Project Dissertation Report on

DIGITAL TRANSFORMATION IN CONSTRUCTION INDUSTRY (CPWD – a case study)

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CERTIFICATE

This is to certify that Indra Kumari**,** Roll No. 2K19/EMBA/523 student of Masters of Business Administration (Executive 2019 – 2021) at Delhi Technological University, Delhi has accomplished the project titled **Digital transformation in construction industry (CPWD – a case study)** under my guidance and to the best of my knowledge completed the project successfully, for the partial fulfilment of the course in 4th semester of the course Executive MBA.

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DECLARATION

I hereby declare that the Project Report entitled "**Digital transformation in construction Industry (CPWD- a case study)**" is submitted for major project EMBA done by me under guidance of Mohit Beniwal.

Place: New Delhi

Indra Kumari

Date: Signature of Candidate

ACKNOWLEDGEMENT

I express my sincere thanks to my project guide Mohit beniwal for guiding me right from the inception, till the successful completion of the minor project. I sincerely acknowledge him for extending his valuable guidance, support for literature, critical reviews for major project and the report and above all the moral support he provided for this project.

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EXECUTIVE SUMMARY

The research project entitled “Digital transformation at CPWD” is an attempt to study and analyze the digitization of the organization.

Organizations in construction Industry influenced by other rapidly changing markets (such as B2C with platforms that have triggered new relationships, tailored products and powerful service levels), now expect also the same from their homes, offices, commercial buildings and infrastructures to make their “connected lives” even more a reality. Constructions need to be more and more individualized, modular, connected to the Internet of Things (IoT) and allow for specific performance tracking, optimization of energy and improved security and health parameters for instance. The expected impacts on direct costs, delays but also safety, image, work satisfaction and environmental protection are numerous. Key here is to select levers very carefully differentiating business units and projects. Not all “great digital ideas” that appear on the market will eventually carry real savings. Numerous data will be generated throughout the construction process and will hold tremendous value that needs to be captured. Tech savviness is spreading in the construction industry, which traditionally has been, resistant to change, accelerating the adoption of digital tools. Cost baselines are quickly evolving making competition even more intense in an environment with traditionally low margins. The time is right for the implementation of a real digital strategy in the construction sector.

This paper explains the concept of digitization, construction industry, challenges faced in digitization, merits of digitization. A premium government organization CPWD has been taken for the case study.

This report deals with descriptive research design, it describes data and characteristics about the phenomenon being studied. The findings in this survey are based on an online survey across all over India and telephonic survey. Random sampling was done to give everyone an equal opportunity to participate. Findings of survey suggest that digitization at CPWD is in its infancy stage, lack of relevant skills and implementation cost appeared as biggest challenge. A lack of BIM expertise could become a serious competitive drawback in the near future. It is recommended that the organization should make BIM use as one of the criteria for the award of public contracts.

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INTRODUCTION

1.1.1 Digital Transformation

The digital revolution has already transformed many aspects of business and even whole industries. Just as the steam engine and electrification revolutionized entire sectors of the economy from the 18th century onward, modern technologies are beginning to dramatically alter today's industries. Previous industrial revolutions have had huge societal impacts, supporting an explosion in the world's population over the past 200 years. The global population has doubled in the past 50 years and is forecast to grow to 11 billion by the end of the century. It took until 1804 for the global population to reach 1 billion. The most recent addition of 1 billion people took just 12 years. To keep up with increasing demand, technology has had to accelerate. It has been frequently observed that improvements in computing power have largely kept pace with Moore's Law. After four decades of exponential increases, the world is now doubling an immense amount of processing power in every two-year period, which is leading to astonishing leaps forward in technological capabilities.

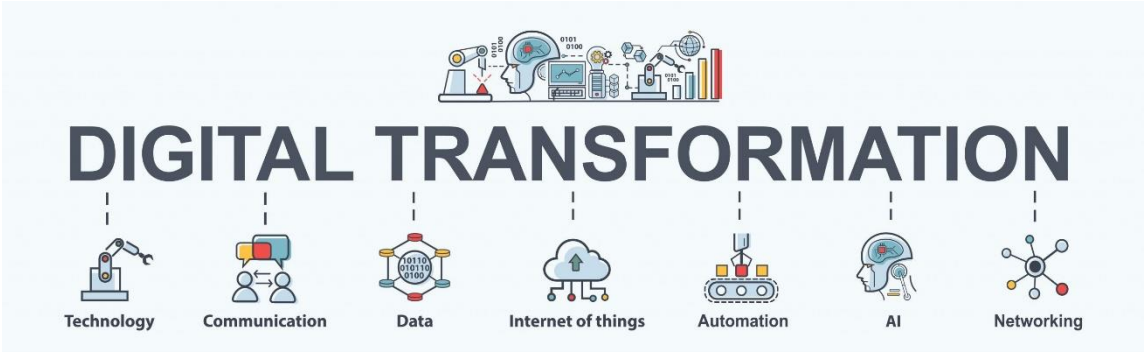


Figure 1.1

Source: Internet

The explosion of data and unprecedented advances in computer processing power have dramatically increased the capacity to support decision making across multiple operations. The world has moved well beyond basic and enhanced process automation and is entering an era of cognitive automation. Some are calling this the "Fourth Industrial Revolution." The impact of advanced technologies touches virtually every industry and organization on many levels, from strategic planning and marketing to

supply chain management and customer service. Digitization is about businesses encountering connected systems at every link in the value chain. It is about working with tools and practices based on information and communication technology. This understanding is changing the role of digital technologies. They are no longer mere tools to help companies do the same things a bit better. Instead, they fundamentally change the way business is done. Digitization permeates every part of every company: multinationals and midcaps, all-rounders and specialists alike.

A glance at other industries shows the extent to which digitization is turning proven and familiar practices on their head. In the music industry, for example, digital offerings already account for 46% of total sales worldwide. On this kind of scale, it is certainly reasonable to speak of a revolution – especially as one has to assume that digitization has replaced legacy business models in their entirety.

The cost of advanced technologies is also plummeting. For example: a top-of-the-range drone cost $100,000 in 2007; in 2015 a model with similar specifications could be bought for $500. As technology becomes cheaper, world demand is being met at lower price points and fueling an explosion of devices with ever more connections. Sophisticated artificial intelligence devices are now mass-market and better known as personal assistants by the names of Alexa, Siri and Cortana. In less than five years, basic queries such as “What is the time?” have quickly moved onto more sophisticated requests such as “Does the person I just talked to like me?” Technology has been the multiplier. The combinatorial effects of these technologies – mobile, cloud, artificial intelligence, sensors and analytics among others – are accelerating progress exponentially (see Figure 1). Once we overcome physical and chemical limitations that are inhibiting exponential gains in mass-market technologies such as battery storage and wireless charging, it is likely that the pace of change will accelerate even faster.

As technology becomes ubiquitous and accessible to the wider population, it is having a profound impact on how customers behave and the expectations they have. Customers across the B2C and B2B worlds are developing an insatiable demand for speed, convenience, contextualization and non-stop connectivity. Further, as newer generations are raised as “digital natives”, they are not only harder to surprise, but can also imagine for themselves how technology can be used to improve their lives. It is possible that

children born today may never need to drive a car due to autonomous-driving technologies. It is even possible that humans will colonize Mars within a generation. Digital transformation provides industry with unparalleled opportunities for value creation from expanding profit pools, creating new revenue models and enabling unprecedented access to global markets. It used to take Fortune 500 companies an average of 20 years to reach a billion-dollar valuation; today's digital start-ups are getting there in four years. Digitalization can produce benefits for society that equal, or even surpass, the value created for industry. Digital initiatives have the potential to improve environmental sustainability, create employment and make our lives safer. For instance, the mass adoption of autonomous vehicles and usage-based car insurance could save 1.1 million lives over the next decade.

The importance of realizing the combined value of digital transformation cannot be overstated, given digitalization's central role in tackling many of the challenges we face today. For instance, the world's energy usage is unsustainable, with emissions from the energy sector doubling over the three decades to 2012. The world's population is forecast to keep growing, increasing pressure on food supplies and natural resources. Maintaining the current trend of rising life expectancy will become more taxing, as overburdened health systems struggle to cope with ageing populations.

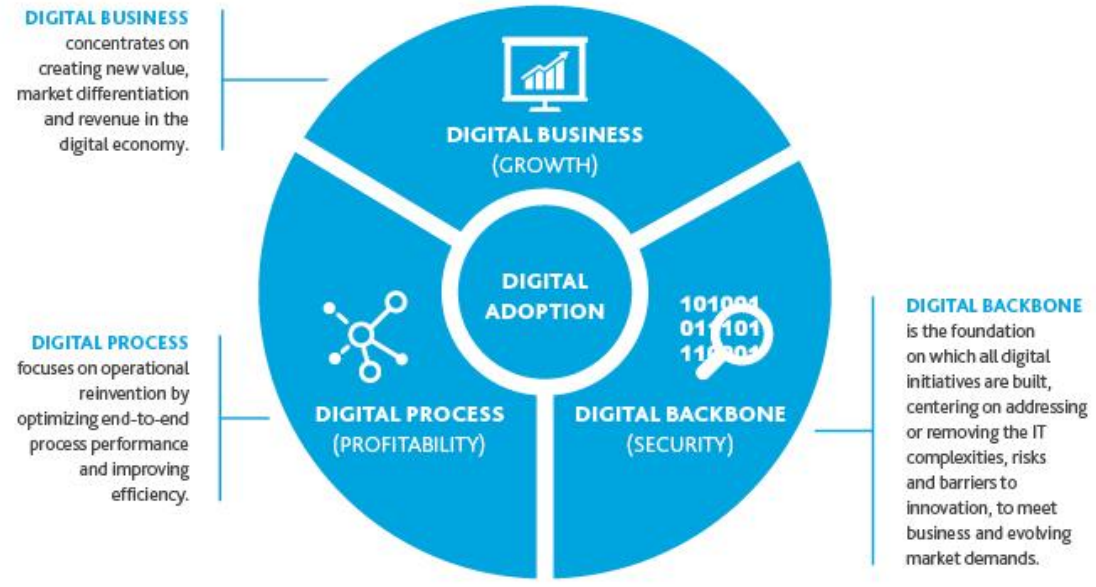


Figure 1.2 **Source: BDO_US**

A business may take on digital transformation for several reasons. But by far, the most likely reason is that they have to, It's a survival issue. In the wake of the pandemic, an organization's ability to adapt quickly to supply chain disruptions, time to market pressures, and rapidly changing customer expectations has become critical.

And spending priorities reflect this reality. According to the May, 2020 International Data Corporation (IDC) Worldwide Digital Transformation Spending Guide, spending on the digital transformation of business practices, products, and organizations continues "at a solid pace despite the challenges presented by the COVID-19 pandemic." IDC forecasts that global spending on digital transformation technologies and services will grow 10.4 percent in 2020 to $1.3 trillion. That compares to 17.9 percent growth in 2019, "but remains one of the few bright spots in a year characterized by dramatic reductions in overall technology spending,".

At a recent MIT Sloan CIO Symposium series event, IT leaders agreed that consumer behavior has quickly shifted in many ways since the start of the pandemic. Sandy Pentland, a professor at the MIT Media Lab, described how optimized automated systems in areas like supply chain management broke down when faced with rapid shifts in both demand and supply, a reality that just about everyone has faced on a personal level during the pandemic.

