6 Civil Engineering Projects

UNIT SPECIFICS

Through this unit we have discussed the following aspects:

- ***Civil Engineering projects and its impact***
  - *Environmental Impact Analysis procedures*
  - *Sustainable Construction - Waste avoidance/ Efficiency increase*
    Advanced construction techniques for better sustainability
    Techniques for reduction of Green House Gas emissions in various aspects of Civil Engineering Projects
- ***Project Management and Contributions of Civil Engineers***
  - *Paradigms & Systems - Waterfall / Traditional Project Management, Agile Construction Management, and Lean Construction Management*
  - *Quality of products, Health & Safety aspects for stakeholders*
  - *Demand and Contribution of Civil Engineers*
- ***Innovations and methodologies for ensuring Sustainability in Projects***

Besides giving a large number of multiple-choice questions as well as questions of short and long answer types marked in two categories following lower and higher order of Bloom's taxonomy, a list of references and suggested readings are given in the unit so that one can go through them for practice.

There is a "Know More" section, which has been carefully designed so that the supplementary information provided in this part becomes beneficial for the users of the book. It is important to note that for getting more information on various topics of interest some QR codes have been provided which can be scanned for relevant supportive knowledge This section mainly highlights applications of the subject matter for our day-to-day real life or/and industrial applications on variety of aspects, case study related to environmental, sustainability, social and ethical issues whichever applicable, and finally inquisitiveness and curiosity topics of the unit.

RATIONALE

This concluding unit on civil engineering projects, offers the civil engineer a pragmatic view of the tasks and responsibilities to be shouldered during professional practice, be it with respect to environmental sustainability assessment and mitigation on site, or project management aspects.

UNIT OUTCOMES

List of outcomes of this unit is as follows:

U6-O1: Knowledge on Civil Engineering projects and its impact

U6-O2: Knowledge on Project Management and Contribution of Civil Engineering

U6-O3: Knowledge on Innovations and methodologies for ensuring Sustainability during Project development.

Unit-6 Outcomes	***EXPECTED MAPPING WITH COURSE OUTCOMES*** *(1- Weak Correlation; 2- Medium correlation; 3- Strong Correlation)*						
	CO-1	***CO-2***	***CO-3***	***CO-4***	***CO-5***	***CO-6***	***CO-7***
U6-O1	*3*	*3*	*3*	*2*	*3*	*3*	*2*
U6-O2	*2*	*1*	*2*	*3*	*3*	*3*	*3*
U6-O3	*1*	*3*	*2*	*1*	*3*	*2*	*1*

Civil Engineering projects are multi-faceted and to address its impact on the environment, various procedures, activities, and strategies are employed by large, multidisciplinary teams, sometimes across geographies. By embracing sustainable practices and technologies, civil engineering projects can minimize their ecological footprint and contribute to a more sustainable future.

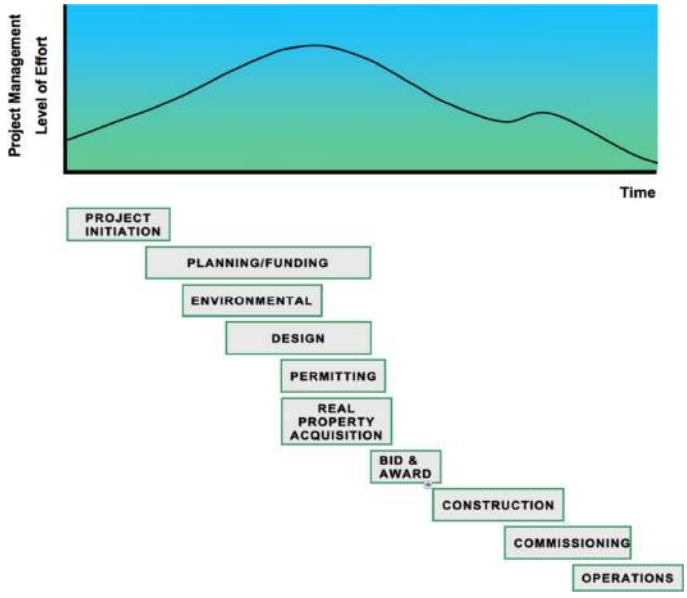
6.1 CIVIL ENGINEERING PROJECTS AND ITS IMPACT

A construction project is a collaborative effort with "*a group of interrelated work activities constrained by a specific scope, budget, and schedule to deliver capital assets needed to achieve the strategic goals of an Agency*" (Shadan and Fleming, 2012), where the agency or client, maybe an individual, a private or public enterprise.

