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**Department of Civil Engineering**

**Lecture Notes - 141CE0105 – Introduction to Civil Engineering**

**(texts are borrowed from different sources)**

**[Main source :** Building Science Concepts - by Ted J. Kesik, University of Toronto]

# UNIT – 3 FEATURES OF INFRASTRUCTURES

Types of Infrastructure - Aspects considered in creating infrastructures – Functions, Importance of safety , stability, Durability, comfort and convenience – types of Materials used - buildings , Bridges, Roads, Railways , Airport, Harbour and Dams - Drainage and water supply system.

## Types of Infrastructure

**Infrastructure** refers to the fundamental facilities and systems serving a country, city, or village, including the facilities necessary for its economy to function. It typically characterises technical structures such as:

**Roads, bridges, railways, airport, harbor, tunnels, water supply, irrigation, sewers, oil & gas structures,** and so forth.

**Engineers** generally limit the use of the term "infrastructure" to describe the above assets that are in the form of a large network, in other words, "hard" infrastructure.

Apart from the above infrastructures(Non-building structures), civil engineers involved in construction of industrial buildings such as

* Brewery
* Distillery
* Poultry farms/Dairy farms
* Silos
* Factory
* Forge
* Foundry
* Nuclear plant/Power plant
* Oil Refinery/Sugar Refinery
* Paper mills/cotton mills/Sawmill
* Warehouse

and construction of real estate buildings.

Real estate buildings can be grouped into commercial buildings and residential buildings.

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| --- | --- |
| Categories of Commercial Real Estate | |
| **Category** | **Examples** |
| Leisure | hotels, public houses, restaurants, cafes, sports facilities |
| Retail | retail stores, [shopping malls](https://en.wikipedia.org/wiki/Shopping_mall), shops |
| Office | office buildings, serviced offices |
| Industrial | industrial property, office/warehouses, garages, distribution centers |
| Healthcare | medical centres, hospitals, [nursing homes](https://en.wikipedia.org/wiki/Nursing_home) |

Real estate builders used many words such as Multistorey apartments, Villas, Gated communities, Township, Row houses, Pent houses and many more. Although there are different types of residential buildings, sometimes the realtors tend to interchange these terms according to understanding of local people. It is better to have a clear idea about these terms.

**Different Types of Apartments**

There are various choices when it comes to apartments. An apartment is a self contained residential unit that occupies a part of the building. It is commonly referred as flats in India and there are different types of apartment complexes which are as follows:

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| **Builder Floor Apartment**  A builder floor apartment is the one where a builder purchases a piece of land, constructs apartments not more than 3 to 4 floors including the ground floor in one compound and sells them to different home buyers. The basic difference is that the builder floor apartments have less number of floors when compared to multi storey apartments | **Multistorey Apartment**  A multistory apartment, as the name suggests, it has multiple floors. The number of floors will be more than 5 and it should have common area and other amenities. According to industry experts, a building is considered multistory, if it has more than 5 floors with multiple residential units in each floor. The availability of lift is also mandatory for multistory apartments in India. |

**Studio Apartment**

A studio apartment determines the number of rooms in a residential apartment regardless of the floor numbers. A studio apartment combines living area, kitchen and bedroom in to a single room to save area and cost. In India, it is also called as Bachelor apartments or efficiency apartments. A studio apartment can be found in both builder floor and multistory residential complexes.

**Different Types of Residential Complexes**

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| **Pent house**  A pent house is the apartment on the top floor of a multistory residential building which is usually referred as a luxury housing unit in the particular residential complex. Hence the price of a penthouse is always higher than the rest of the apartments in the building. | **Row Houses**  A row house is one of the series of houses which has identical or similar plan and design located side by side to adjacent houses and shares a common wall between them. As they are joined by common walls, they differ from villas. These houses will be similar in architecture, appearance and design pattern. These types of houses are common in United States and England, rarely found in India. |
| **Villa**  A villa is a country house or a farm house estate separated from one another as individual units with all the facilities. These days, villas are meant to be luxury houses, usually present in gated communities in groups. These residential structures are surrounded by landscaped gardens and lawns. | **Villament**  Villament is a combination of a villa and an apartment unit providing luxury and privacy of a villa under your budget. According to this type, a maximum of 4 to 6 villaments form a building which contains penthouse and duplexes also. The lesser number of homes provide privacy and the interiors resembling a villa with private garden area offers luxury at the price of an apartment. This way, one can gain the ownership of a landed property also. |
| **Gated Community**  Image result for Gated CommunityA gated community is a residential complex having multistory apartment structure, row houses or villas inside the community protected with controlled access and strict security by closed perimeter of fences and compound walls. In some projects, gated community is meant for specific demographics like retirement homes etc. A gated community usually provides services and amenities limited to the residents. These days, gated communities have local stores, gym, restaurants etc., inside the campus. | **Integrated Township**  A small town or a small area of land is generally referred to as township. An integrated township is a self contained town community having all the essential civic amenities such as roads, water, electricity, schools, healthcare units, garbage facility, recreational centers, parks, restaurants etc. Initially townships were established by government in India but these days, the private realtors launch integrated townships. These are the residential complexes usually found in the suburbs with all the urban modern amenities. The difference is that integrated townships are usually large self contained residential complexes while gated community is a residential complex which need not have all the civic amenities. |