Digital transformation framework

Digital transformation varies widely based on organization's specific challenges and demands, there are a few constants and common themes among existing case studies and published frameworks that all business and technology leaders should consider as they embark on digital transformation.

For instance, these digital transformation elements are often cited:

- Customer experience
- Operational agility
- Culture and leadership

- Workforce enablement
- Digital technology integration

Digital consumption

The relentless pace of technological progress is contributing to a constant reshaping of customer expectations. At the same time, expectations now transcend traditional industry barriers, with customers expecting levels of personalization, on-demand access and accessibility that match the leaders in customer experience. The race for companies to deliver what digital, on-demand customers want has sped up dramatically. The new battleground where enterprises will need to compete to win over the "digital customer":

Products and services to experiences: A number of companies are using digital technologies to offer customers unique and unforgettable experiences, as enterprises are seeing customer experience as an increasingly important differentiator.

Hyper-personalization: Customers increasingly expect personalized and highly relevant interactions, catering to their individual contexts. Digital technology is enabling companies to meet these expectations by delivering personalization to large numbers of customers at low cost.

Ownership to access: Customers are attracted by the convenience of on-demand access, the prospect of financial savings and its potential to improve their quality of life. Companies traditionally engaged in ownership models are evaluating opportunities to cater to new expectations of access.

Digital enterprise

Although disintermediation and disruption are happening, it is not too late for analog incumbents, which is defined as successful enterprises that predate the digital revolution, to compete with digitally native start-ups. Analog enterprises need to digitize quickly, using their existing assets, such as vast volumes of customer data and invested capital, to radically remodel their business.

Digital business models. Companies need to fundamentally change the way they identify, develop and launch new business ventures.

Digital operating models. Digital leaders follow a lean approach to both core and support functions.

Digital talent and skills. Enterprises should attract, retain and develop the right digital talent. It is imperative for organizations to encourage millennials to join their workforce and adapt to different ways of working, whether it's integrating robots or on-demand workers.

Societal implications

Digital transformation is also starting to have profound societal implications. The digital transformation of industries has the potential to deliver societal benefits that are greater than the value generated for industry. However, organizations looking to realize that societal value face some substantial challenges, which can only be overcome through collaboration with other businesses, regulators and policy-makers.

Employment. Overall, there is huge uncertainty about the impact of digital transformation on jobs, with concerns also about its impact on wages and working conditions. But digital also has significant potential to create employment. A huge premium rests on the near-term ability of businesses to upskill employees and shape the next generation of talent for the machine age.

Environmental sustainability. We have so far failed to decouple economic growth from emissions growth and resource use. Current business practices will contribute to a global gap of 8 billion tones between the supply and demand of natural resources by 2030, translating to $4.5 trillion of lost economic growth by 2030. Moving to a more sustainable world requires a number of hurdles to be overcome, not least relating to the adoption of new, circular business models and the environmental impact of digital technology itself. Some leading technology companies are already acting to shrink their environmental footprint. In fact, 27 technology companies now use 100% renewable energy in their operations, including Intel, Apple, SAP, Data pipe and Motorola. Similar action is needed across all sectors beyond technology.

Trust. Social media, RFID tags and user-generated websites have all been instrumental in increasing the transparency of businesses and overcoming information asymmetries.

However, according to the Edelman Trust Barometer, trust in all technology-based sectors declined in 2015, with concerns over data privacy and security a key factor. Going forward, establishing new norms of ethical behavior with digital technology and establishing higher levels of trust with stakeholders will be critical elements of successful digital transformation.

Action Is Needed to Realize Societal and Industry Value

The value of digitalization will not accrue automatically to industry or society. There is a risk that the promise offered by the digital transformation of industries will go unfulfilled. There are barriers to realizing both industry and societal value. Here, are some most important ones:

1. Lack of collaboration for societal gains. At present, incentives primarily focus on meeting profit targets, undermining collaboration and the potential for maximizing societal benefits. Investors are not yet adequately rewarding public companies for the benefits they produce for society in addition to the profits they earn.
2. Regulation and protection of consumer interests. Innovation is taking place at a far greater speed than regulation can keep up with. Regulatory frameworks that were originally put in place to protect consumers are no longer always appropriate. Possible new frameworks, such as self-regulation through customer reviews, include substituting legacy legislation. For example, the logistics industry alone contributes 13% to global emissions, but stakeholders need to act quickly to develop safe and trustworthy approaches to unlocking benefits from digital technologies such as drones. With the promise of reducing emissions by up to 90% and costs by 25% in last-mile deliveries, drone technology is ready but regulation is not.
3. The innovator's dilemma. Publicly listed incumbents are being held back from radical innovation, as a result of a conservative corporate culture and the short-termism of investor interests. For instance, some technology companies are taking a revolutionary approach to building driverless cars (e.g. Google Lidar), while some car manufacturers are taking an evolutionary approach e.g. GM Super Cruise) through assisted driving technologies. In the electricity industry, despite the societal benefits of decentralized

renewable energy, few utilities are actively cannibalizing their existing business to offer subsidized renewable technologies such as solar. Clayton Christensen's theory continues to hold true: the pace and scale of societal gains from digital will be slower through disruption by new entrants than through innovation led by incumbents.

4. Skills for tomorrow's workforce. Significant skills gaps exist today and are projected to grow in the future for digital roles. STEM (science, technology, engineering and mathematics) skills are often a focus, but robots lack the qualities of creativity and empathy that are crucial for many roles in the labour market. For example, Cisco has identified 1 million unfilled digital security roles globally. Likewise, Brazil faces a shortage of 360,000 engineers and technical workers. Digital skills are not just for frontline employees, as the boardroom is a critical hotspot for improving digital literacy. Digital is having a profound effect on business, fundamentally changing how customers behave and disrupting the competitive dynamics of industries, requiring incumbents to become more agile to stay ahead of evolving customer expectations. Moreover, organizations do not always understand what impact their digital initiatives will have on different aspects of society – from employment to the environment and beyond – or what responsibility they should bear for addressing any unintended consequences of digitalization.

1.1.2Construction industry

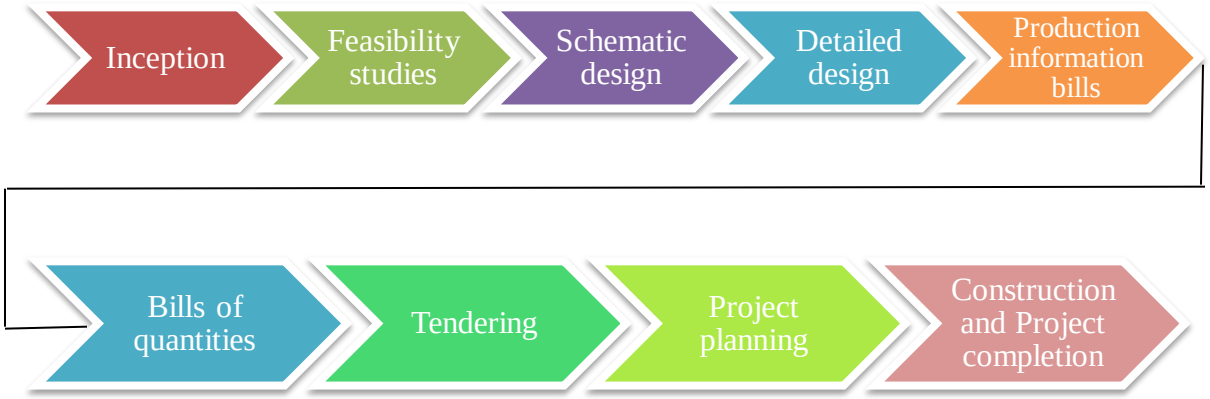
In construction industry project is managed essentially from its conception to its completionand needs to be discussed in terms of various stages of a project life cycle. A project could be viewed as a system, which is dynamic and ever changing from one stage to another in a life cycle, considering a generic project, its status changes from that of an idea or a concept through to feasibility studies, execution and finally completion. But projects are nowadays far more complicated than ever before. They involve larger capital investments, and embrace several disciplines, widely dispersed project participants, tighter schedules, stringent quality standards, etc. Coupled with high speed developments in ICT, these factors have influenced project management practices to take a new turn taking advantage of newly developed management tools and the latest technology.

"Construction Project Management is the planning, control and coordination of a project from conception to completion (including commissioning) on behalf of a client. Itis concerned with the identification of the client's objectives in terms of utility, function, quality, time and cost, and the establishment of relationships between resources. The integration, monitoring and control of the contributions to the project and their output, and the evaluation and selection of alternatives in pursuit of the client's satisfaction with the project outcome are fundamental aspects of Project Management."

The overall planning, coordination and control of a project from inception to completion aimed at meeting a client's requirements in order to produce a functionally and financially viable project that will be completed on time within authorized cost and to the required quality standards.

A construction project goes through various stages along the path to completion. In a typical project, the status changes from that of an idea or concept, through to feasibility studies, execution and final completion.

According to the Royal Institute of British Architects (RIBA 2000), the project life cycle is divided into a number of stages each of which has assigned project management practices and project managers with defined responsibilities. In general, the following stages are defined: Inception, Feasibility studies, Schematic design, Detail Design, Production Information, Bills of Quantities, Tendering, Project Planning, Construction and Project Completion.



RIBA (2000) has well defined the roles of the different participants such as architects, engineers, surveyors, planners, project managers, contractors and sub-contractors in each of the aforementioned stages. These roles are focused on managing and coordinating the project information and the flow among the various participants with the aim of satisfying the objectives of each stage.

The overall role of managing the project, in this scenario, is to harmonize the functions of planning, communicating, monitoring and control in order to meet the project's overall objectives as defined by the scope, time, cost, quality and client satisfaction.

There are three essential requirements in managing the project: thinking ahead, communicating and evaluation.

According to Peters (1981) half the value of project planning is to provide the opportunity and motivation, simply to get people to *think ahead about the project* that they are undertaking. This process tends to reveal problems, which helps to find solutions at early stages of a project.

Communication, deals with producing, issuing and transmitting reports/documents, and with holding occasional meetings among the project participants so that the proposed timing, method and strategy are made available and understood. In

essence, the collaboration of the various participants in a project is measured by how effectively the communication channels were managed.

Evaluation of the outcomes are critical to improve current practices. Communicating and feeding back information and messages to the project team is also essential to the achievement of the project goals by all the participants. Thus, the effectiveness of the project manager to communicate with, evaluate, and feedback to the rest of the project team during each stage of the life cycle determines how efficiently the project's goals will be achieved.

Traditional project management practices have evolved over time as the requirements for managing and controlling construction projects unfolded. Nonetheless, with the advances of management techniques and information and communication technology, traditional practices have proven to be insufficient in meeting the new project requirements.

Construction Projects are being designed by diverse number of designers (which may well be placed at different geographical locations), procured and managed by new partnering strategies, materials are purchased and delivered through strategic alliance with suppliers, etc.

If we focus on construction, projects are intricate, time-consuming undertakings. The total development of a project normally consists of several phases requiring a diverse range of specialized services. In progressing from initial planning to project completion, the typical job passes through successive and distinct stages that demand input from such disparate areas as financial organizations, governmental agencies, engineers, architects, lawyers, insurance and surety companies, contractors, material manufacturers and suppliers, builders, etc. During the construction process itself, even a modest structure involves many skills, materials, and literally hundreds of different operations. The assembly process must follow a natural order of events that constitutes a complicated pattern of individual time requirements and restrictive sequential relationships among the structure's many segments.

