equipment, delays in material procurement, client's problems, inadequate and slow decision-making mechanisms, poor coordination among parties, rework, and improper accommodations for workers. It was recommended that lean construction techniques be adopted in developing countries, due to the simplicity and efficiency of such techniques. Swefie (2013) also revealed that standardisation, continuous improvement, housekeeping, customer focus, and reduced variability were efficiently used in the Egyptian projects investigated.

Similarly, Adamu and Hamid (2012) investigated the implementation of Last Planner System, increased visualisation, and huddle meetings in 80 housing units in Yobe State, Nigeria. 5S was not used, due to some constraints, such as unwillingness of the project participants. Leaders were assigned to each tool to monitor its application, implement the guidelines, and give feedback. It resulted in a reduction of the number of site operatives and the project duration when compared to similar projects that did not implement the selected techniques. It was observed that the project team did not welcome the idea of using the techniques, due to their perceived tediousness, but that team members' cooperation improved with the promise of financial incentives by the project manager. This indicates unwillingness among members of the construction industry to use lean techniques, as mentioned earlier, although awareness of such techniques is growing. It is interesting to note that in Adamu and Hamid's (2012) study, only three lean techniques were reluctantly used on the 80 housing units, and there were many constraints. The lean concept was linked to the objectives of the project, and the procedure was explained to the team before the reverse phase schedule meeting. All the team members participated in developing the reverse phase schedule activity programme. The weekly work plan was compiled for submission by the various trades before the weekly meeting, which addressed key issues on schedules, manpower, safety, construction, an early warning chart, and weekly work done, among other things. Safety signs, start and completion times of weekly work, and a Percent Plan Complete (PPC) chart were posted on the site, as part of implementation of increased visualisation. Weekly meetings were held for implementation of daily huddle meetings, but the meetings were more

frequent in the first, second and third weeks of the projects. All PPC values were above 70%, and information sharing on the project was enhanced.

Rajprasad et al. (2014) found that contractors in India were not familiar with the Last Planner System (LPS). Swefie (2013) found that visual management, just-in-time, collaboration, benchmarking, and prefabrication were not used in projects in Egypt. Rajprasad et al. (2014) reported that residential contractors use the Master Schedule method instead of LPS for their projects. However, LPS improved the schedule performance and prevented mistakes in the construction projects in which it was used. Thus, Rajprasad et al. (2014) concluded that with effective training on LPS, builders can avert schedule delays and improve the standard of projects via implementation of LPS. Realising this, this study investigates implementation of selected lean techniques in some Nigerian projects.

RESEARCH METHOD

The population of the study was building projects in Lagos metropolis, while the respondents were construction professionals. The professionals included architects, builders, quantity surveyors, and engineers. The convenience sampling technique was used to select a sample of 10 professionals from five indigenous and five foreign companies. These organisations were selected because, even though there is no list of organisations that practise lean construction techniques on their projects, the number of organisations that do implement such techniques are very few (Adamu and Hamid, 2012), especially in the research area. Data were collected via structured interviews conducted in five projects from each of the organisations, totalling 50 projects in all. The data were analysed using frequencies, percentages, means, and modes. The interview questions consisted of two parts. Part A solicited general information on the respondent and the organisation, including the type and the age of the organisation, and the experience and qualifications of the respondent. Part B investigated the usage, implementation, benefits, and measures used to improve implementation of 12 lean construction techniques on 50 projects from the respondents' organisations. The techniques were fail-safe quality and safety, daily huddle meetings, increased visualisation, the 5S process, the Last Planner® System (LPS®), first-run studies, just-in-time (JIT), total production maintenance, concurrent design, kaizen, design for buildability, and supply chain management. These techniques were selected because they are considered essential for the Nigerian construction process. Furthermore, they are among the most used lean techniques, especially the LPS, in several countries, with many benefits.

Mean usage percentage is calculated as

$$M = (n/50) * 100$$

where n is total number of projects on which a strategy was used, and
M is mean usage percentage.

FINDINGS AND DISCUSSION

Profile of the organisations and the respondents

The profile of the organisations and the respondents is presented in Table 1. Seven of the organisations were contracting firms, while three were consulting firms. Two of the organisations had existed in the Nigerian construction industry for between 0 and 5 years, three for between 6 and 10 years, two for between 11 and 15 years, one for between 16 and 20 years, and one for more than 20 years.

The profile of the respondents in Table 1 shows that two of the respondents held Higher National Diplomas (HNDs), four held a BSc degree, and four held an MSc degree. In terms

of experience, four respondents had been practising for a period of 0 to 5 years, four had been practising for 6 to 10 years, and two had been practising for 11 to 15 years. In terms of participation in projects, two of the respondents had participated in the production of between 1 and 5 projects, while eight had participated in between 6 and 10 projects. This finding suggests that the respondents can supply the required information.

