6.2.1 Project Management paradigms and systems

Paradigms and Approaches

In construction project management, different **paradigms or approaches** are employed based on the project's unique characteristics and requirements, such as;

1. ***Traditional/Waterfall Paradigm***: The traditional paradigm follows a linear sequence of project phases, where each phase is completed before moving on to the next. This includes distinct stages such as initiation, planning, design, construction, and handover. It emphasizes detailed planning, documentation, and a hierarchical management structure.
2. ***Agile Paradigm***: Agile project management focuses on flexibility, adaptability, and iterative development. It emphasizes collaboration, frequent feedback, and continuous improvement. Agile methodologies, such as Scrum and Kanban, allow for dynamic project planning, quick decision-making, and shorter development cycles.
3. ***Lean Construction Paradigm***: Lean construction aims to maximize value and minimize waste by streamlining processes and eliminating non-value-adding activities. It emphasizes continuous improvement, visual management, and the reduction of bottlenecks. Lean principles, derived from the manufacturing industry, are applied to improve efficiency and productivity in construction projects.

Other systemic approaches based on Project Delivery strategy are ;

1. **Design/Bid/Build** approach is when the owner manages the project, contracts out design to engineering consultants and construction to contractors, and retains a General Engineering Consultant (GEC), Construction Management (CM) and Program Management consultant (PMC).
2. **Design/Build** approach is when a single entity, typically a design-build contractor, is responsible for both the design and construction of the project. This integrated approach reduces coordination issues and promotes efficient communication, resulting in faster project delivery and potentially lower costs.
3. **Turnkey or D/B/O/M approach** is when a turnkey contractor is in charge from design conceptualisation to operation and maintenance.
4. **Integrated Project Delivery** (IPD) is a collaborative approach where all project stakeholders, including the owner, architects, engineers, contractors, and suppliers, work together from the project's inception. It emphasizes early involvement, shared decision-making, and risk/reward sharing, fostering collaboration, and improving project outcomes.
5. **Public-Private Partnership** (PPP) is a contractual arrangement between a public agency and a private sector entity. It combines public sector requirements with private sector innovation

and expertise. PPPs can help finance, develop, and operate infrastructure projects, leveraging private sector resources while sharing risks and rewards.

Project Management Systems

Cleland (1977) proposed a model for project management system, through the perspective of '*systems approach'*, with the project team at the focus interacting with the various functional sub-systems, as below;

Fig. 6.4: Project management Model, showing the focal position of the project team and the interacting sub-systems (Cleland, 1977)

- The ***Organizational Facilitative Subsystem*** refers to the arrangement within an organization that combines project teams with the functional structure. This creates a "matrix" organization that establishes formal authority, responsibility patterns, and reporting relationships to facilitate the initiation and completion of specific projects. In this context, two key organizational units emerge: the project team and the functional units.
- The ***Project Planning Subsystem*** focuses on the selection of projects, identification of project objectives and goals, and the formulation of a strategy to achieve those objectives and goals. Project plans outline the necessary resources and allocation methods to support the project, drawing from the organization's resources regardless of their location.
- The ***Project Control Subsystem*** involves setting performance standards for the project's schedule, budget, and technical aspects. This subsystem incorporates feedback mechanisms to compare actual progress with planned progress and initiates corrective action when necessary. The control subsystem ensures effective monitoring of the various organizational units involved in the project, ensuring timely and within-budget project delivery.
- The ***Project Management Information Subsystem*** encompasses the essential intelligence required for effective project control. This subsystem can be informal, involving periodic meetings where project participants report on their project work's status. Alternatively, it can be a formal information retrieval system that provides regular updates on project activities. This subsystem enables project team members to make informed decisions and implement effective project management strategies.
- ***Techniques and Methodology***, while not a subsystem in the traditional sense, encompass various management science techniques such as PERT, CPM, PERT-Cost related scheduling techniques, modeling, simulation, linear programming, and regression analysis. These techniques help evaluate risk and uncertainty factors in project decision-making.

- The ***Cultural Ambience Subsystem*** reflects the organization's environment and the practice of project management within it. The cultural ambience encompasses how individuals and social groups perceive and feel about project management practices in the organization. Factors such as emotions, attitudes, assumptions, experiences, and values shape the organization's cultural ambience. This ambience influences individual behaviours, thoughts, feelings, and expressions, ultimately determining socially acceptable behaviour within the organization.

Construction Project Management Software

The Global construction management software market is expected to expand at a CAGR (Compound Annual Growth Rate) of 8.70% from 2020 to 2027 and reach a net worth of $2.73 billion by 2027, as per the (Data Bridge Market Research).