Essentially, a project is conceived to meet market demands or needs in a timely fashion. When starting a project, various possibilities may be considered in the conceptual planning stage, and the technological and economic feasibility of each alternative is assessed and compared in order to select the best possible project. The financing schemes for the proposed alternatives must also be examined, and the project is programmed with respect to the timing for its completion and for available cash flows. Once the scope of the project is clearly defined, detailed engineering design provides the blueprint for construction, and the definitive cost estimate serves as the baseline for cost control. In the procurement and construction stage, the delivery of materials and the erection of the project on site must be carefully planned and controlled. After the construction is completed, there usually is a brief period of start- up or shake-down of the constructed facility when it is first occupied. Finally, the management of the facility is turned over to the owner for full occupancy until the facility lives out its useful life and is designated for demolition or conversion.

On this ground, the main stages for construction project management are:

- **Market Demands or Perceived Needs.** The aim of this stage is to define project objectives and scope. Once an owner has identified the need for a new facility, the owner must define the requirements and delineate the budgetary constraints. It involves establishing broad project characteristics such as location, performance criteria, size, configuration, layout, equipment, services and other owner requirements needed to establish the general aspects of the project.

- **Conceptual Planning and Feasibility Study**. Conceptual planning stops short of the detailed design, although a considerable amount of preliminary architectural or engineering work may be required. The definition of the work is basically the responsibility of the owner, although a design professional may be called in to provide technical assistance and advice.

- **Design and Engineering**. The objectives of this stage are Construction Plans

and Specifications. This phase involves the architectural and engineering design of the entire project. It culminates in the preparation of final working drawings and specifications for the total construction program. In practice, design, procurement, and construction often overlap, procurement and construction beginning on certain segments as soon as the design is completed and drawings and specifications become available.

- **Procurement and Construction**. Procurement refers to the ordering, expediting and delivering of key project equipment and materials, especially those that may involve long delivery periods. This function may or may not be handled separately from the construction process itself. Construction is, of course, the process of physically erecting the project and putting the materials and equipment into place, and this involves providing the manpower, construction equipment, materials, supplies, supervision, and management which are necessary to accomplishthe work.
  - **Start-up of occupancy.** After the construction is completed, there usually is a brief period of start-up or shake-down of the constructed facility when it is first occupied. When the occupancypermit is issued and the facilities are accepted, then the occupancy is allowed.
  - **Operation and maintenance.** Finally, the management of the facility is turned over to the owner for full occupancy. This stage is focused on the use of facilities and the maintenance ofthe whole building. In this stage the possible renovations of the building are also included.
- **Disposal of facility**. When the facility lives out its useful life and is designated for demolition or conversion. This stage refers to the demolition and possible recycling of the facilities and partsof the building.

1.2 Problem Statement

Construction industry which is labor intensive suffers from sluggish productivity growth and relatively low financial returns. This industry involves a lot of complex processes, resources, and tools for any given project is never short of challenges.

Some of the common challenges every construction firm faces are productivity, communication, product traceability, employee safety, on-time completion, leading to the lowest profit margin and unhappy customers. In general, R&D spending in construction runs well behind that of other industries: it accounts for less than 1.0 percent of revenues, versus 3.5 to 4.5 percent for the automotive and aerospace sectors. Traditionally, the sector has tended to focus on making incremental improvements. Projects are ever larger and more complex. The growing demand for environmentally sensitive construction means traditional practices must change. And the shortage of skilled labor and supervisory staff will only get worse. These are deep issues that require new ways of thinking and working.

1.3 Objectives of the study

- To study the prospect of digitization in the construction industry.
- To study the benefits and challenges in digital transformation of construction industry.
- To study various challenges faced by CPWD in digitization of organisation.
- To study essential factors for growth of digitization in CPWD.

1.4 Scope of the study

As technology adoption and infrastructure improvements bring employees online and familiarity and comfort with digital platforms increase, the continued growth of connected digitization is inevitable. But today there is much uncertainty about the convergence between online and real time information and how to integrate value chain. The purpose of this study is to know what motivates and deters organization to shift towards digitization. How organizations can make use of technology to integrate their value chain which will enhance their productivity. A case study of CPWD (Central public work department) is done to study the stage of digitization and challenges faced in digitization. Sample of 120 respondents were obtained across various employees from all over the states in India. Finally, some insights are recommended about how to succeed in digitization of organization.

Chapter 2
LITERATURE REVIEW

2.1 Digitization of construction Industry around the globe

The construction industry involving a lot of complex processes, resources, and tools for any given project is never short of challenges. Some of the common challenges every construction firm faces are productivity, communication, product traceability, employee safety, on-time completion, leading to the lowest profit margin and unhappy customers. Digitization is about businesses encountering connected systems at every link in the value chain. It is about working with tools and practices based on information and communication technology. This understanding is changing the role of digital technologies. They are no longer mere tools to help companies do the same things a bit better. Instead, they fundamentally change the way business is done. Digitization permeates every part of every company: multinationals and midcaps, all-rounders and specialists alike. A large majority of players in the construction industry today recognize how digitization is affecting every part of their business too. According to one study by the Association of German Chambers of Commerce and Industry (DIHK), 93% of companies agree that digitization will influence every one of their processes.

This perception places construction on a par with retail and only just behind both the manufacturing industry and service providers – despite the fact that the needs and approaches of different actors vary very considerably. Producers of building materials tend to focus more on digitizing production and distribution (along the lines of Industry 4.0 and the design of the customer journey). By contrast, construction companies concentrate primarily on the digitization of planning, construction and logistics (building information modeling – BIM – and the connected "building site 4.0"). For their part, building material traders add a strong focus on digital sales (online trading) to their logistical considerations. Clearly, the industry is aware of the importance of the mega trend toward digitization. The problem lies rather with implementation. This was found in a Roland Berger management survey, above all among construction firms and their suppliers in Germany, Austria and Switzerland. The results of the survey paint an up-to-date picture of how industry players rate the potential of digitization and the extent to

which implementation has progressed. We call the picture that emerges "Construction 4.0"

Faced with challenges around project efficiencies, ongoing safety concerns and flat lining labor productivity levels, the industry's sluggish adoption of new technologies has reached an inflection point. Digital transformation requires changing processes and using new resources that harness the power of data to improve communication, efficiency, productivity and safety. This can position construction firms for profitable growth in a highly competitive industry, while also addressing workforce challenges.

The construction industry has a workforce that skews older, and as more baby boomers head toward retirement, the industry faces a labor shortage that's poised to get worse. According to the U.S. Bureau of Labor Statistics, there were about 300,000 construction job vacancies in June 2019, and the industry is expected to need 747,000 more workers by 2026. While the demand for skilled craftspeople has continually increased, fewer young people are entering the industry.

Potential recruits just don't see construction as an attractive and viable career option, especially when other sectors are considered more tech-savvy and offer perks that appeal to millennial workers. To navigate these conditions and sharpen their competitive edge, construction companies need to adopt a bifurcated strategy: invest in new technologies to streamline operations and lower costs from blueprint to final product, and invest in the workforce through retraining initiatives and by bolstering the talent pipeline.

Four keys to unleash the potential of digitization

Digitization gives players in the construction industry ways to improve their productivity. While other industries are already benefiting – along the entire value chain – construction still lags behind. Few players have yet turned to the potential of digitization as a way to resolve this problem. Such hesitant implementation is all the more surprising when one considers the trend in productivity in the construction industry. Over the past ten years, productivity in Germany has edged up by a meager 4.1%. By comparison, productivity across the whole of the German economy has increased by 11% in the same period. The gap between construction and industry is

particularly wide: Manufacturing has seen productivity rise by 34.1% on average over the past decade, against a gain of 27.1% for the whole of the secondary sector. In other European countries, productivity in the construction sector has actually declined – by 5% per annum in Italy and Spain in the period from 2010 through 2015. France just about managed a 1% per annum gain in the same period.

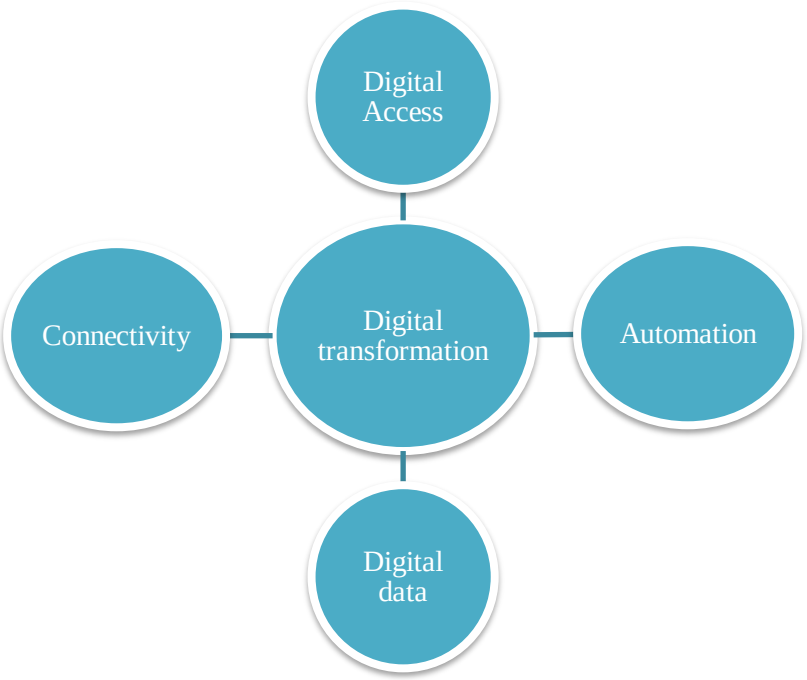


Figure 2.1 Source: Roland Berger

The potential of digitization across individual divisions, departments and functions, is split into four key areas: digital data, digital access, automation and connectivity. Digital data covers the electronic collection and analysis of data to gain fresh insights into every link in the value chain and then put these insights to good use. Automation groups together those new technologies that create autonomous, self-organizing systems. Digital access describes the potential afforded by mobile access to the internet and internal networks. Lastly, connectivity explores the possibilities to link up and synchronize hitherto separate activities.

One crucial factor regarding the vast potential of digitization is that each of these four keys can be turned at every link in the value chain. For players in the construction industry, the value chain breaks down into the following links:

- Logistics: Flow of goods, storage and transportation
- Procurement: Purchasing, supplier management and supplier evaluation

- Production/construction: Production and quality management
- Marketing/sales: Sales/dealer management
- After sales/end-customer marketing: Pull marketing, user support and services

The precise content of each link in the value chain varies from player to player. While suppliers of building materials focus primarily on production, construction companies naturally concentrate more on completing building projects. Building material traders in turn apply themselves to procurement and sales, with a corresponding focus on logistical services.

The degree of across-the-board implementation in the corporate community is correspondingly low. Even "moderate" implementation currently only applies for connectivity (in the context of procurement) and digital data (in production). Cloud computing solutions for collaborative production processes are one example. At all other links in the value chain, however, implementation is currently low, very low or non-existent. The figure at right also shows low to very low levels of implementation even in those areas where companies claim to recognize the potential of digitization.