Table 1: Profile of the organisations and the respondents

Organisations	**Type**	**Frequency**
	Contracting firm	7
	Consulting firm	3
	Total	**10**
	Age	**Frequency**
	0–5 years	2
	6–10 years	3
	11–15 years	2
	16–20 years	1
	More than 20 years	1
	Total	**10**
Respondents	**Academic qualification**	**Frequency**
	HND	2
	BSc	4
	MSc	4
	Total	10
	Experience	**Frequency**
	0–5 years	4
	6–10 years	4
	11–15 years	2
	Total	10
	Number of executed projects	**Frequency**
	1–5	2
	6–10	8
	Total	10

Usage of lean techniques

Table 2 shows that the lean technique that is used most is fail-safe quality and safety, with a mean usage percentage of 8%, followed by increased visualisation, with a mean usage percentage of 6%, followed by daily huddle meetings and 5S, each with a mean usage percentage of 4%. The other eight techniques were not used at all on any of the 50 projects. These techniques were LPS, first-run studies, just-in-time (JIT), total production maintenance, concurrent design, kaizen, design for buildability, and supply chain management. This shows that usage of lean techniques is very poor. In fact, the average mean usage percentage of the 12 techniques is 1.83%. This finding reveals the actual state of usage of lean techniques in Nigeria, which should hopefully stimulate efforts to improve implementation of such techniques. This finding confirms the findings of Rajprasad et al.'s (2014) study conducted in India, namely that contractors on residential projects did not use LPS. It seems that the scenarios in developing countries are similar, because lean construction is yet to be adopted in most developing countries; it is still a new concept (Adamu and Abdulhamid, 2015). Olamilokun (2014) opines that although there is readiness to adopt lean techniques in Nigeria, the required resources in terms of management, people, and technology are not available. He maintains that availability of trained professionals and education and skills development are the most important drivers of lean construction

principles. Thus, more awareness, education, and training are required to improve usage of lean techniques (Oladiran, 2008; Olamilokun, 2014).

Table 2: Usage of lean construction techniques

Lean construction technique	N	% M	R
Fail-safe quality and safety	4	8	1
Increased visualisation	3	6	2
Daily huddle meetings	2	4	3
5S process (visual workplace)	2	4	3
Last Planner® System (LPS®)	0	0	5
First-run studies	0	0	5
Just-in-time	0	0	5
Total production maintenance	0	0	5
Concurrent design	0	0	5
Kaizen	0	0	5
Design for buildability	0	0	5
Supply chain management	0	0	5
		1.83	

Implementation of lean construction techniques

The following are the various strategies or processes that are adopted for implementation of lean construction techniques by the various organisations that participated in the research:

Contracting organisation 1 (F 1)

- Daily huddle meeting: This is a daily start-up meeting, where team members quickly give a report of the previous day's activities. An expatriate from the United Kingdom who handled one of the projects introduced the principle. After the principle proved to be successful, it was accepted for implementation.

The daily huddle meeting was mandatory, and it was held between the project manager and the foremen. It started at 8 a.m. The longest meeting that was held lasted 30 minutes. The duration of the meeting depended on what was discussed in the meeting. The work of the previous day was reviewed, after each foreman gave a report, which included the number of workers in each section, the jobs done, the materials, tools, and equipment used, and the challenges faced by each trade section in terms of standardisation and safety and health of the workers. The daily huddle meetings improved the level of communication between the project manager and the foremen, resulting in a high level of commitment from workers on-site.

- Fail-safe quality and safety: This method relies on generation of ideas, which prevents potential defects in projects in terms of quality. All materials brought to the site were approved by the Standards Organisation of Nigeria (SON), and most of the time the materials were tested in designated workshops and laboratories, to ensure good quality. In terms of safety, a safety officer certified with the Nigerian Institute of Safety Professionals (NISP) ensured that all workers were properly kitted out before commencement of the day's work, such as wearing of safety boots and helmets at all times during site work. Any workers that were not properly kitted out were dismissed from that day's work without pay. A toolbox and warning signs were also routine features on-site. Efforts by the team to check for quality and safety on-site were problematic because of social problems, and much effort was required to ensure that all foremen were well informed of their job description and the need for compliance with safety procedures.

The level and process of communication on-site concerning fail-safe quality and safety was significant, such that if any worker noticed that anyone was not safety-compliant, or noticed any defect in materials brought to site, he would notify the project manager.

