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LEAN SOLUTIONS FOR PROGRAM DEVELOPMENT FOR CONSTRUCTION DAILY REPORT

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ABSTRACT

The construction industry follows societal trends in the Fourth Industrial Revolution and seeks to apply new Information and Communication Technologies (ICT). ICT can capture, store, process, and distribute information electronically and in large quantities. Thus, ICT can contribute to many construction documents, such as the Construction Daily Report (CDR), which has a considerable amount of data for processing and shared responsibility with several project team members. The research method used is the case study through a qualitative analysis of the information management software. The results demonstrated that its use enabled greater control of the production process, shared responsibility with the corporate sectors, and became a basis to minimize conflict between the stakeholders. The solutions incorporated in the program are presented to meet the principles of standardization, flow improvement, and increased transparency. Furthermore, the software collaborates with the solidity and quality of the enterprise's official document and their management information, bringing better storage reliability and greater agility in information retrieval.

KEYWORDS

Information management, Contract management, Production planning and control, Construction industry, Site construction.

INTRODUCTION

Information and Communication Technologies (ICT) are used in different sectors to improve data collection and processing processes. Computerization also helps automate contractual procedures, manage information, and monitor the work's stages and conditions. The construction industry follows this trend and has applied ICT to facilitate the acquisition and management of information on the progress of the building (El-Omari and Moselhi, 2011). To support contractual or legal obligations and simplify the

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collection of daily activities, the Construction Daily Report (CDR) is an important document for construction projects. The daily report centralizes the project's information from different work teams, whether activities performed in the field, meteorological data from the construction site, records of the supply chain and strategic communication, contractual milestones, requests for scope changes, among others (Navon 2007). As a result, the CDR is considered a strategic document and is consulted frequently to support agreements and resolve claims (Russel, 1993).

The CDR is an information management system that uses computational assets to improve and increase the competitiveness of construction companies (Russel, 1993; Shiau and Wang, 2003). Gurley and McManus (1998) propose an information management system based on the principles of lean construction, whose most important characteristics are transparency and the inclusion of the various agents participating in the construction project. The authors emphasize that information flows must accompany workflows so that all participants must have access and trust in this building information system. Furthermore, the management system tools can be customized according to the company's communication needs and ways of hiring.

The amount of data collected in complex projects is significant, needs criteria to be filled in, involves several stakeholders, and signature collection. Typically, the CDR is filled with a focus on execution information, with little focus on other processes such as acquisitions, hiring, or projects. Thus, there is a need for CDR to meet the management specifics of the companies involved and promote incremental improvements.

Although there are commercial CDR options on the market, the program will not always meet the user's or the company's needs, may not have the customization option available, or present limited customization opportunities. Furthermore, a commercial program cannot always cover all possible solutions, as each construction company has specific forms of management and organization. That way, customizing can seek the development of specific tools that meet a particular type of construction company.

The use of ICT can integrate management system processes adopted by the construction company, streamlining the collection, approval, and standardization of data, establishing formal channels of communication, and facilitating access to information and records of the work. Different agents can have shared access to information, reducing access time and facilitating decision-making. However, guidelines on the information to be incorporated in designing a CDR elaboration system were not verified. This article presents an exploratory contribution to fomenting the discussion about the subject.

This article will describe the importance of the daily report and the procedures adopted by a construction company using ICT to standardize their CDR and improve the management information. To this end, the company sought to incorporate lean construction concepts, such as transparency and improved information flow. As a limitation of this research, the results are restricted to this case study. Still, the article points out needs for future research, aiming to organize a procedure for designing information systems for CDR in the construction industry.