Looking at the digital devices used as work tools by players in the construction industry, at most companies, more than 80% of employees have access to a PC and the internet. On the downside, there is still a very sizable number of firms where the corresponding figure is only between 20% and 40%. For smartphones the picture is even more ambivalent. The image of building workers organizing their work with tablets is evidently still far removed from reality on today's building sites. Yet precisely these devices and the apps they contain hold out the promise of huge benefits.

Recognizing potential and seizing opportunities: How digitization raises productivity.

Digitization has an influence on the industry. The issue in many cases is that little has been done about this realization. Above all, players in the industry seem uncertain about how exactly to realize the benefits of digitization at the various links in the value chain. Some applications are already established in business practice, while others are still in the development phase.

More than four out of five UK construction companies say that digital transformation is a priority for their organization, according to a survey of 835 construction professionals from across 12 countries in Europe, the Americas and Asia Pacific.

According to the survey conducted by IDC 72% of construction companies said digital transformation is a key priority to drive much-needed changes to their processes, business models and/or ecosystems. the UK is slightly above the global average, with 83% stating digital transformation is a priority for their organizations and 81% engaged in digital transformation.

As the operation dynamics of the construction business in India continues to evolve and the need to usher in innovations at all levels of business processes become imperative; digital transformation techniques can go a long way in improving quality, cutting costs, enhancing safety, reducing risks and boosting profits. The silver lining is that with increasing Internet penetration and the rapid technological advancement in the country, it is a good time for construction companies to accelerate their digital transformation.

Autodesk-IDC's latest research report, 'Digital Transformation: The Future of Connected Construction in India' highlights how the construction industry can benefit from digital transformation and how the sector can overcome the bottlenecks. The report also looks at how private companies are spearheading the BIM adoption revolution in India. At a time when consumer behavior patterns are witnessing a sea change, digital tools can aid construction companies in meeting personalized customer specifications while maintaining efficiency. By implementing automation processes, the decision-making processes can be streamlined and communication gaps can be easily eliminated. This can help in improved workflow, lower costs, better resource management, and faster turnaround times.

The demand for smart and sustainable technologies has been gaining ground since the last few years what with increasing concerns about the environmental impacts of construction activities. By making use of digital technologies, construction companies can stay ahead in the race of incorporating innovations that are sustainable and align with the rising trend of constructing smart buildings and cities across the globe.

The construction industry is sensitive to socio-economic changes like market demand, labour movement, etc. In light of the ongoing tremors being felt in the economy, cloud-

based software and mobile apps can ease collaboration among stakeholders that can strengthen the quality control process. Construction costs can be optimized by creating offsite, prefabricated materials and digital tools can help in proactively monitoring onsite safety and risk management through offsite manufacturing along with predictive maintenance. Although a chunk of India's construction companies has a long way to go in terms of digitalization, they are quickly climbing the rope and picking up knowhow from players in more developed markers for responding to local demand. Construction companies in India are increasingly turning to new technologies to speed up their digital transformation progress. Project management, enterprise resource planning (ERP), and client relationship management (CRM) have emerged as the core areas for planned software investments by construction enterprises. They are also waking up to the potential of increasing investments in predictive analytics/big data, internet of things, and 3D printing. One aspect is incorporating BIM techniques.

BIM

With BIM, digital 3D models that include data associated with physical and functional characteristics can be designed. BIM allows architects, engineers and contractors to collaborate on coordinated models so that everyone can have valuable insights into how their work fits in the overall project. According to the results of IDC's survey, private companies are spearheading the BIM adoption revolution and it is mostly being used for overseas clients. The report says, "There is a correlation between most mature construction organizations (stages 3 and above) in Asia/Pacific and their usage of BIM-based workflows – the higher the maturity, the higher the proportion of BIM-based workflows usage in daily operations. In India notable structures that have made use of the BIM technology includes Bangalore Airport and the Delhi Metro Rail but the industry as a whole is lagging in this regard.

IDC has defined digital transformation as "the application of third platform technologies such as cloud, mobile, big data and social coupled with organizational, operational and business model innovation to create new ways of operating and growing businesses." The digital transformation process has been categorized into five stages where stage 1, called the Ad Hoc stage represents companies whose digital initiatives are poorly aligned with enterprise strategy and do not focus on customer experiences. Stage 5,

called the digital disruptor stages includes enterprises that have been leading the charge in terms of usage of new digital technologies and have been driving business innovation by building a healthy ecosystem of awareness and feedback. According to IDC's findings, more than 70% of the companies are in stages 1 and 2 and only 3% of the companies have successfully traversed the digital transformation journey.

Challenges in ushering digital technologies in construction industry

The construction space in India has been relatively slow in the adaptation of relevant technologies. According to Autodesk-IDC report there are five major problems that have been plaguing the sector in terms of reaping the benefits of digital technologies. Digital transformation roadmaps, platform, performance score card, organization structure and organization capabilities are the digital impasse where the companies are stuck and are trying to unlock these in order to evolve as a digital enterprise. According to the IDC report, 47% of construction companies in India developing digital capabilities and skills across the organization remains the top digital challenge, about 42% are facing troubles with respect to creating a strategic roadmap for digital investments. Building the right organizational structure remains a pain point for 41%. Besides organizational and industry-specific concerns, companies believe that the construction phases involving planning and briefing, design development, site execution, documentation as the construction phases that require the maximum improvement.

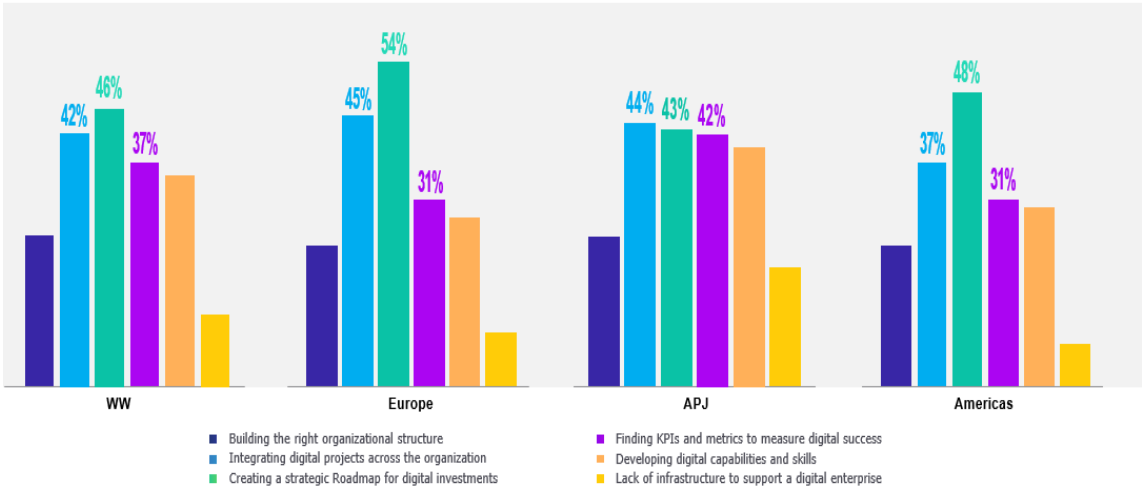


Figure 2.2 Source: IDC info brief

Along digital deadlocks, creating a strategic roadmap for digital investments is the top digital transformation challenge for construction companies worldwide. This is followed by integrating digital projects across the organization and finding KPIs and metrics to measure digital success. Unlocking these "digital deadlocks" can help organizations mature and progress along their digitization journey, moving past the early and mid-level stages into the most mature stages, where digitization is central to the way the company works and delivers a competitive advantage in the market.

Digital construction solutions for improved performance

Identifying and adopting valuable digital tools, data-enabled hardware and field software can provide a solid foundation for sustained growth. For example, using drones or unmanned aerial vehicles (UAVs) for aerial photography can help expedite a land survey and assist planning through digital imaging techniques, precise topographic mapping software and data analytics that inform building strategy. Continued UAV surveillance can also help secure the site and inspect for safety hazards or structural issues. When applied in conjunction with 3-D printing, automated equipment tracking and progress reporting, these innovative building techniques reduce the time, effort and cost involved in more traditional construction approaches.

Innovative software can identify and quantify work tasks, reducing or eliminating extraneous work to help maximize time and minimize effort. Supply chain information can even be tracked in the cloud, increasing transparency and accuracy by collecting that data within a single platform. Automation and informed decision-making from a single source of truth for construction projects can lead to improved workflow, lowered costs, better resource management and faster turnaround times. Digital technologies can be utilized for proactive onsite safety and risk management through offsite manufacturing, along with predictive maintenance.

Creation of offsite, prefabricated materials and modular construction continue to gain popularity, addressing time constraints and costs. Digital tools not only support the project budgets and timelines, but also promote worker safety and sentiment.

Navigating Workforce Woes

Workforce challenges in construction abound. The industry has been contending with a lack of organized site management, miscommunications between the field and regional office and a downward trend in employee morale.

The flow of information from job site to regional office to corporate can be fragmented, delayed and incomplete. The amount of time it can take to input information into the system leads to lack of real-time visibility into a project's progress, which can ultimately have an impact on cash flow. Integrating data can streamline communication and deliver more accurate information more quickly. Work in Progress (WIP) tools track work in real-time, making sense of data that can then be used to inform subsequent project plans. They also allow for more accurately designed scheduling with the appropriate amount of margin and risk tolerance built into project plans. Similarly, Building Information Modeling (BIM) can synthesize all essential aspects of a project's input into a single plan with 3-D modeling, wherein contributors can stay in timely communication.

Digital transformation can also help attract younger workers to the industry by creating more jobs that require tech skills. Modernizing processes through increased adoption of technology can both create new jobs and future-proof the industry.

Technology also enables construction managers to standardize approaches across a project (or multiple projects), facilitating additional clarity in delegating responsibility and even safety. The IDC predicts 279 million wearables will be in use by the end of 2023, a technology that can be applied to increase site safety and monitor for productivity. For instance, sensors attached to workers' clothing or hard hats can track signs of fatigue to prevent an accident, monitor body temperature to avoid hypothermia or heat exhaustion, send an alert through noise or vibration to indicate a hazard and provide supervisors with real-time information about the number and location of employees on site.

Future of construction companies

IDC report states, "35% of construction companies are planning to establish this roadmap within the next 12 months, highlighting how digitization is a priority for

construction companies in the country. However, 24% still have no plans to do so." The ease with which companies can participate in the digital transformation movement largely depends on the investments they are willing to make in new technologies on tools. Only 9% of India's construction organizations spend more than 5% of their annual turnover on technology which is way lower than the 22% average clocked by the Asia Pacific region.

The global economy has been clobbered by COVID-19. Given that infrastructure development is an important factor in economic growth, it has become the need of the hour for the construction sector to jump on to the digital transformation bandwagon.

Chapter 3

RESEARCH METHODOLOGY

Research is a systematic method of finding solutions to problems. It is essentially an investigation, a recording and an analysis of evidence for the purpose of gaining knowledge. According to Clifford woody, "research comprises of defining and redefining problem, collecting, organizing and evaluating data, reaching conclusions,".

3.1 Research Methodology

This report deals with descriptive research design because it describes data and characteristics about the phenomenon being studied. The findings in this survey are based on an online survey across all over India and a telephonic interview in the state of Delhi. While an online survey methodology allows for tremendous scale and national reach, it provides a perspective only of few employees, vendor and not total populations.
Secondary information was obtained through the internet, journal, and annual report and research papers. Primary data analysis is done through statistical tool using Column graphs, Pie charts, as it is a descriptive research.
Survey responses are based on claimed behavior rather than actual metered data. Cultural differences in reporting sentiment are likely factors in gathering information about digital transformation across states. The reported results do not attempt to control or correct for these differences.