A construction project typically has the following phases (refer Fig. 1);

- ***Project initiation*** which entails, defining the project requirements, scoping the project, develop a project delivery strategy and contract management planning.
- ***Planning/Environmental Clearance and Real Estate Acquisition*** which entails, planning various site studies, checking compliance and applying for Environmental clearance, acquiring or relocating and taking possession of the land.
- ***Design*** entails designing the built environment as per stakeholder requirements and site conditions, design management, design reviews, feasibility/constructability reviews, risk assessment, Quality assurance and Quality control, incorporating Sustainability (Green building) standards and codes, and Certification.
- ***Construction*** entails construction management, third-party coordination, Quality management, Safety management during construction.
- ***Commissioning*** entails validating the building equipment and systems with operations personnel and third parties.
- ***Project Close-out / Operations*** is when the project begins to function as intended and all hand-over is done to the Agency/client.

The success of a project requires; Collaborating with architects, engineers and contractors to develop plans and establish timelines, Estimating and negotiating project costs, Creating and monitoring project budgets, Securing permits and design evaluations, Making schedules and work timetables, Determining what methods and strategies are appropriate for a project, Communicating with clients, contractors and other stakeholders, Assembling and leading construction teams, Working with building, construction and regulatory specialists, and Managing the day-to-day workflow of a project. The environmental impact of the project has to be systematically addressed and mitigated at each phase through procedure and a sustainable construction commitment.



Capability	Resource	Function
Management and Control	Project Management	Manage the overall project and its phases – initiation, planning, design, construction, and closeout
	Project Management Oversight	Oversee project performance by a party independent of the project team and report to project sponsor(s)
	Configuration Management	Control changes to project deliverables/scope of work
	Cost Control	Control project costs within budget
	Schedule Control	Control project progress within schedule
	Accounting	Record project expenditures, issue payments, and manage project funding
	Records Management	Capture, store, control, and retrieve project records/documents
	Procurement/ Administration	Procure and administer project contracts
Planning, Engineering, and Technical	Architectural	Develop architectural and design concepts
	Engineering	Prepare detailed engineering and final design documents
	Environmental	Undertake environmental planning and clearance
	Real Estate	Acquire real estate and perform relocation functions
	Communications	Communicate with the community/media/ government
Construction and Supply	Construction Contractor	Construct facilities
	Third Party Agency	Relocate or gain access to public and private utilities
	Equipment Supplier	Supply/install equipment

Fig. 6.1 : (*Top*) Typical Project Life Cycle - Traditional Design/Bid/Build, (*Bottom*) Project Resources (Shadan and Fleming, 2012)

6.1.1 EIA Procedures : Environmental Clearance for Project

During project planning and pre-design, a critical step is acquiring the **Environmental Clearance**. The EIA Notification of 2006 mandated Prior Environmental Clearance, which involves four stages namely, screening; scoping; public consultation; and appraisal, for certain category of projects. The Ministry of Environment, Forest and Climate Change (MoEF), GoI, manages and publishes EIA Notifications and develops Sector specific Standard Terms of References (ToR) and manuals for the different sectors. The MoEF categorises all projects under ten sectors, i.e., (1) Mining, (2) Mineral Beneficiation, (3) Ports and Harbours, (4) Airports, (5-A) Building Construction, (5-B) Townships, (6) Asbestos, (7) Highways, (8) Coal Washery, (9) Aerial Ropeways, and (10) Nuclear power plants, Nuclear fuel processing plants and Nuclear waste management plants, and states that certain type (B) do not require to submit an EIA report for the clearance. EIA methodology, as explained in earlier Unit, has various steps, namely: Screening, Scoping, Impact Analysis, Mitigation, Reporting, Review of EIA, Decision-Making, and Post Monitoring, to develop a report on the state of affairs of the proposed project and its possible impact on the environment.

To begin an **Environmental Clearance for Project,** following are the steps outlined by the Centre for Science and Environment, India;

Step 1: Project proponent identifies the location of proposed plant after ensuring compliance with existing siting guidelines.

Step 2: The project proponent then assesses if the proposed activity/project falls under the purview of environmental clearance. If it is mentioned in schedule of the notification, the proponent conducts an EIA study either directly or through a consultant, however, B2 projects do not require preparation of EIA reports.