LITERATURE REVIEW

There is a diversity of information to be collected and processed in construction industry projects. A computerized system can facilitate the identification of the current situation of each activity, with different statuses (such as start, ongoing, completed, and postponed, for example), meteorological records, team productivity indicators, among others, enabling a flow of more efficient and faster communication (Russel, 1993). The author

presents the management system called REPCON (Representing Construction) for a project, indicating its integration with the daily site and the planning and control system. Shiau and Wang (2003) propose a model integrating several functions into the CDR, such as project modification control and pricing, budgeting, and accounting systems. As will be shown in this paper, a computer information management system presents standardized procedures for data entry, visualization facilities for the analysis of results, and eventual corrections. The periodic or daily collection of relevant information and its organization will facilitate decision-making by the different stakeholders. In addition, the collected data can serve different internal processes of the company. This can provide agility, and reliability in the results, establish a form of communication and reduce conflicting results. With this, it was possible to improve the accuracy of the information, reduce human typing errors, control the actual cost, and integrate customers and designers.

The daily monitoring system of activities and services can be integrated with the Production Planning and Control (PCP). Lee and Cho (2020) verified the consistency between the daily work report and the schedule plan. They noticed that in 58% of the interviewed cases, the execution of the activities recorded in the daily work report was not according to the schedule. For this, Lee and Cho (2020) propose a CDR integration model with Last Planner System (LPS) and Line of Balance (LOB) planning techniques, allowing for effective communication about the plan and the execution of work between different teams. This paper will show that the developed system has an interface with the PCP, providing data on its physical progress.

Using a computer system associated with the development of the work can help formalize and optimize the company's communication channels with its suppliers and customers. To support the complex information system within a construction site, CDR models must consider established communication channels, eliminate barriers, and favor the flow of information (Tsai, 2009). Cho and Chang (2019) conceived a model using chatbot technologies aiming at an interactive and uniform communication interface. The communications database was designed to feed the CDR automatically. The system presented in this paper is developed for computer use, its data is stored in the cloud, following the data security standard, and accessible to all authorized stakeholders, facilitating information sharing.

The use of communication technologies can increase productivity in the management of the project. Chen et al. (2019) propose a web-based CDR management system with digital pen input. Data can be verified anywhere with an Internet connection available via PC or mobile device. Harstad et al. (2015) analyze that the application of tablets will improve information management in construction projects and may gradually improve the cost/benefit ratio after an initial introduction of computer systems. Although interesting, this system present does not have versions for mobile device applications or facilitating devices such as digital pens or tablets.

El-Omari and Moselhi (2011) present an automated system for collecting data from construction sites to measure execution progress. The user can power the system through a tablet to record data on the system, photos, and handwritten comments. The main entities of the database are Projects, Activities, Labors, Equipment, Materials, Photos, Sound, Videos, 3D Images, and Drawings. These options are present a computerized CDR program that integrates with other management processes, such as planning, supplies, and customer service. The computer program's development made it possible to standardize information, establish communication between stakeholders, monitor the construction process, insert photos and relevant information, and use the internet network.

Unlike other authors who presented a specific analysis of the CDR or a process, this article presents a study integrated with the management system of the construction company studied. It is expected to highlight that the CDR impacts the operational, tactical, and strategic management of the business and legal and contractual needs.

RESEARCH METHOD

The case study adopted the research method, which uses qualitative data collected from actual events to explain, explore, and describe phenomena in their context (Voss et al., 2002; Yin, 2009).

The first step of the research consisted of a literature review to identify the main functions expected for CDR use. Then, a protocol for the investigation of the studied program was followed, consisting of the following steps: knowing the program's essential functions, identifying the primary information and how it is completed, identifying the main stakeholders involved, and their routine procedures. Then, the collected information was analyzed, compared with previous results, and verified the improvements obtained from implementing the CDR informatized and the opportunities for advancing knowledge. Finally, discussions were held on the results found and the potential solutions to the problems. Figure 1 shows the scheme of the methodological procedure adopted.

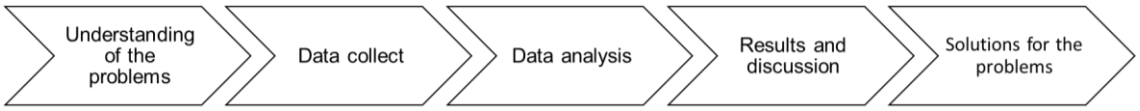


Figure 1: Methodological procedure adopted.