3.1.1 Purpose of the study

As technology adoption and infrastructure improvements bring employees online and familiarity and comfort with digital platforms increase, the continued growth of connected digitization is inevitable. But today there is much uncertainty about the convergence between online and real time information and how to integrate value chain.
The purpose of this study is to know what motivates and deters organization to shift towards digitization. How organizations can make use of technology to integrate their

value chain which will enhance their productivity. Finally, some insights are recommended about how to succeed in digitization of organization.

3.1.2 Objectives of the study

- To study the prospect of digitization in the construction industry.
- To study the benefits and challenges in digital transformation of construction industry.
- To study various challenges faced by CPWD in digitization of organisation.
- To study essential factors for growth of digitization in CPWD.

3.1.3 Research design

This study investigation was conducted for some definite purpose with the help of a structural questionnaire to gather primary information as much as possible.

The study deals with descriptive research design. Descriptive research, also known as statistical research, describes data and characteristics about the population or phenomenon being studied. Descriptive research answers the questions who, what, where, when and how.

3.1.4 Sampling design

Sampling Method: A sample design is a finite plan for obtaining a sample from a given population. Simple random sampling is used for this study.

Sample Size: Number of the sampling units selected from the population is called the size of the sample. Sample of 120 respondents were obtained across various employees from all over the states in India.

Sampling Procedure: The procedure adopted in the present study is probability sampling. Under this sampling design, every item of the frame has an equal chance of inclusion in the sample.

3.2 Data collection process

3.2.1 Methods of data collection

The data was collected through Primary and secondary sources.

Primary Sources

Primary data are in the form of "raw material" to which analysis is done. The primary sources are interview with the employees and data collected through questionnaire.

Secondary Sources

Secondary data are in the form of finished products as they have already been treated statistically in some form or other.

The secondary data mainly consists of data and information collected from records, company websites. Secondary data was collected via internet.

3.2.2.Questionnaire design

A well-defined questionnaire was designed to effectively gather information on both existing system as well as information on using new technologies in the organization. It consists of closed-ended questions and open ended questions. The questions were arranged in proper order, in accordance with the relevance.

Nature of Questions Asked

The questionnaire consists of close ended (5 point Likert Scale Rating method, /Multiple choice). The sample selected for the distribution of questionnaire was 200. Out of 200 samples,120 employees, vendors responded to the questionnaire effectively.

The questionnaire is comprised of 11 questions which covered all the aspects of studying trends, challenges, opportunities of digitization in CPWD.

Presentation of Data

The data are presented through Pie-charts, Column graphs and tables.

3.3 Data analysis process

Data analysis is done through Statistical Tools:

- Pie Charts and Column Graphs.

3.3.1 Procedure for analysis

- Analyzing the close-ended question's responses of employees/vendors using Pie chart and Graphs and evaluating the positivity of responses.

3.4 Limitations of the study

The limitations of the study are the following:

1. The data was collected through internet sources. The response from the respondents may not be accurate.
2. The sample taken for the study was only 120 who were tech savvy so the results drawn may not be accurate for all population.
3. Lack of experience of Researcher.

Chapter 4

CASE STUDY, ANALYSIS AND RECOMMENDATIONS

4.1 CPWD - A case study

The CPWD Vision aims to create an Integrated IT system for the capture of all the valuable in-process online data not only from its vast operations, but also from all Electrical & Mechanical and construction equipment under its control. This will be done by bringing all CPWD stakeholders such as CPWD Officials, Contractors, Consultants, Vendors, Clients, Allottees, Arbitrators, for online real time collaboration to cut down cost and time over-runs in works, improve quality of works and services, reduce wastage, and improve safety at work site. CPWD has the potential to leverage its vast organizational learning, accumulated over the past 167 years of its glorious history, for preparation of designs, estimates, tender documents and standards quickly and efficiently as per the requirements of the clients and enable the department to use modern IT tools such as data analytics, machine learning and artificial intelligence for delivery of quality works and services on time.

Central public work department (CPWD) came into existence in July, 1854 when Lord Dalhousie established a central agency for execution of public works and set up Ajmer Provincial Division. Through the professional expertise in disciplines including Architecture, Engineering, Project Management coupled with comprehensive experience in building construction and maintenance CPWD has been serving the nation for last 164 years and has executed priority of works in difficult and demanding geographical and climatic conditions. It has now grown into a comprehensive construction management department, which provides services from project concept to completion, consultancy and maintenance management.

CPWD is the premier construction agency of the Government of India and plays a pivotal role in the construction programme of Government projects. Its activities are

spread throughout the length and breadth of the country. It also undertakes the projects of Autonomous Bodies and Public Sector Undertakings as Deposit Works. Besides being the construction agency of the Government, it performs a regulatory function in setting the pace and programmes for the building industry in the country. CPWD executes projects on turnkey basis including all the services viz. water supply, sewerage, roads, electrical, air-conditioning, fire-fighting etc. Expertise in all fields of building construction namely Architecture, Civil Engineering, Structural Engineering, Electrical and Mechanical Engineering and Horticulture are available under one umbrella. The department takes upon itself full responsibility for planning designing, estimation, evaluation of bids, finalization of contracts, defending arbitration and court cases. Once the work is entrusted to CPWD, the client is relieved of the responsibilities of preparing plans, estimates, appointing contractors, arranging materials, resolving disputes with the contractors, arbitration, court cases etc. The department provides comprehensive building construction management services and the project becomes the responsibility of the department.

Figure 4.1: Central Vista Project

Source: Internet

It is headed by DG who is also the Principal Technical Advisor to the Government of India. The regions and sub-regions are headed by Special DGs and Additional DGs

respectively, while the zones in all state capitals (except a few) are headed by Chief Engineers. CPWD has PAN India presence and has ability to undertake construction of complex projects even in difficult terrain and maintenance in post construction stage. CPWD had been involved in construction of stadiums and other infrastructure requirements for Asian Games 1982 and Commonwealth Games 2010. Zeal and spirit of endeavor of CPWD officers have taken the organization beyond national boundaries. CPWD is right now engaged in construction of Afghan Parliament Building.

Organizational structure

Central P.W.D. is executing works across length and breadth of the country. There are seven Regions, namely; New Delhi Region, Delhi Region, PWD Region, North Region, South Region, East Region and West Region which are headed by Addl. Director General/Engineer-in-Chief apart from dedicated unit of Additional Director General (Border), which is looking after border fencing, road and lighting works along Indo-Pak and Indo-Bangladesh borders. Regions are an independent unit in the matters of execution of works and Chief Engineer Civil, Electrical and Chief Architect of the Region report to the Regional head i.e. Additional Director General. ADG (Arch) is assisting the Director General (Works) at the headquarters in Architectural Planning and designing of projects. ADG (Trg.) is in charge of Training activity in CPWD. ADG (Strategy & Planning) and ADG (Technical Development), are in charge of New Delhi Region and Delhi Region respectively. They are also discharging Headquarters functions relating to administrative, personnel matters, technical policies etc.

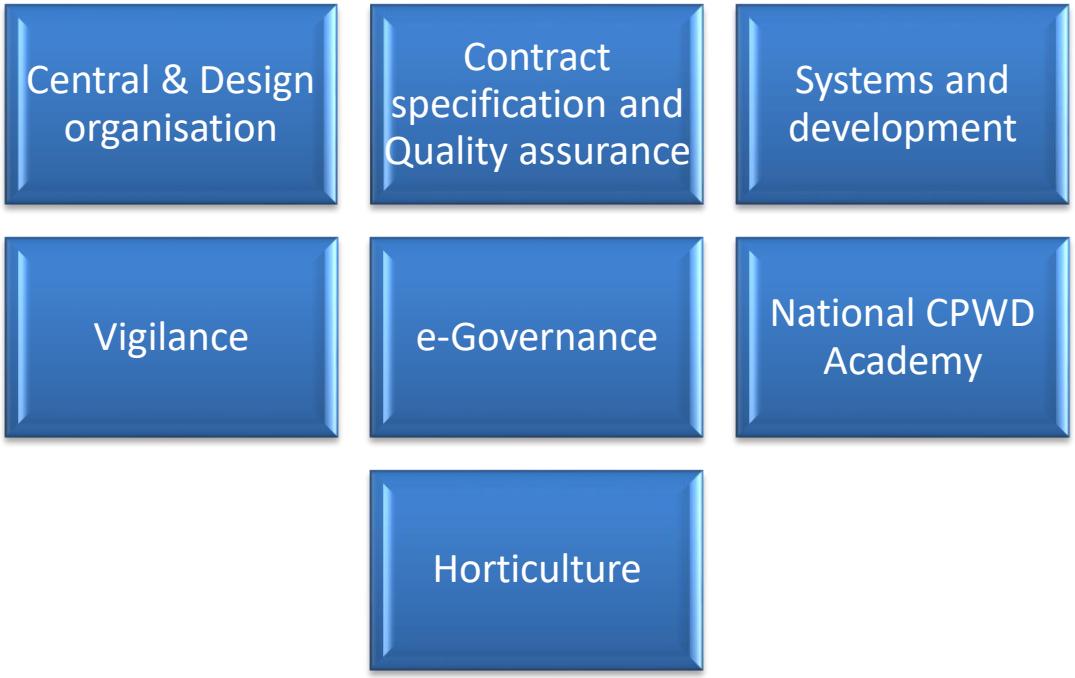


Figure 4.2: Units of CPWD **Source: CPWD**

Central Design Organization: Central Design Organization was created in the year 1969 with a view to provide higher level of design inputs in multistoried projects which could not be handled by the design units under Chief Engineers. As pressures on availability of land increased, CPWD could utilize the services of CDO for high rise built habitats and complex projects such as jetties and bridges. CDO has provided its services to over 350 projects in CPWD and 35 projects in last four years alone. Important projects designed by CDO are Parliament Library Complex, Parliament Annex Building, National Gallery of Modern Art, National Museum, Supreme Court Extension, National Stadium, Afghan Parliament in Kabul, Lal Bahadur Shastri National Academy of Administration Mussoorie, Hall of States ITPO etc.

At present, Central Design Organization has the responsibility of structural design of complex structures (with structural cost over Rs. 25 Crores) incorporating state of art engineering practices and technology. It is also responsible for contributing to the consultation process of BIS for framing new Codes and Handbooks and thus setting standards for the construction industry as a whole. CDO also offers its

services in preparing several technical documents/reports such as Handbook on Seismic Retrofitting, Design Manuals, Fly ash utilization guidelines, and seismic assessment reports of critical government buildings.

Contract Specification and Quality Assurance: The Contract Specification and Quality assurance unit of CPWD is responsible for contract related matters and quality assurance functions.

The unit headed by a Chief Engineer is located in Nirman Bhawan and has 5 separate cells headed by Superintending Engineers to look after specific areas which are as under:

1. Contract & Manual
2. Technical Application Development
3. Technology Application & Standards Unit.

Systems & Development: The Systems & Development unit deals with cadre related policies, recruitment rules, cadre review proposals, re-structuring and re-organisation, annual reports, annual action plan, celebration of CPWD day, management and SIU studies, parliament questions, issues related to expenditure and administrative reforms. It is assisted by Executive Engineer (S&D), and Section Officer.