Construction project management software is a solution employed by professionals to streamline the construction planning process. These tools provide engineering estimates and capital maintenance capabilities, making them suitable for managing projects of varying sizes and complexities. It enables users to define categories or jobs, track itemized costs, and automatically generate financial reports. By incorporating features such as GIS/ESRI mapping, data warehouses, and budget and risk analysis, construction project management software facilitates smoother project development processes. Many construction ERP software packages include construction project management as a prominent feature.

Construction software aids in tracking project progress and monitoring offsite teams.

- ***Automated accounting*** functions streamline tasks such as accounts payables/receivables, payroll management, and work order entries.
- ***Job costing*** capabilities within construction management software enable builders and contractors to define costs associated with employees, production managers, contractors, and supervisors.
- ***Service management*** features in top-notch construction management software handle production schedules, work orders, and asset allocation.
- ***Scheduling*** for the project delivery lifecycle is critical, the tool helps with rescheduling timelines, managing resources, and updating schedules.
- ***Workload automation*** capabilities are beneficial for planning project timelines and balancing workloads across multiple channels, including predicting equipment and labor interdependencies.
- ***Reporting functionalities*** in construction project management software provide data summaries, evaluate project status, and present architectural services costs.

- ***Inventory management*** features in construction software help locate lost inventories, track assets on job sites, and conduct inventory audits.

There are several **construction project management software** presently available, each with certain pros and cons, briefly discussed below (https://project-management.com/) ;

Smartsheet provides a collaborative platform that enables users to work together, gather project requirements, and monitor initial cost estimates using a spreadsheet format. Teams can centralize project requirements and conveniently manage documentation by attaching files. The software also offers dashboards and portals to showcase key visual information relevant to the project. Additionally, users can utilize features such as project cost calculations, forms, and reports to enhance project management capabilities.

monday.com is a versatile platform designed to cater to the needs of architects, builders, general contractors, and engineers. It facilitates seamless collaboration and file sharing, enabling users to easily exchange files, images, updates, RFIs (Requests for Information), and feedback. The platform includes a built-in progress tracking feature that automatically monitors, calculates, and updates crucial information such as budgets, timelines, and resource allocation at every stage of the project. This data is presented through high-level dashboards and charts, providing users with a comprehensive overview of project performance. In addition, monday.com offers a range of valuable features including pre-built construction templates, tools for financial management, portfolio management capabilities, and efficient document management.

CoConstruct (Buildertrend) offers streamlined construction project management that incorporates a Schedule feature with Gantt charts and various views to ensure the smooth progress of all jobs. Users have the ability to create, assign, and monitor to-do tasks for team members and subcontractors, and can even set reminders for clients. The software allows for easy creation of to-dos through voice-to-text functionality, along with the ability to attach documents and photos and send automated notifications. Additionally, CoConstruct provides built-in communication tools for clients and trade partners, financial features for estimating and forecasting, capabilities for bidding and proposals, timesheet management, and seamless integration with other systems.

Fieldwire offers a communication platform that enables team members to engage in real-time conversations tied to specific tasks, promoting quicker decision-making and issue resolution. Users have the ability to monitor and manage all construction tasks, activities, and issues within the software. They can document and annotate issues, as well as update plans with detailed notes, photos, and videos. The construction project management software also provides scheduling and reporting features, along with mobile applications for on-the-go access. Field teams can effortlessly update plans and generate digital forms, streamlining the construction process.

Procore construction project management software incorporates mobile collaboration tools that foster task clarity, enabling teams to adhere to schedules and minimize rework. It captures and centralizes all project correspondence, ensuring easy accessibility. Real-time updates of information enhance visibility and mitigate risks. The software offers a comprehensive project overview, tracks all project steps, and expedites the approval process through features like a contact directory, document management, specification management, integrated scheduling, task management, Requests for Information (RFIs), drawing management, time card tracking, and email integration.

6.2.2 Quality of Products, Health and Safety aspects for stakeholder

Quality control and safety in construction projects are critical determinants of project success, and are intertwined with each other as a lack of quality may lead to a safety issue. Defects or failures in constructed facilities can lead to requirement for re-construction, thereby, affecting facility operations and causing project delays, cumulatively resulting in increased costs. It may also lead to accidents causing injury or fatality leading to further costs, such as incentive, insurance, inspection, etc. Specifying **quality requirements** in the design and contract documentation is crucial during the construction process. They should be well-defined and verifiable to ensure understanding and compliance among all project stakeholders. Decisions made during the planning and design phases have implications on both, quality and safety aspects as certain conformity and compliance can be built into the project management process from the start. However, both are subject to site conditions and other uncertainties, such as, change in the client request, or increase in material prices leading to the need of changing designs or revisiting decisions. Effective project managers strive to ensure that the work is done correctly from the beginning and that major accidents, at product and people level, are avoided. Beyond design decisions and planning vigilance, safety depends on education, alertness and cooperation amongst all stakeholders during the construction process.