Step 3: After the EIA report is ready, the investor approaches the concerned State Pollution Control Board (SPCB) and the State Forest Department (if the location involves use of forestland). The SPCB evaluates and assesses the quantity and quality of effluents likely to be generated by the proposed unit as well as the efficacy of the control measures proposed by the investor to meet the prescribed standards. If the SPCB is satisfied that the proposed unit will meet all the prescribed effluent and emissions standards, it issues consent to establish (popularly known as NOC), which is valid for 15 years.

Step 4: The process of public hearing is conducted prior to the issue of NOC from SPCB. The District Collector is the chairperson of the public hearing committee. Other members of the committee include the official from the district development body, SPCB, Department of Environment and Forest, Taluka and Gram Panchayat representative, and senior citizen of the district, etc. The hearing committee hears the objections/suggestions from the public and after inserting certain clauses it is passed on to the next stage of approval (Ministry of Forest and Environment).

Step 5: The project proponent **submits an application for environmental clearance** with the MoEF if it falls under Project A category or the state government if it falls under project B category. The application form (1 and 1A, *details given below in next Section*) is submitted with EIA report, EMP, details of public hearing and NOC granted by the state regulators.

Step 6: Environmental appraisal: The documents submitted by an investor are first scrutinised by a multi-disciplinary staff functioning in the Ministry of Environment and Forests who may also undertake site-visits wherever required, interact with the investors and hold consultations with experts on specific issues as and when necessary. After this preliminary scrutiny, the proposals are placed before specially constituted committees of experts whose composition is specified in the EIA Notification.

Step 7: Issues of clearance or rejection letter: When a project requires both environmental clearance as well as approval under the Forest (Conservation) Act, 1980. The clearance granted shall be valid for a period of five years for commencements of the construction or operation of the project.

Application Forms for Environmental Clearance

Details of **Form1** is to be filled, which comprises of general project information and a checklist for confirmation on the Activity and Environmental Sensitivity of the proposed site is to be filled out, as below;

1. ***Basic Information,*** *on*

   1.1. Name of project, Proposed capacity/area, Type of Project (New, Modernisation, Expansion), Existing capacity/area, Category of project, Location, etc.

   1.2. Whether the proposal involves approval/clearance under: if, yes details of the same and their status to be given a) The Forest (Conservation) Act, 1980? (b) The wildlife (protection) Act, 1972? (c) The CRZ Notification, 1991?

   1.3. Whether there is any Government Order/policy relevant/relating to the site?

1.4. Forest land involved (hectares)

1.5. Whether there is any litigation pending against the project and/or land in which the project is proposed to be set up?

2. ***Activity*** *(Each sub-section has several Information/Checklist confirmation)*

2.1. Construction, operation or decommissioning of the Project involving actions, which will cause physical changes in the locality (topography, land use, changes in water bodies, etc.)
2.2. Use of Natural resources for construction or operation of the Project (such as land, water, materials or energy, especially any resources which are non-renewable or in short supply):
2.3. Use, storage, transport, handling or production of substances or materials, which could be harmful to human health or the environment or raise concerns about actual or perceived risks to human health.
2.4. Production of solid wastes during construction or operation or decommissioning (MT/month)
2.5. Release of pollutants or any hazardous, toxic or noxious substances to air (Kg/hr)
2.6. Generation of Noise and Vibration, and Emissions of Light and Heat:
2.7. Risks of contamination of land or water from releases of pollutants into the ground or into sewers, surface waters, groundwater, coastal waters or the sea:
2.8. Risk of accidents during construction or operation of the Project, which could affect human health or the environment.
2.9. Factors which should be considered (such as consequential development) which could lead to environmental effects or the potential for cumulative impacts with other existing or planned activities in the locality.