Vigilance: The vigilance unit of the CPWD is responsible for vigilance in the organization under the general superintendence of the Central Vigilance Commission, the apex organization of the Government of India that controls anti-corruption measures and probity in public life. The vigilance unit is headed by the Chief Vigilance Officer who has a three-fold function

i. To act as an adviser to the DG, CPWD in all matters pertaining to vigilance.

ii. To provide a link between CPWD and the CVC on the one hand and between CPWD and the CBI on the other hand and

iii. To collect intelligence about the corrupt practices committed or likely to be committed by the employees of CPWD, investigating or causing an investigation to be made into verifiable allegations reported to him.

e-Governance: CPWD provides services from concept to completion of projects and maintenance of built assets for various ministries and departments of the central government. It has country wide presence with vast human resource of about 30,000 employees. There are about 1,70,000 residential units and 2.3 million sqm non-residential area maintained by CPWD. The construction and maintenance works are executed through contracts made after call of tenders.

It was imperative for CPWD to adopt e-gov tools for efficient management of its manpower, tenders, contracts, accounts, and maintenance services, and a humble beginning was made in 2000s.

This unit deals with maintenance, improvement, and development of software and CPWD website. Following software are being used extensively.

(i) Personnel Information Management System (PIMS) : for HR management

(ii) Project Monitoring System (PMS) : for monitoring of projects

(iii) e-Tendering: for online tendering

(iv) CPWD Sewa : for quarters maintenance management.

(v) Contractors' Enlistment : for enlistment of contractors.

National CPWD Academy

The National CPWD Academy is looking the training needs of Engineers, architects, Horticulturists and workers. The main academy is located at Ghaziabad. Regional National Academy and Workers Training Centres are located in the four metros i.e. New Delhi, Mumbai, Kolkata and Chennai. The Institute imparts training/refresher courses in all the aspects of public works. The academy conducts training programmes, workshops, brain-storming sessions, seminars etc. to upgrade the techno-management skills of CPWD officers as well as other

Central Government Departments, State Government, PSUs etc. The training programmes are conducted in diverse streams such as Civil Engineering, Electrical and Mechanical Engineering, Architecture, Computer Application and Management Techniques. A number of new courses on Green Buildings, their rating system and certification, energy efficient buildings, conservation of heritage buildings etc. have been introduced to cater to the current changing construction scenario. New courses on Horticulture have also been added.

Horticulture

CPWD is basically working on the ornamental horticulture developing and maintaining the landscape gardens attached to the buildings of GPRA and GPOA. This is the only department in Govt. of India which is working and executing the landscape works and no other Govt. departments are having such type of infrastructure and staff. This is basically the work of greening and decorating the buildings and create habitable environment with pleasant and attractive activities. The horticulture word also relates to the crops and plants which are dealt in the Ministry of Agriculture. Some other bodies like NDMC, DDA, MCD, GDA and HUDA have also created such type of establishments which is parallel to the CPWD. CPWD is working as bench mark institution for the other horticulture department which are working at par with the CPWD. The guidelines and Manual prepared by CPWD are being followed by all these departments and by the other agencies who are executing such types of works.

4.2 Data analysis and findings

4.2.1 Descriptive statistics

Analysis based on questions asked

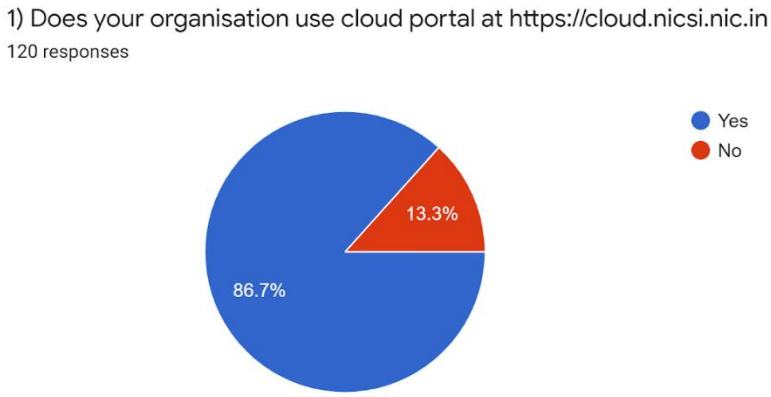


Figure 4.3

Inference: Out of all the respondents' majority 86.7% said they use the cloud portal followed by 13.3% of respondents who said they were not using cloud portal as they belonged to vendor category.

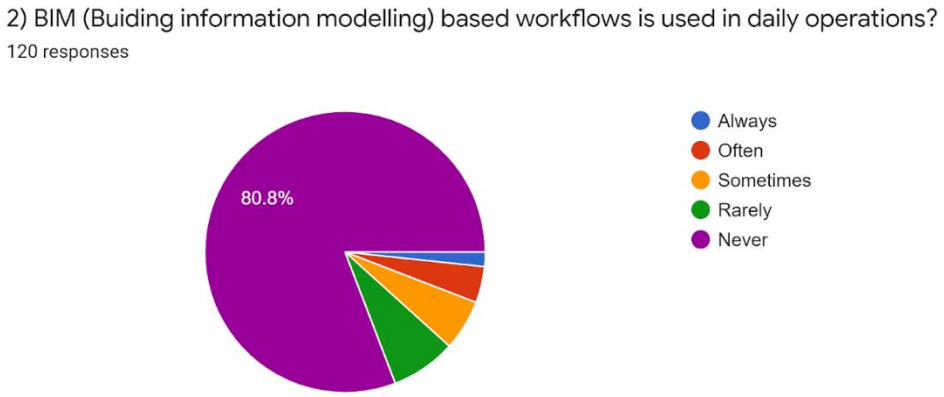


Figure 4.4

Inferences: 80.8% of respondents said they never used BIM based workflows in their operations. Government has not yet made BIM mandatory for use in its contract. The remaining 19.2% had a mixed response because of few global tenders that CPWD has taken with Multinational companies' participation.

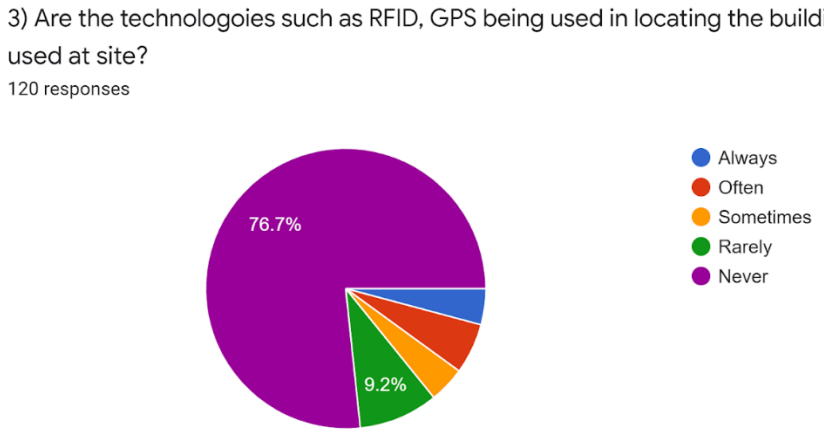


Figure 4.5

Inference: Out of all the respondents 76.7% said they never used RFID, GPS in locating the building material/equipment at site. The remaining 23.3% had a mixed response because of GPS enabled T & P and other vehicles hired by the contractors and officers.

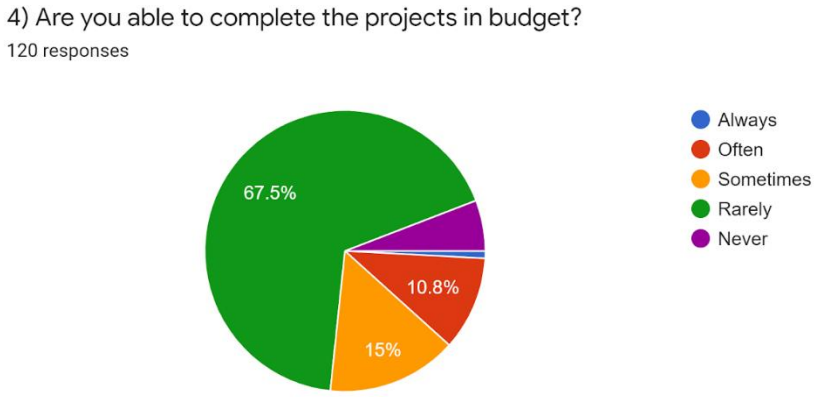


Figure 4.6

Inferences: Out of 120 respondent mere 0.8 % could say they were able to complete the project within budget, 15% said they could sometime complete projects within budget while 67.5% said they were rarely able to complete the project within budget. The main reason behind this being increase in wholesale price index and also increase in the scope of work over a period of time.

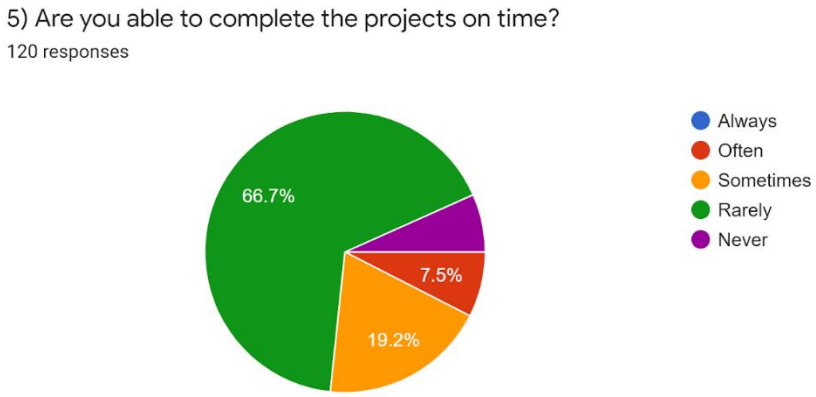


Figure 4.7

Inference: Out of 120 respondent majority 66.7% said they rarely completed the project on time, 6.7% said they could never complete projects on time. This is because of 3-4 months of monsoon rainy season adversely affecting the progress of work. Shortage of labor during festivals, sowing/harvesting season are also the main reasons for the delay

of projects.

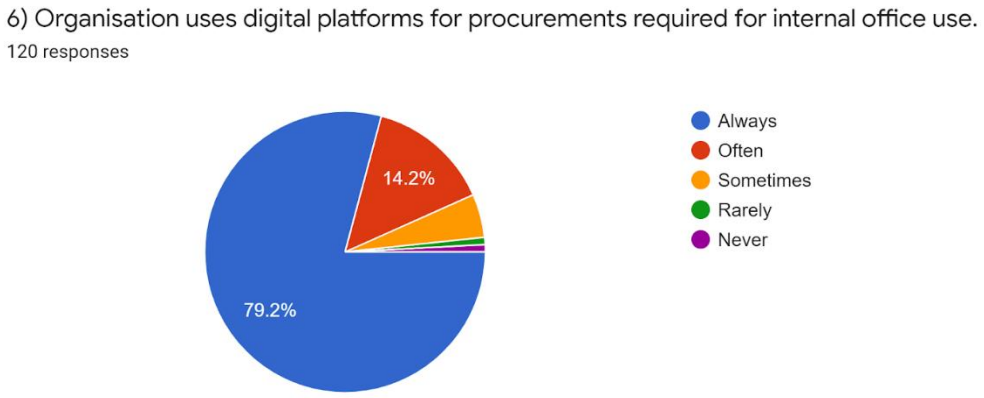


Figure 4.8

Inference: Almost 79.2% of respondent agreed that they were using digital platforms for procurements required for internal office use. 14.2% said they used it oftenly. Remaining had mixed response because few items may not be available in the list of department of e-procurement.