Bugalia, Maemura and Ozawa (2019) note across their study comparing high-speed railways in India and Japan, that ***safety is a culture*** and that "*that top management must adopt a multi-pronged approach to improve the safety culture of an organization. There is no one-dimensional management strategy that is sufficient for improving the level of an organization's safety culture*". They further report that organisational reforms are required to bring about a shift in the safety culture and may be achieved through strong training systems, and recommend the need to study cultural aspects in tandem with technology, people and organisational aspects.

National and international bodies, such as, **National Occupational Safety and Health (OSH)** in India and Occupational Safety and Health Administration (OSHA) in the US, routinely conducts site visits of workplaces in conjunction with approved state inspection agencies. In India, Health and Safety is overlooked as per the '*The Building and other construction workers (Regulation of employment and conditions of service) Act 1996'*, under which, Section 38 deals with Safety Committee and safety officers in every establishment; Section 39 deals with Notice of certain accidents (which causes death or any bodily injury by reason of which the person injured is prevented from working for a period of forty-eight hours or more) and prescriptions for the same; and Section 40 deals with Power of appropriate Government to make rules for the safety and health of building and other construction workers.

6.2.3 Demand and Contribution of Civil Engineering

According to the RICS (Royal Institution of Chartered Surveyors) Research on '*Real Estate and Construction Professionals in India by 2020'*, industry projections, India's construction industry is predicted to reach a value of USD 1 trillion by 2030 and contribute around 13% to the country's GDP by 2025. It is the fastest growing sector and is on track to become the largest employer by 2022, providing jobs for over 75 million individuals. Presently, skilled (Supervisors, Technician, Foremen, Tradesmen, etc), semi-skilled and unskilled workers (helpers and Labourers) constitute 95.3% of the workforce, while only 1.2% is occupied by the Core Professionals, such as, Civil Engineers, Architects and Planners.

To fulfil the country's real estate needs (approximately 1.27 million civil engineers) and infrastructure requirements (approximately 3 million civil engineers), an annual average of 4 million civil engineers in the next decade is necessary, in spite of 1.5 million graduates in India every year. Due to the sustained shortage in annual supply and an increasing year-on-year demand, the cumulative demand for civil engineers between 2010 and 2020 is projected to be around 40.2 million. Unfortunately, there is an estimated shortfall of approximately 39.4 million civil engineers during the same period and recent surveys indicate a 6.27 percent decline in employment within the construction industry.

To Civil engineers play a **crucial role** in society by contributing to the development and maintenance of social infrastructure, as well as working towards building a sustainable future.

One of the key contributions of civil engineers is the planning, design, and construction of essential infrastructure such as roads, bridges, airports, water supply systems, and wastewater treatment plants. These infrastructure projects not only facilitate the movement of people and goods but also improve the overall quality of life by providing access to basic amenities and

services. Civil engineers ensure that these structures are safe, efficient, and environmentally sustainable, taking into account factors such as traffic flow, environmental impact, and resource efficiency.

Civil engineers also play a vital role in *addressing the challenges of urbanization* and population growth. They are involved in urban planning and the design of sustainable cities, taking into consideration factors like land use, transportation systems, and the efficient utilization of resources. By *integrating principles of sustainable development* into their projects, **civil engineers contribute to reducing environmental impact**, promoting energy efficiency, and creating resilient and liveable urban environments.

In the face of climate change, civil engineers are at the forefront of developing solutions to mitigate its effects and enhance resilience. They work on projects related to flood management, coastal protection, and the design of structures that can withstand natural disasters such as earthquakes and hurricanes. By *incorporating climate adaptation strategies* and utilizing innovative technologies, **civil engineers contribute to building a more resilient society** that can withstand the challenges posed by a changing climate.

Furthermore, **civil engineers contribute to the sustainable use of resources** through their focus on efficient design and construction practices. They promote the use of renewable materials, energy-efficient systems, and sustainable construction techniques, thereby minimizing the environmental impact of infrastructure projects. By embracing concepts such as *green building design and sustainable construction practices*, civil engineers help to reduce carbon emissions, conserve resources, and create environmentally friendly structures.

Moreover, **civil engineers actively engage in research and development** to drive innovation in their field. They explore *new materials, technologies, and methodologies* that can improve the efficiency, durability, and sustainability of infrastructure.