CASE DESCRIPTION

The construction company operates in the management segment and supports its clients in business development, leading pre-construction services. The company has been working for over 50 years in industrial constructions, buildings, and infrastructure. A finished project was selected to be explored in this paper to present the software interface and main results. This project is called Teatro Cultura Artística (TCA), held between 03/26/2018 and 07/31/2019.

The software studied is part of a set developed by a company specializing in computer programs that provide software dedicated to the construction industry. The program was created to improve CDR management information that is electronic, easy to access, and in version 4.0. The construction company designated a person responsible for internal monitoring of the development of the program who held the position of the architect in the Innovation area. In addition, the same was defined as a "key-user" of the system. He centralized all requests for improvement, monitoring, and testing of customizations with the service provider that developed the CDR program. Since 2017, the construction company has used the software in 29 projects, including infrastructure, industrial, and building projects. Access to the platform is done through an internet browser, and it works online. The data is collected by the different sectors and operators involved, who fulfill the document from computers. Data storage is performed in the cloud.

Prior to using this program, the CDR was filled in a standard form in MS Excel and later printed for signature by the parties. However, searches for any information were performed manually on the form, which generated delays and, possible loss of relevant

information. In addition, the process was too slow and error-prone due to the concentration of data reception in the engineering sector.

CDR ACCESS LEVELS

The fulfillment of the CDR is carried out collaboratively and simultaneously by teams of the construction company. Each team inserts the specific information. The sectors that manage the information are Engineering or Production, Human resources (HR), Contracts, Design, Planning, Supply chain, Health, Safety, and Environmental (HSE). The contracting customer (Owner) also can indicate different access profiles, such as managers and consultants. Finally, the builder can assign "Executive Office" profiles to the higher hierarchical levels with access to various projects. Table 1 shows a summary of the system's usage permissions.

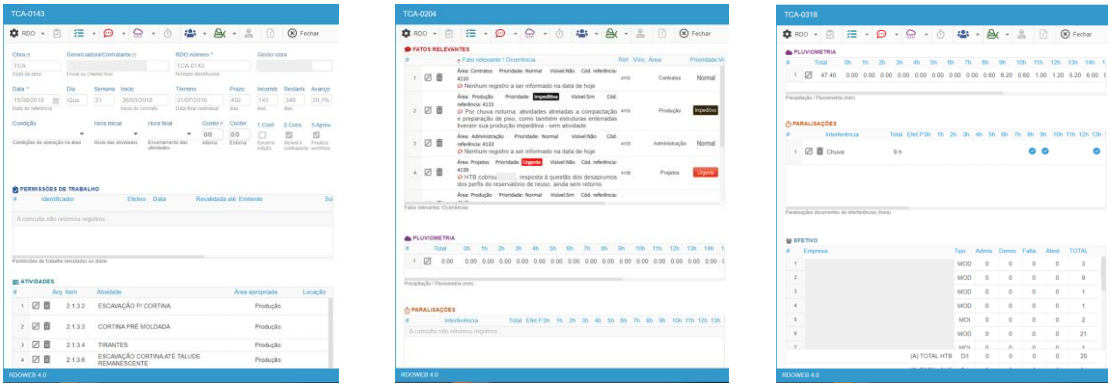
Table 1: System permissions by the levels of hierarchy and stakeholders

Sector	System permissions for construction project
Executive office	EXECUTIVE OFFICE – Access to all projects in the consultation-only mode
Engineering	SITE MANAGERIAL – Allowed to insert information, assign, and remove "checked" and "consolidated" status that releases the CDR to external users
	SITE ADMINISTRATION – Allowed to insert information from all sectors and assign "checked" status, locking out the CDR to the internal public
Other sectors	AREA MANAGERIAL – Allowed to insert information in area-specific, allowed to access information from other areas
	OPERATION – Allowed to insert information exclusively in area-specific
	CONSULTATION – Only query. ADM defines what he can see
Owner (external)	CLIENT MANAGERIAL – Allowed to make defense/contestation and comments, to apply for the "approved" status, closing the approval flow
	CLIENT AREA MANAGERIAL– Allowed to make defense/contestation and comments in area-specific and assign the status "area conference"
	CLIENT – Allowed to make contestation and comments in area-specific
	CONSULTATION – Only query. ADM defines what he can see
ADM	DEVELOPER – System key user access