3. Environmental Sensitivity

3.1. Areas protected under international conventions, national or local legislation for their ecological, landscape, cultural or other related value
3.2. Areas which are important or sensitive for ecological reasons - Wetlands, watercourses or other water bodies, coastal zone, biospheres, mountains, forests
3.3. Areas used by protected, important or sensitive flora or breeding, foraging, resting, over wintering, migration.
3.4. Inland, coastal, marine or underground waters
3.5. State, National boundaries
3.6. Routes or facilities used by the public for access to recreation or another tourist, pilgrim areas
3.7. Defence installations
3.8. Densely populated or built-up area

3.9. Areas occupied by sensitive man-made land uses (hospitals, schools, places of worship, community facilities)
3.10. Areas containing important, high quality or scarce resources (ground water resources, surface resources, forestry, agriculture, fisheries, tourism, minerals)
3.11. Areas already subjected to pollution or environmental damage. (*Those where existing legal environmental standards are exceeded*)
3.12. Areas susceptible to natural hazard which could cause the project to present environmental problems (earthquakes, subsidence, landslides, erosion, flooding or extreme or adverse climatic conditions)

Then, Proposed **Terms of Reference** (TOR) for EIA studies applicable, is to be agreed by the proposer.

Details of **Form 1A**, which is a check list of environmental impacts is to be filled out, which is a table of 9 sections across the different environmental categories, which are;

1. Land Environment (1.1-1.9 questions)
2. Water environment (2.1-2.14 questions)
3. Vegetation (3.1- 3.3 questions)
4. Fauna (4.1- 4.3 questions)
5. Air environment (5.1- 5.6 questions)
6. Aesthetics (6.1- 6.4 questions)
7. Socio-economic aspects (7.1- 7.3 questions)
8. Building materials (8.1- 8.4 questions)
9. Energy conservation (9.1- 9.13 questions)
10. Environment management plan (for Construction phase and Functional /Use phase) across 5 subheadings; i.e., Environmental Components (Ambient Air, noise, water, Land Aesthetics), Predicted Impact, Probable source of Impact, Mitigation Measures and Remarks.

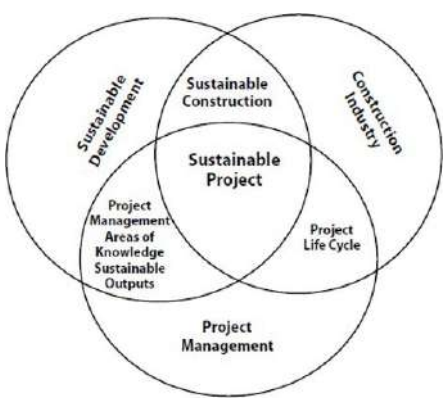


Fig. 6.1: Elements of a Sustainable Project

6.1.2 Sustainable Construction

Sustainable construction is defined as "*how the construction industry together with its product the 'built environment', among many sectors of the economy and human activity, can contribute to the sustainability of the earth including its human and non-human inhabitants*" (Kibert, 2007). The goal of sustainable construction is to minimize the environmental impact caused by the construction industry, through the following objectives:

1. Utilise renewable and recyclable materials.
2. Decrease the embodied energy within building materials.
3. Reduce the energy consumption of the completed building.
4. Minimize on-site waste generation.
5. Safeguard natural habitats.

Sustainable construction encompasses various activities, ranging from extracting materials and manufacturing products, to assembling them into buildings, maintaining and replacing systems, and ultimately disposing of waste, building systems, and the building structure, whilst considering the above mentioned objectives throughout the entire lifecycle of the construction process and the resulting built environment. Additionally, the physical distribution and relationships between buildings and infrastructure play a role in determining consumption patterns, which are influenced by planning decisions. The implementation of sustainable construction is further complicated by the involvement of public policy in the form of regulations, incentives, and disincentives. It also involves the participation of industries such as real estate, finance, and insurance, as well as institutions like higher education, design firms, and construction companies.

Waste Avoidance/ Efficiency Increase

Overall **efficiency increases**, in terms of material usage, manpower and equipment utilisation, energy and other resource consumption, and its associated economic costs, by waste avoidance. *Reducing disposal of waste* construction and demolition materials, reduces the environmental impact caused by the extraction and consumption of virgin resources and the production of new materials is offset. It brings about cost reductions in overall building projects by avoiding purchase costs through the reuse of materials and by donating recovered materials to qualified charities, which can provide tax benefits. Furthermore, the *use of onsite material reuse* helps lower transportation costs. Employing *deconstruction and selective demolition methods* leads to the creation of jobs, stimulates economic activities in recycling industries, and generates increased business opportunities within local communities. Last but not the least, *implementing sustainable construction practices* reduces the need for disposal facilities, thereby mitigating associated environmental issues, which in turn, contributes to the conservation of landfill space by diverting materials from disposal.