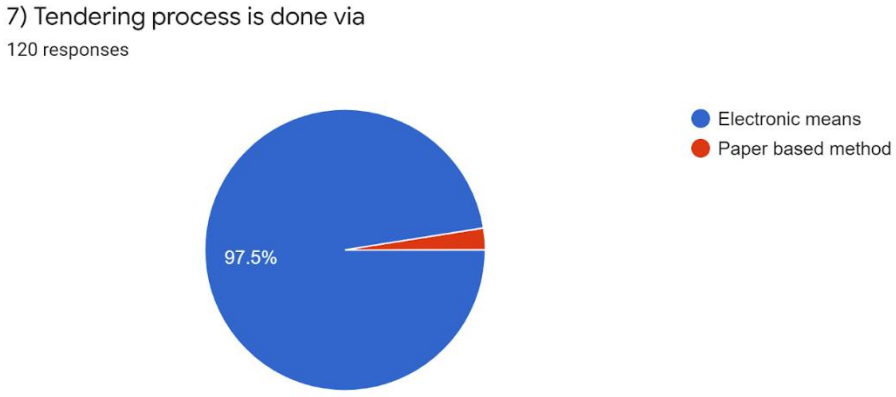


Figure 4.9

Inference: Almost 97.5% respondent agreed that tendering is done via electronic means. It means government has made the tendering process completely online. The remaining 2.5% said work-order by paper based method is mainly for the work of emergent nature.

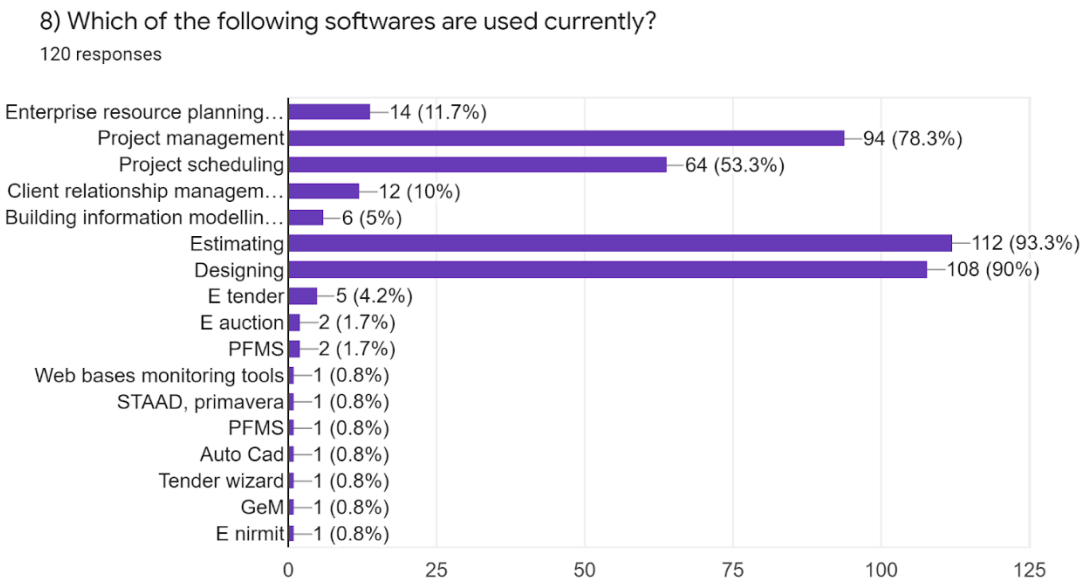


Figure 4.10

Inference: Almost 93.3% of the respondents said that they used Software such as Esta is used for estimating the project. 90% said they use software for designing projects. For Architectural drawing they use Autocad whereas for structural designing STAAD, IDAB is used. 78.3% said they used project management software such as Primavera. 64% said they used MS projects for project scheduling. ERP, CRM and BIM were used in global tender. Tender wizard is being used for e-tendering work. PFMS is used for accounting and bill payment. GeM for e procurement.

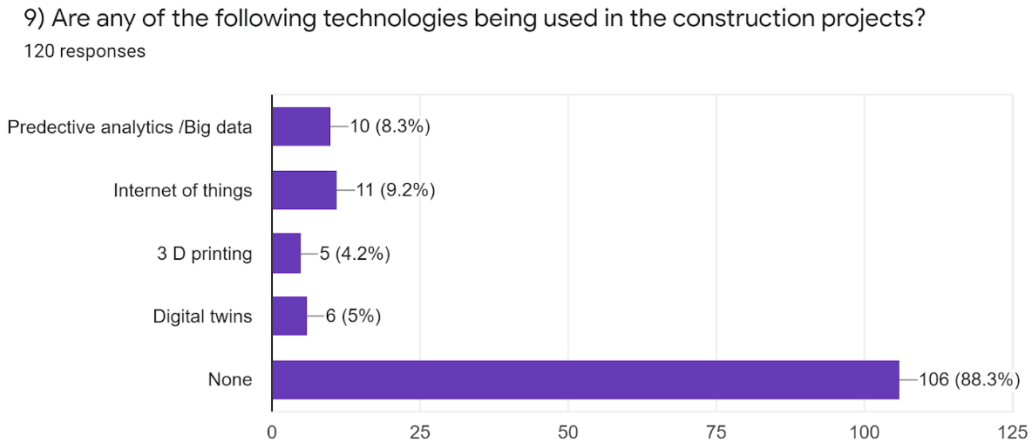


Figure 4.11

Inferences: 88.3% of respondent said they did not use any of the technologies as these were not yet being used at sites. Mixed response of remaining respondent is due to global tender called by CPWD.

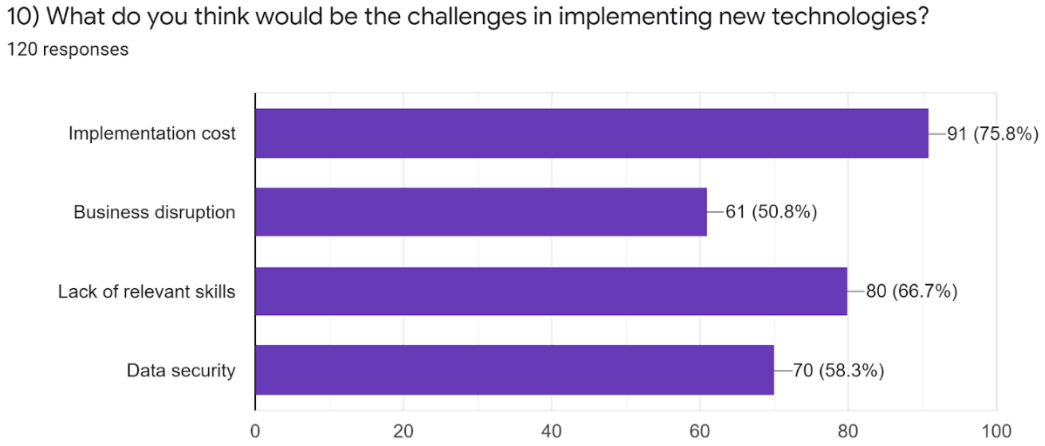


Figure 4.12

Inference: All the four options have been given due weightage while implementation cost with 75.8% being the top challenge followed by lack of relevant skills with 66.7%, data security with 58.3 % and business disruption with 50.8%. Respondent did not have the confidence that the existing skills can handle the new technology. Also

they feel that the technology costs as of now is very high.

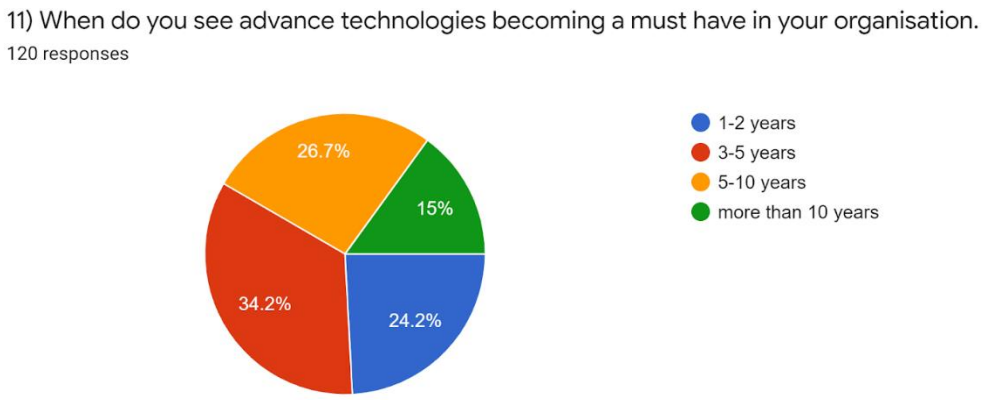
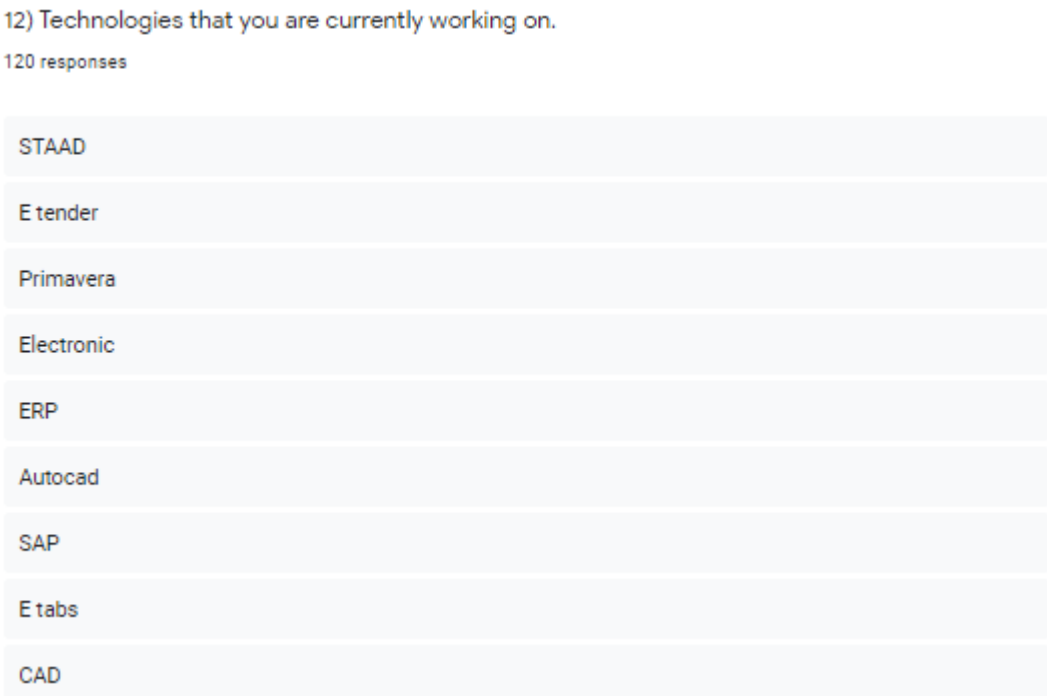


Figure 4.13

Inferences: While 58.4% of the respondent are hopeful that the advance technologies will be implemented within 5 years where as 41.6% said that it would take more than 5 years to fully implement the technologies and 15% expect it to take even more than 10years as they feel it will take few years for the technology costs to come down and also to prepare the workforce with relevant skills.