COMPLETION OF THE CDR

The fulfilling information or "Launches" in the CDR occurs by selecting pre-registered items in the system, thus generating a standardization in the data included. All team members of each sector are previously registered in a database standardized by the construction company. Figure 2-a shows the initial screen of CDR, with several automatically filled data, such as the project's duration and the CDR number. Moreover, this figure shows the project activities planned based on the project's Work Breakdown Structure (WBS). To fulfil the information about the Production Sector, it must select the activities carried out that day. Selecting WBS items instead of typing the activities ensures the records standardization and facilitates their traceability. Figure 2-b shows the "Relevant facts" indicated by each corporate sector related to the project. The black marking indicates a "blocking factor" for developing a particular activity; the red mark indicates a "critical priority" to solve a particular pending issue. Then the occurrences

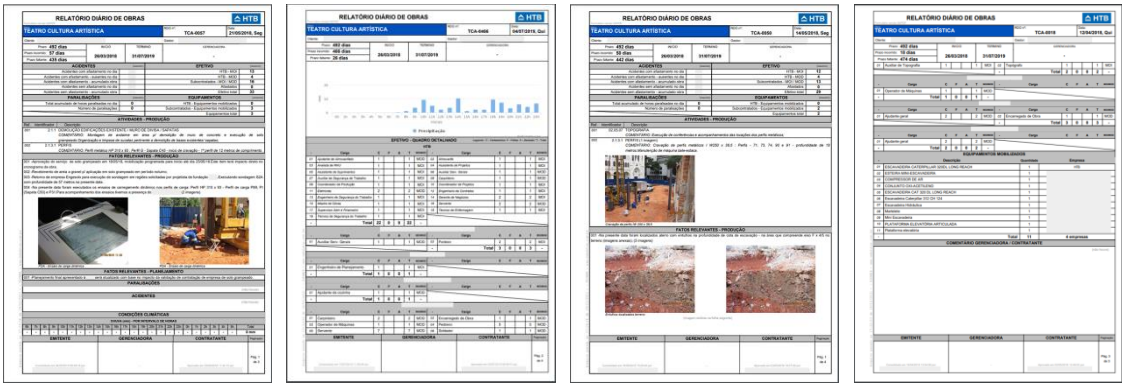
related to the pluviometry are shown in a bar graph. Figure 2-c shows the software's integration with existing weather station data in the construction site region. The software automatically converts rainfall information to the standard established by the builder. This figure also shows the number of workers present at the construction site and their companies (identification omitted). Furthermore, the system allows importing information from past CDR, highlighting the recurrence of similar records. Information about the equipment used that day is inserted below.



(a) **(b)** **(c)**

Figure 2: CDR daily launch views.

When filling out the CDR, it is possible to include daily photographic records and attached documents. The daily report's export is adaptable to a standard defined by the construction company and PDF format. Figure 3 shows the CDR of TCA-0057, corresponding to the project "Teatro Cultura Artística" on its 57th day of execution.



(a) (b) (c) (d)

Figure 3: Views of the final CDR standard.

After all the information is inserted, the CDR progress for approval by the project manager. Based on the contract, the internal approval flow may contain these steps: approval within a specific area (e.g., production), approval by the project ADM (usually from the agreement sector), and then finally, the approval of the project manager. However, in most construction company projects, just one level of approval (project manager) is used. After approvals, the document is blocked for edition by the system, which guarantees its reliability.