Techniques for reduction of Green House Gas emissions

The construction industry has several activities which result in direct or indirect Greenhouse gas emissions. The buildings and construction sector were responsible for 36% of total energy consumption and 39% of carbon dioxide (CO2) emissions related to energy use and industrial processes. Out of these emissions, approximately 11% can be attributed to the manufacturing of building materials and products, including steel, cement, and glass, as per IEA (2018). Thus, the concept of embodied carbon captures the implied CO_2 equivalent/GHG emission, as discussed earlier, and is the critical decider when it comes to strategizing techniques to reduce GHG emission.

Techniques recommended by AIA are;

- ***Limit carbon-intensive materials*****,** like aluminium, plastics, and foam insulation, and use judiciously.
- ***Choose lower carbon alternatives***, such as, wood structure instead of steel and concrete, or wood siding instead of vinyl, and review Environmental Product Declarations for selecting alternatives.
- ***Choose carbon sequestering materials*****,** like wood, straw or hemp insulation and bring down the embodied carbon in a project.
- ***Reuse materials***, like brick, metals, broken concrete, or wood, as salvaged materials typically have a much lower embodied carbon footprint than those newly manufactured.
- ***Use high-recycled content materials***, particularly for metals as they are carbon-intensive but can be recycled, which brings down its embodied carbon value.
- ***Use fewer finish materials***, such as, polished concrete slabs in place of tiled, carpet or vinyl finished flooring saves the embodied carbon.
- ***Minimize waste***, as discussed above. Modularity and standard sizes for common materials like plywood, gypsum boards, wood framing, and pre-cut structural members can be factored in during design and wastage can be minimised.
- ***Maximize structural efficiency***, as it is the highest contributor to the embodied carbon of the project, and using optimum value engineering wood framing methods, efficient structural sections, and slabs are all effective methods to maximize efficiency and minimize material use.
- ***Reuse buildings instead of constructing new ones*****,** as renovation and reuse projects typically save between 50 and 75 percent of the embodied carbon emissions compared to constructing a new building.

Advanced Construction Techniques For Better Sustainability

Following are the technologies in construction have potential to significantly enhance sustainability;

1. ***Prefabrication*** involves the manufacturing of building elements/components or modules off-site and their assembly on-site, allowing for better quality control, reduced material waste, and faster construction timelines. This technique improves construction efficiency, reduces waste, enhances quality control, and minimizes disruption to the surrounding environment. It also enables easier deconstruction and material reuse at the end of a building's life cycle. In addition, employing a controlled environment in which to construct and pre-fabricate, results in improved quality of building components and less waste, as external conditions can no longer hinder its properties.

Fig. 6.2: Prefabricated building elements

2. ***Modular construction*** takes this a step further by assembling pre-made modules to create complete structures, offering flexibility, reduced on-site disruptions, and potential for deconstruction and reuse.
3. ***Mass Timber Construction*** refers to the use of large, prefabricated timber panels or components for structural elements, such as cross-laminated timber (CLT) and glued-laminated timber (glulam) which offer high strength, reduced carbon emissions, and faster construction times.
4. ***Robotic construction*** is an advanced technique involving robots and automation technologies, to perform various construction tasks, such as bricklaying, concrete pouring, and material handling, revolutionizing the construction industry. It offers high accuracy and efficiency, improved safety, enhanced productivity, and reduced labour costs.

5. ***3D printing*** utilizes robotic arms or gantries to precisely deposit layers of construction materials, such as concrete or specialized composite materials, based on complex and customised digital designs. 3D printing in construction offers several benefits, including faster construction timelines, reduced material waste, enhanced design flexibility, and cost savings, and additionally, allows for the integration of sustainable features, such as incorporating insulation directly into the printed structure.

Fig. 6.3 : Advanced technologies : (*Top Left*) Modular construction, (*Top Right*) Mass timber construction, (*Bottom Left*) Robotic construction and (*Bottom Right*) 3D printing

6.2 PROJECT MANAGEMENT

Project management in construction projects refers to the *discipline of planning, organizing, and controlling resources and activities to successfully deliver construction projects within defined constraints of time, budget, and quality.* It involves coordinating various stakeholders, managing risks, and ensuring the project progresses smoothly from initiation to completion The PMC (project management consultant) includes the project manager, project & planning engineer, construction manager, site engineer, surveyor, Quality control engineer, Health and safety officer, etc. It is their responsibility to ensure timely and quality construction of projects.