6.3 INNOVATIONS AND METHODOLOGIES FOR SUSTAINABILITY

While in the previous Units several technological and methodological innovations have been discussed, for project management a cutting-edge innovation is **Virtual Design and Construction (VDC)**. It is a technology that aids in the coordinated management of comprehensive performance models for design-construction projects, which encompasses various aspects such as the facilities themselves, work processes, and the organization of the design-construction-operation team. VDC involves using digital tools, such as Building Information Modeling (BIM), to visualize, simulate, and coordinate various aspects of a construction project. It enables better collaboration, clash detection, and data-driven decision-making, leading to improved project coordination, cost control, and reduced rework.

VDC offers several benefits, such as;

- **Integrated Approach with a Common Data Environment** (CDE) and allowing communication and collaboration with different project team members, third party members and other stakeholders.
- **Risk mitigation and Enhanced safety** for workers and end-users, as the level of detail allows decision-makers to identify potential hazards and mitigate them
- **Sustainability** that can be conceptualised and planned for, as VDC can support assessment of energy efficiency, carbon emissions, environmental impact, embodied carbon, etc. It can not only help incorporate strategies like, adaptive reuse of materials, but also aid design of improved IEQ and plan for future use.

The VDC is a combination of several tools and can to be tailored, such seen in the Singapore VDC Framework below which boasts the slogan "*Build Twice*" (*first Virtual, then real*) ;

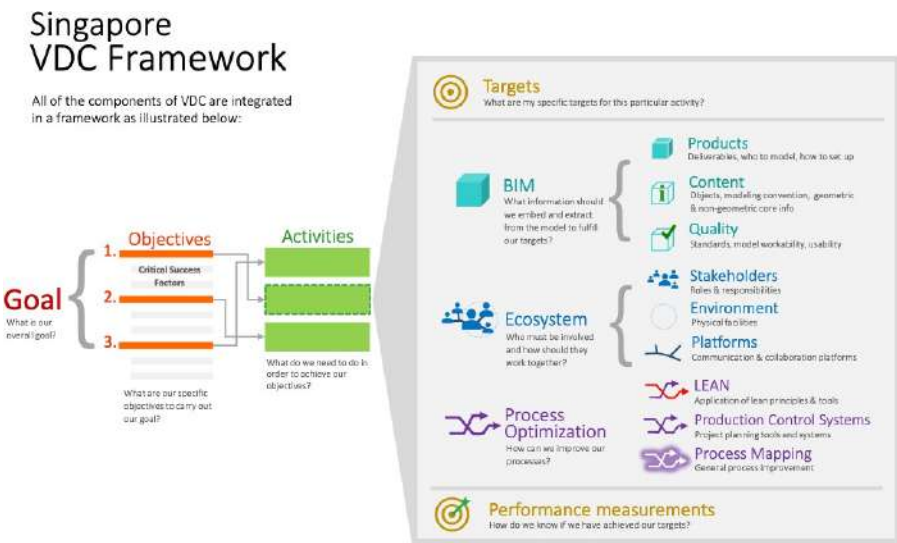

Fig. 6.5 : Singapore VDC Framework 2017 (www.corenet.gov.sg)

In essence, this technology – which is a culmination of all the understanding, knowledge, discussions, and practical applications so far explored in this book, bringing sustainability hand in hand with design and construction, is the apt point for reflecting on the global and societal impact of civil engineering and the great onus on the future civil engineer.

UNIT SUMMARY

This concluding unit on projects in civil engineering covers the procedures and techniques directly applicable to construction and related activities during practice. The specific procedure for 'environmental clearance' that is mandated in India as per EIA Notification,2006, is outlined and Sustainable construction practices, with techniques for reducing GHG emissions and improving sustainability are covered to inform the requirements and consideration while proposing a project. Further, the elements of Project management, its paradigms, responsibilities, and overall contributions are discussed to give an overview on the systemic connections between decision-making during a project. Finally, the latest innovations for supporting projects are presented to make the aspiring civil engineer aware of the current trends in the domain.

EXERCISES

Q. 6.1 What is an important element of an Environment Management Plan?
(a) Probable source of Impact & Predicted Impact
(b) Environmental components (ambient air, noise , water, land aesthetics)
(c) Mitigation Methods
(d) all of the above

Q. 6.2 Which of the following are not objectives of sustainable construction?
(a) Utilise renewable and recyclable materials
(b) Green Building Certification
(c) Minimize on-site waste generation
(d) Safeguard natural habitats

Q. 6.3 Which of the following techniques for reduction of GHG emissions requires Environmental Product Declaration information?
(a) Minimising waste
(b) Limiting carbon-intensive materials,
(c) Choosing lower carbon alternatives
(d) Reusing materials