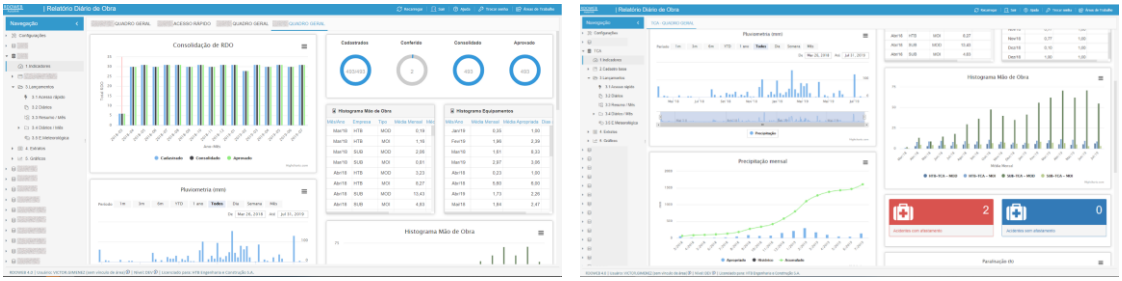
DATA ANALYSIS

The operations available in the system and the corresponding objectives can be seen in Table 2.

Table 2: Operations and indicators available in this information management system

Operation	Objectives
1. General Control	A dashboard of summary information containing graphs of CDR consolidation per month; comparative of issued x consolidated diaries, consolidated by project, released by the client; histograms of crew and equipment, graphs of weather information, a graph of shutdowns, and safety accident occurrences
2. Base Registration	Registration of standardized information in the database that will be selected: Management areas, Technical Record Annotations (TRA, *in Portuguese: Anotações de Registro Técnico - ART*), Activities (WBS), Service Authorizations, Positions, Classes, Disciplines, Staff, Companies, Equipment, Teams, Manufacturers, Supplies, Locations, Levels, Shutdowns, Historical Rainfall; Work period, Projects, blueprint/sites; Sector
3. Launches	Information consolidation by the construction company: Quick access to CDR for information fulfill; Diaries: check of pending information by organizational sector; filters with general information; access to Meteorological Station data
4. Extracts	For traceability records about information search segmented by: Safety accident, Activities, Contractor Comments, Consolidation Time, Worker, Nominal Histogram, Equipment, Relevant Facts, Shutdowns, and Rainfall
5. Diagrams	Various graphics for analysis and capturing management information: Consolidation of diaries, Shutdowns, Temperature, Rainfall, Histogram of the Workers, and Map of Contents. The graphs are dynamic, and the information can be crossed according to analysis. In addition, it is possible to export the diagrams in PDF, XLS, or image file format outside the system.

Figure 4 shows the software dashboard containing a summarized and graphical form of project management's leading indicators. Figure 4-a shows the following indicators: CDR consolidation by day, rainfall index (mm), workers, and equipment histograms in charts. Figure 4-b shows the following indicators: monthly rainfall, histogram of the worker (graph), number of safety accidents, and absenteeism. In addition, information about the occurrence of stoppages and the physical progress of the work can be presented. Thus, this information's systematic and simplified presentation brings a holistic view of the project's development.



(a) (b)

Figure 4: Information summary dashboard.

The software allows the view of the daily and monthly control of the CDR, pointing out activities in progress, the relevant facts, the workers in the project, the quantity of equipment, status of evaluation and consolidation of the CDR, registration of contributions, and access to the complete CDR. Furthermore, multiple graphs can be generated about service shutdowns in a detailed and daily form. The way information is disseminated through customized graphics fulfills several lean objectives: increasing

transparency, improving communication between agents, using visual management tools, recording evaluation indicators, and monitoring performance.

Results and Discussion

The development of the program over five years also aimed at integration with other sectors of the company, such as planning. Through the CDR, it is possible to report the physical progress of the work. However, compliance with the plan is verified through another procedure - the follow-up of the action plan, which is discussed weekly at the team meetings. The planning report presents the control planning indicators, such as removing restrictions and compliance with the Percentage of Plan Completed (PPC).