Consulting organisation 1 (F 2)

- Increased visualisation: This was used to deliver key information effectively to the workforce, through the process of posting signs on the site, especially safety signs. Safety signs were posted all over the site by a certified safety officer. Mobile signs were also posted so as to enable workers and guests know how to move on the site. A chart of project milestones, which is essential, was also available in the project manager's office. It was extracted from the project planning chart using a Gantt chart.
- 5S process/visual workplace: This was used to increase transparency and eliminate wasteful resources on the site. Foremen were given complete responsibility for selecting the tools needed for an operation, and for submitting the list of tools to the site engineer for cross-checking and approval. The list would be given to the storekeeper, who would make it available to the workers when it was needed. After tools had been issued to the workers, a list was prepared to ease the way the tools would be returned. The tools would be placed neatly in the presence of the storekeeper. The material layout design was also prepared, which contained key details of the work activities of each day, together with the tools that would be needed. Foremen were given the task of ensuring that each worker tidied up where they had worked, and also that they informed the site clerk that they could inspect where they had worked.

Contracting organisation 2 (F 3)

- 5S process/visual workplace: The site clerk was charged with selecting and placing separately the materials/tools needed for each day's operations, with the help of each trade foreman. He also ensured that materials and tools were placed in a regular pattern where they were to be used, for ease of access during operations. The site clerk collected the material layout design, and the foreman set about familiarising himself with each work activity on-site, in order to provide the needed tools. After the day's work, the site clerk ensured that the work area was cleaned, and that all tools were also cleaned, lubricated, and arranged neatly in the store.
- Fail-safe quality and safety: The slogan "Safety first" was posted in designated areas, which made all workers on-site safety-conscious and compliant with safety rules and regulations. All materials brought and used on-site had to meet SON standards.

Contracting organisation 3 (F 4)

- Fail-safe quality and safety: Materials brought to the site were certified by the SON, and proof of the certification was seen by the site manager. Material testing was done, namely concrete and reinforcement testing. All foremen were in charge of the safety of their workers, and they distributed safety gadgets to their workers. Workers were mandated to wear the safety gadgets that were given to them.
- Daily huddle meetings: Meetings were held with the workers on-site on a weekly basis, especially on Mondays. The discussions in the meetings were about overlapping activities and identifying potential problems on the jobsite. Site management personnel met on a daily basis for at least 10–15 minutes to review work. This helped to enhance communication between project personnel and the foremen. The level of late-coming to site was reduced, and the level of commitment of workers increased.

Contracting organisation 4 (F 5)
None of the techniques were known or used.

Consulting organisation 2 (F 6)
Daily huddle meetings: The huddle meetings were not as consistent as those of previous years. As at the time of this survey, the meetings were held every month on a Saturday, with the full involvement of all employees on the projects. Issues were tabled during meetings to find quick solutions. The meetings usually involved the site foremen. The project manager held meetings with the engineers on-site, including the site foremen, and he later gave feedback to the management.

Contracting organisation 5 (F 7)
Fail-safe quality and safety: The qualities of materials brought to the site by long-standing suppliers were of a good standard. Workers were given training on safety on-site, so as to increase the level of safety on-site. Certified safety officers ensured that workers on-site complied with safety rules, and they also made sure all workers were properly kitted out before commencement of the day's work. Any worker that was not safety-certified was not employed.

Consulting organisation 3 (F 8)
None of the techniques were known or used.

Contracting organisation 6 (F 9)
Increased visualisation: Signs were posted on the site to communicate key information that must be adhered to. The signs posted were those related to safety, the schedule, and quality. The schedule stipulated the work to be done for each day, within a specific period.

Contracting organisation 7 (F 10)
None of the techniques were known or used.

The above findings have established the extent to which lean techniques are implemented on Nigerian projects. The findings could serve as a benchmark for implementation of lean techniques in any project undertaken elsewhere. It is noteworthy that the pattern of implementation, particularly for increased visualisation and daily huddle meetings, is similar to that observed in Adamu and Hamid's (2012) study conducted in Yobe State, Nigeria. The similarity of the findings in the two studies confirms the actual state of implementation of lean techniques in Nigeria.

Benefits of lean construction techniques
The various benefits of lean techniques on the investigated projects are shown in Table 3. A major benefit is waste reduction, both in materials, labour, and time. One of the key problems noticed on Nigerian construction sites is material waste. This study has confirmed that lean construction is a solution to this problem if it can be fully embraced and integrated into the Nigerian construction industry. This study gives credence to Ogunbiyi et al.'s (2012) assertion that usage of lean practices and techniques results in improvement in environmental performance, a reduction in waste, an increase in profits, and improvement of workflow. All the benefits mentioned by Ogunbiyi et al. (2012) were experienced in the projects investigated. Other benefits experienced in this study were enhanced communication and worker participation, maximisation of value, safety, and worker satisfaction, among other things.