Esta
E nirmit
Autocad
Sap
EPC
Electronic media
Iadb
Primavera
SAP
STAAD primavera
PFMS
Tender wizard
Pert
E auction
E tender
PFMS
Dgsnd
Building construction

GeM
Integrated Analysis & Design of Buildings
Tender wizard
Enterprises resource planning
E-auction
iADB
Staad
E-tender
sAp
Auto cad, GPS
IADB
As required for Architectural consultancy & project management consultancy.
E governance
None . Technological Development is not in my purview.
E procurement
PIMS
E-procurement
Nil

Figure 4.14

Inference: Respondent expressed various types of software used in CPWD for the purpose of Estimation(Esta), Structural design (Staad, Etab, IADB, SAPetc.), Architectural design (Autocad), Accounting (PFMS), Tendering (Tender wizard, e tender), E-procurement (GeM), ERP (e-nirmit), HR management (PIMS), Project management (Primavera, PMS, MS project)

4.3 Recommendations

Based on findings and requirements

- ✓ CPWD should explore new technological capabilities available in the market and the technologies used in other countries (such as virtual and augmented reality, drones, robotics and additive printing)
- ✓ CPWD should train its younger generations for emerging tech-related projects. Many new projects can be created in the years to come with the adoption of new tools and processes.
- ✓ Soil testing is important in construction industry for designing the foundation, CPWD should make use of predictive analytics for the analysis of soil.
- ✓ CPWD should make BIM mandatory in their projects as BIM can trigger significant improvement potential (direct costs, quality, delays, security, image) along the full construction value chain (design, construction, operations and destruction). This potential can be further enhanced if possible connections to the BIM are used. Productivity can be increased in the organization through pre-fabrication, modular production or 3D printing.
- ✓ CPWD is already implementing ERP E-nirmit in its organization. A new function in the organization should carry out the centralized vision that would hold the operational responsibility of the project and will symbolize the change.
- ✓ CPWD should make a strong framework with working groups and regular reporting to track progress and ensure efficiency for digitizing the project.
- ✓ CPWD should address the road blocks such as relevant skills, managing mindset of people who otherwise are resistant to change, bringing in new technology without delay.
- ✓ Digitalization has the particularity of confronting the organization with various options that should be considered with an open mind.
- ✓ CPWD can incentivize its officers for their involvement in the organization effort of digitizing and rewarding early adopters of the new mindset.

- ✓ Implementation of ERP at CPWD is in slow progress, training its workforce should be a priority dimension as the organization needs to rapidly shift processes and sensitivities of construction site officers.
- ✓ CPWD should make it compulsory to shift from a siloed POC mode to a real overall strategy, with a clear mid/long term disruptive vision communicated to the organization and a three to five years roadmap.

4.4 Limitations of the study

The limitations of the study are the following:

1 The data was collected through internet sources. The response from the respondents may not be accurate.

2 The sample taken for the study was only 120 who were tech savvy so the results drawn may not be accurate for all population.

3 Lack of experience of Researcher.

Chapter 5

CONCLUSION

Digitization in the construction world is in its infancy. While innovation is booming it still remains scattered and not really organized. Nonetheless, digitalization in construction will eventually generate usages and breakthroughs that we simply cannot conceive yet. Demands are quickly rising and become more and more complex with expectations increasingly on the "usage" more than on the product itself.

The construction industry involving a lot of complex processes, resources, and tools for any given project is never short of challenges. Some of the common challenges every construction firm faces are productivity, communication, product traceability, employee safety, on-time completion, leading to the lowest profit margin and unhappy customers. Supply chain problems, scope changes, design errors, unforeseen risks, and build failures are just some of the obstacles encountered in projects. These problems are exacerbated by the industry's continued reliance on paper or other outdated means to manage design, operational processes, supply chains, communications, and deliverables. However, the introduction of techno-enabled digital solutions like IoT-enabled application, RFID tracker, QR-code scanner, asset tracking app, web apps (thanks to digital transformation services) has started to impact the industry and the construction experts have started to shift their eyeballs towards the future technologies to improve profit and customer satisfaction. Building Information Modeling (BIM) and a connected data environment, enables both broad and detailed views of all phases of a project, helping mitigate or avoid problems that can stall a project. An important advantage of a complete digital construction process is its ability to be both predictive and reactive. In contrast with earlier digital forms, digital twinning through BIMs goes beyond simply speeding up analog processes to driving improvements in core project management practices, thereby reducing project delays.

The digital transformation at CPWD is far from satisfaction. Although many initiatives have been taken under Digital India scheme, however the complete transformation will take few years to happen. Although the premiere Government institution CPWD, NBCC

are fully accustomed with software for Architectural/Structural design and estimate, however they are not versed with real time software such as BIM, 3D printing, predictive analytics, others. Respondents have said that relevant skills for newer technology is lacking among the workforce.

Most of the respondents have said that they were rarely able to complete the projects on time which reflects that the productivity is marred as the value chains are not integrated. The delay in projects also increases the budget of project. There is desperate need to integrate the value chain which will increase the productivity of organization and will reduce the cost of project making it economical and increasing the financial returns of CPWD.

In the booming start-up environment, Startups can take advantage of the market opportunities induced by digitization to fill newly created added-value gaps. There is a significant change coming in, all players in the organization, whether they are promoters, engineering companies, builders, suppliers of equipment, materials, or distributors will be impacted by digital pressures. Each one will experience this differently. The digitization is putting pressure on incumbents (both equipment and traditional construction and service players) by producing a more complex and dynamic competitive landscape and the progressive disruption of traditional channels.

Government should make Building information modeling (BIM) mandatory as the new way of working and target the digital strategy given that different elements (such as various software, drones, construction engines, building and infrastructure equipment) should ultimately be connected to it. Launching a new strategy is not an option for organization, it has now become necessity.

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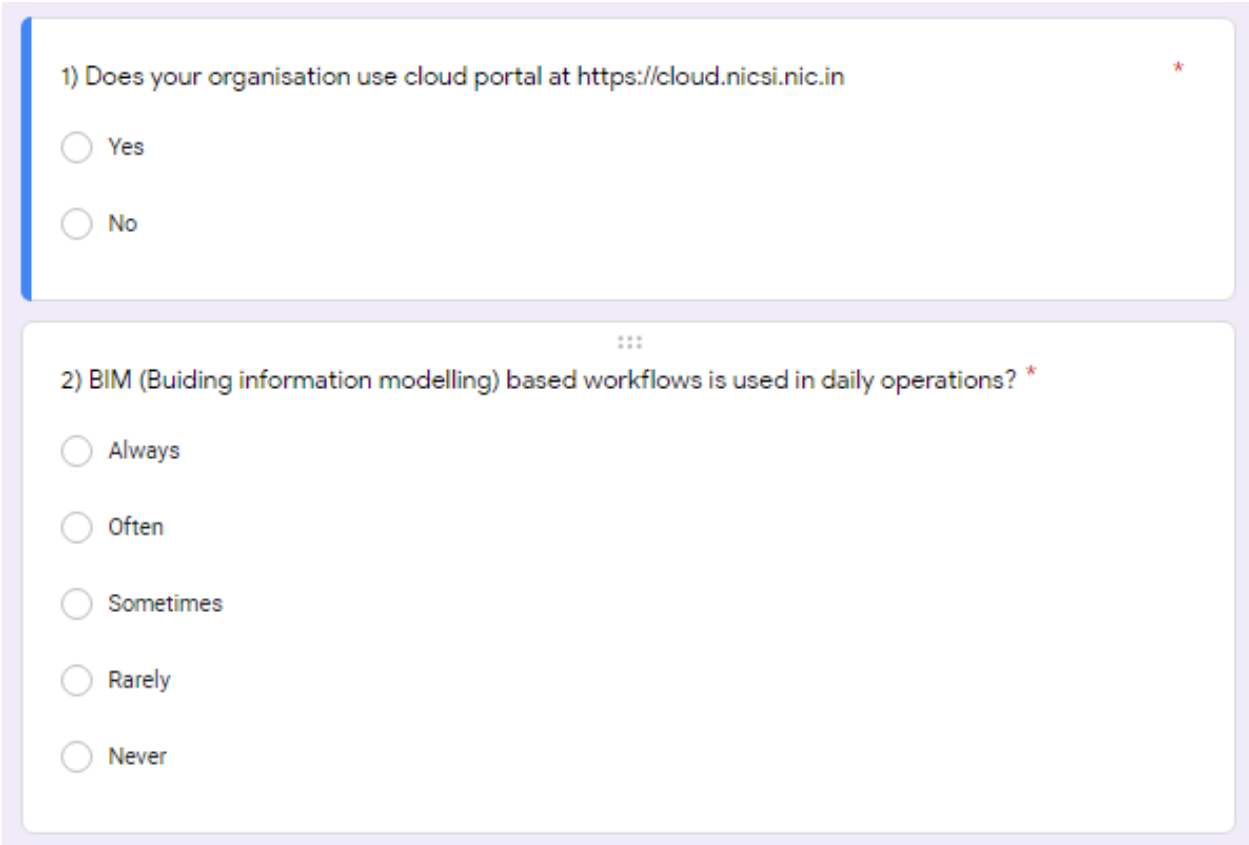
ANNEXURE

A snapshot of Questionnaire



1) Does your organisation use cloud portal at https://cloud.nicsi.nic.in *

- Yes
- No

2) BIM (Buiding information modelling) based workflows is used in daily operations? *

- Always
- Often
- Sometimes
- Rarely
- Never

3) Are the technologoies such as RFID, GPS being used in locating the building material/equipment used at site? *

- Always
- Often
- Sometimes
- Rarely
- Never

4) Are you able to complete the projects in budget? *

- Always
- Often
- Sometimes
- Rarely
- Never

5) Are you able to complete the projects on time? *

- Always
- Often
- Sometimes
- Rarely
- Never

6) Organisation uses digital platforms for procurements required for internal office use. *

- Always
- Often
- Sometimes
- Rarely
- Never

7) Tendering process is done via *

- ( ) Electronic means
- ( ) Paper based method

8) Which of the following softwares are used currently? *

- [ ] Enterprise resource planning(ERP)
- [ ] Project management
- [ ] Project scheduling
- [ ] Client relationship management (CRM)
- [ ] Building information modelling(BIM) based workflows
- [ ] Estimating
- [ ] Designing
- [ ] Other...

9) Are any of the following technologies being used in the construction projects? *

- [ ] Predective analytics /Big data
- [ ] Internet of things
- [ ] 3 D printing
- [ ] Digital twins
- [ ] None

10) What do you think would be the challenges in implementing new technologies? *

- [ ] Implementation cost
- [ ] Business disruption
- [ ] Lack of relevant skills
- [ ] Data security

11) When do you see advance technologies becoming a must have in your organisation. *

- ( ) 1-2 years
- ( ) 3-5 years
- ( ) 5-10 years
- ( ) more than 10 years

12) Technologies that you are currently working on. *

Long answer text