The time spent to fill in the CDR at work is, on average, 5 to 20 minutes per day/employee. This time directly depends on the amount of information (for example, if there are many production fronts with personnel and equipment or many concomitant activities). At the construction site, the filling team is usually made up of five people responsible for each department: engineering, field, HSE, HR, and project manager. They work concurrently and independently due to the program's features. Figure 5 shows the current procedures for daily elaboration of the CDR.

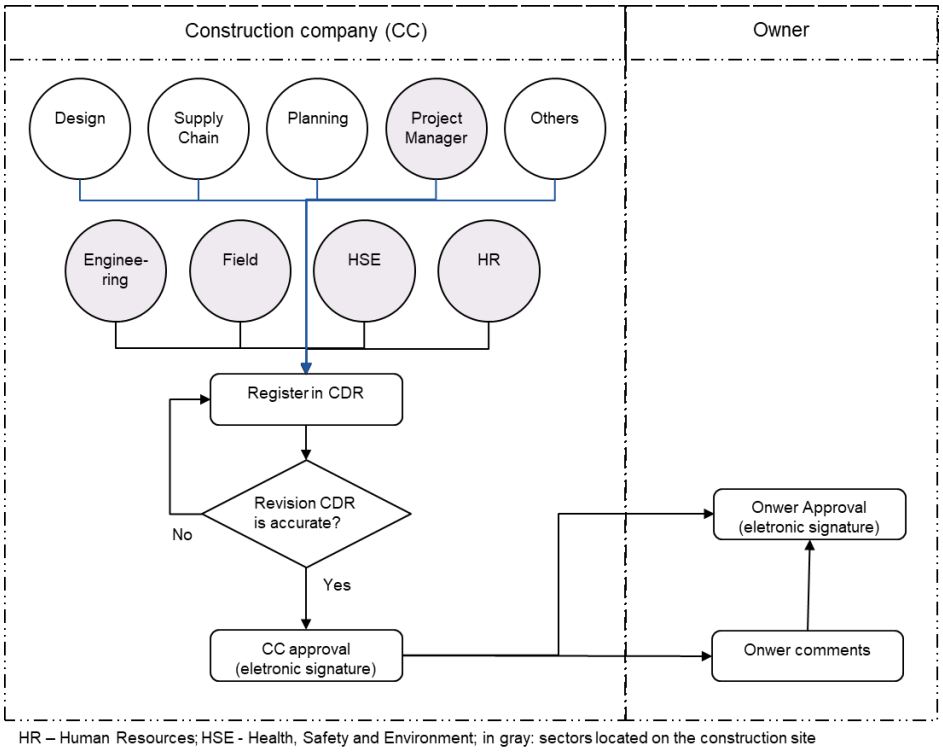


Figure 5: Procedures after the implementation of the computer program.

The customization of the program CDR with the developer allowed aspects of lean construction such as standardization of management activities, increased transparency, and improvement of the communication process, among others. For this study's constructor, the CDR has documentary value, considered more relevant than the minutes of meetings and other documents exchanged between the stakeholders. Both companies signed this document and have daily regularity and a wealth of managerial and technical information on the project day-by-day. Before the ICT implementation, problems were usually identified in filling and approving some records. The delay in consulting the

records can lead to divergences of understanding regarding contractual issues. Table 3 shows the difficulties, causes, and proposals or guidelines to solve problems.