Table 3: Benefits of lean techniques

Technique	Organisation	Benefits
Daily huddle meetings	F 1	They helped significantly to reduce waste in terms of the workforce in some operations. They created a sense of belonging among the workers. They promoted free flow of information on-site, which fostered good relations among the workers.
	F 4	They improved communication between the project personnel and the foremen. The level of commitment of the foremen on-site was high, which reduced the level of late-coming to site.
	F 6	They increased employees' job satisfaction, and workers' problem-solving ability was enhanced. They added value and promoted discipline.
Fail-safe quality and safety	F 1	It led to a reduction in site accidents. It improved quality.
	F 3	It helped to ensure safety. Certified professionals trained workers on-site, which improved work performance on-site.
	F 4	Communication was enhanced, because the foremen took charge of their workers' welfare. It helped to maintain a standard safety culture.
	F 7	It drastically improved the workers' safety (the number of injuries on-site were reduced) and customer satisfaction, it increased value, and it lowered costs.
Increased visualisation	F 2	It gave team members a sense of belonging on-site, and it reduced waste. It eliminated idleness on-site, and it helped team members to know the scheduled duration of a project.
	F 9	The performance of workers improved, as well as their level of commitment. It improved the workflow on-site, and the level of wastage was reduced.
5S process (visual workplace)	F 2	It helped to maintain a high level of site organisation, and it helped to reduce waste on-site. The level of housekeeping was high.

	F 3	It improved the rate of workflow on-site, and it facilitated maximum coordination in the handling of tools.

Measures for improving implementation of lean construction techniques

The following are suggestions by the interviewees for improving usage of lean construction techniques in Nigeria:

- Training: Construction project stakeholders require ample training for knowledge and skills acquisition on the concept of lean. Training shouldn't be restricted to skilled workers only, but should be available to foremen on sites, in order to improve productivity and performance.
- Top management support: Adequate support from decision makers, or policy formulation in organisations, is necessary for the concept of lean to thrive in construction projects.
- Government intervention: The Nigerian government needs to promulgate laws or codes of practice that will enhance usage of novel techniques, such as lean and others.
- Good communication and collaboration: There is a need to improve communication between all parties in projects. There should be active communication among clients, consultants, and contractors. Regular meetings between parties are required to educate workers on the concept of lean, as well as lean principles.
- Deep understanding: The level of understanding of the concept of lean is directly proportional to its usage and benefits.
- Commitment: successful implementation of this concept will require commitment and cooperation from workers.

The above suggestions are compelling reason for implementing lean construction techniques in Nigerian construction companies. However, Olamilokun (2014) is of the opinion that Nigerian companies are not ready for adoption of lean. His study, however, recommends continuous awareness and training for Nigeria, which is consistent with the findings of this study. Oladiran (2008) also recommends education and skills development, management and four other groups of strategies in order to adopt lean in Nigeria, which is consistent with the findings of this study. It can be concluded that concerted execution of the findings of this study and those of Oladiran (2008) will assist greatly in implementing lean in Nigeria.

CONCLUSIONS

The study was premised on the finding that lean construction techniques are not adequately used in Nigerian construction projects. Based on this premise, the study investigated 12 selected lean techniques on construction projects. The study concluded that lean techniques are poorly used in Nigeria. Implementation of the techniques that were used on the sites involved various processes and steps to realise the benefits associated with lean techniques. Some of the benefits of implementing lean construction techniques include waste reduction, enhanced communication and worker participation, maximisation of value, safety, and worker satisfaction. Measures that can be applied to improve the low level of usage of lean techniques include training, top management support, government intervention, good communication and collaboration, deep understanding, and commitment.

RECOMMENDATIONS

The following recommendations are made based on the findings of this study:

- Construction organisations should increase their usage of lean construction techniques, so as to attain better project performance. This can be done through deliberate decisions by the management, and formulation of policies that favour new construction technology, such as lean. Outcomes of increased usage of lean techniques could include a good construction workflow, a reduction in water consumption, and increased profits, among other things.
- Construction professionals that are tasked with implementation of construction techniques on projects should expose themselves to the state-of-the-art process of implementing lean techniques. This can be done by learning from expatriates that have used lean in foreign projects, reading relevant research articles and books, and participating in seminars, workshops, and conferences.
- Government should promulgate laws, regulations, and codes of practice that will embrace the use of lean construction techniques. They could be part of the items or sections in government documents regulating the construction industry.
- The measures for improving implementation of lean construction techniques should be applied by all stakeholders. This could start by creating more awareness and conducting training on lean for various stakeholders. Specific lean techniques could also be stipulated and mandated by clients, project team leaders, project coordinators, and construction agencies.

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