Table 3: Difficulties, causes, and solutions for the management process of the CDR

Category	Difficulty	Causes	Solution proposal
STANDARDIZATION	Lack of forms of standardization	The file was editable, and each responsible for filling it out adapted it according to the needs of the project	Non-editable form, with fields to meet all types of situations encountered in the projects
	Lack of information standardization	Information was recorded in different ways on each CDR, defaulting traceability	Cadaster of repetitive records, avoiding spelling divergences, and facilitating traceability
	Non-detailed information	Manual fulfillment causes data inaccuracy and difficulty of understanding by external agents	Select items listed on the project's WBS to fulfill the CDR
	Difficulty retrieving information	Forms were printed to collect signatures, generating analogical documentation, hard to be cataloged and retrieved	Digitalization of the entire process documentation. Information traceability facilitated through smart search functions
FLOW	Difficulty in filling in information from different sectors	It was a single file, and it allowed only one to edit it at a time. The nomination of one responsible for filling out the CDR in each project (usually from the production area) neglected relevant information from other areas.	Simultaneous access by agents to the same document, the different fields' editing is authorized according to the sector. Through pending control, all areas must discharge the information.
	Slow flow and extensive process	As was a single file, the process flow had pauses between steps para signatures different	Reduction steps number and duration
	Delays in the approval of documents by stakeholders	The signature of the counterparty only occurred after document approval, which generated revisions	Linking the CDR review with the signature, allowing comments on the subsequent CDR
	Process monitoring by different agents	Access to documents was physical, limited to the construction site on which it was developed	Permission to access the CDR and extract the process flow by management sectors, remotely
TRANSPARENCY	Difficulty accessing information outside the construction site	Access to documents was physical, limited to the construction site on which it was developed	The information can be easily accessed remotely by authorized people whenever necessary

These difficulties generated impacts on contractual administration, often giving rise to discussions regarding deadlines, unsolicited scope changes, limitations on on-site service at the project, limitations on project activities and acquisitions, supply, or modification of designs resulting from other impacts. Therefore, the CDR process was studied for optimization, and ICT was identified as the best strategy to face the founded problems. Among the results obtained, the flow of the current CDR process was reviewed. As a

result, it is observed that different agents involved in the project can perform the insertion of data simultaneously.

Furthermore, the printing step has been suppressed, and the approval steps have merged due to the possibility of remote approval. It also appears that the interaction with the project's stakeholders occurs in a fluid, tangible, way and with no room for misinterpretation. With the review of the CDR documentation process aided by software, it was observed that the Flow and Standardization problems were solved. The Standardization problems were solved by using a digital document format and the facilities for using them remotely. The concurrent development process of the program proved to be an efficient procedure, as it incorporated user suggestions and best practices into the project management process.

CONCLUSIONS

Several benefits could be seen in adopting an ICT for the CDR management process in project construction. This study showed that its most significant benefits are processing information and preserving it from technical, judicial, financial, and deadline impacts. Conflicts are increasingly recurrent in enterprises due to the greater competitiveness of the market and customer specialization. They arise from specific situations and market dynamics that depend on numerous factors internal and external to the business. In this way, conflict resolution is not directly linked to the use of this tool. However, its use facilitates the search for information, records the exchange of information during the work, and speeds up decision-making by agents.

With the standardization and centralization of information, a technical database of the projects was created. However, despite the success in implementing the digital CDR, it has not yet been possible to analyze quantitatively the impact of its use in the resolution of contractual conflicts. This may be a new focus for the continuity of this research.

The system incorporated several lean construction principles, such as improving the flow of information and communication between the participating agents. In addition, it managed to standardize the collection and processing of information, making the entire management process quite transparent.

In addition to the benefits mentioned, a culture change was noticed after implementing the system related to the importance that the construction teams started to give to CDR. Employees understood that a well-formulated and information-rich CDR can be a great ally in several aspects. The project members started to become more responsible for their daily records, regardless of the project's activity area. They cultivated the daily habit of systematically detailing the records so that the CDR is always up-to-date. In addition, the use of electronic CDR has become a new paradigm in the company, which does not start any new work without it. The work teams recognize how this digital practice has greatly facilitated daily records in each sector.

Five years after the start, the program's update project is still ongoing and may seek integration with more lean principles and new technologies, BIM models, and mobile devices. Further research can realize more in-depth analyses of the data available, such as observation of recurring patterns in contracts and productivity calculations, which will serve as an essential basis for lessons learned, impact prediction, and process optimization.

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