## Factors to be considered while buying the house

Once the construction is completed and before handing over the building(house or any other building), final inspection checklist will be verified by engineer/supervisor/buyer. Sample of the building inspection list is given below:

**Inspection checklist:** [http://www.totalhomeinspection.com/totalhomeinspectionchecklist.pdf]

**Grounds**

* Proper grading drainage away from house
* No evidence of standing water
* No leaks from septic tank or leech field
* Yard, landscaping, trees and walkways in good condition
* No branches or bushes touching house or overhanging the roof
* Exterior structures (fences, car sheds) in good condition, no evidence of termite damage or rotted wood
* Railings on stairs and decks are adequate and secure
* Driveways, sidewalks, patios, entrance landings in good condition, and pitched away from structure
* Downs pout drainage directed away from structure

**Structure**

* Ridge and fascia board lines appear straight and level
* Sides of house appear straight, not bowed or sagging
* Window and doorframes appear square (especially bowed windows)
* Visible foundation in good condition - appears straight, plumb, with no significant cracks

**Exterior Surfaces**

* Adequate clearance between ground and wood siding materials (6" minimum); no wood-to-earth contact
* Siding: no cracking, curling, loose, rot or decay
* Masonry veneers: no cracks in joints, no broken, spalling or flaking components
* Stucco: no large cracks (discuss all stucco cracks with a professional inspector)
* Vinyl or aluminum siding: no dents, damage, no bowing or loose siding
* No vines on surface of structure
* Exterior paint or stain: no flaking or blisters
* No stains on exterior surfaces

**Windows, Doors and Wood Trim**

* Wood frames and trim pieces are secure, no cracks, rot or decay
* Joints around frames are caulked
* No broken glass (window or storm panes) or damaged screens, no broken double-paned, insulated window seals.
* Muntin and mullion glazing compound in good condition
* Storm windows or thermal glass used
* Drip caps installed over windows

**Roof**

* Composition shingles: no curling, no cupping, no loss of granulation particulate, no broken, damaged or missing shingles, no more than two layers of roofing
* Wood shingles or shakes: no mold, rot or decay, no cracked/broken/missing shingles, no curling
* Flat roofs: no obvious patches, no cracks or splits, minimal blisters/"alligatoring" and wrinkles, no silt deposits (indicates improper drainage), sealed tar at flashings
* Flashing around roof penetrations
* No evidence of excess roofing cement/tar/caulk
* Soffits and fascia: no decay, no stains
* Exterior venting for eave areas: vents are clean and not painted over
* Gutters: no decay or rust, joints sealed, attached securely to structure, no bending or sagging, no sections of gutter or downspout missing, gutters clean, no mud deposits
* Chimneys: straight, properly flashed, no evidence of damaged bricks or cracked joints, mortar/cement cap in good condition

**Attic**

* No stains on underside of roofing, especially around roof penetrations
* No evidence of decay or damage to structure
* Sufficient insulation and properly installed insulation (moisture barrier installed closest to the heated area of the house)
* Adequate ventilation, clear path into attic for air entering through soffit vents, adequately sized gable end louvers, all mechanical ventilation operational
* No plumbing, exhaust or appliance vents terminating in attic
* No open electrical splices

**Interior Rooms**

* Floors, walls and ceilings appear straight and plumb and level
* No stains on floors, walls or ceilings
* Flooring materials in good condition
* No significant cracks in walls or ceilings
* Windows and exterior doors operate easily and latch properly, no broken glass, no sashes painted shut, no decay; windows and doors have weather-stripping, "weep holes" installed
* Interior doors operate easily and latch properly, no damage or decay, no broken hardware
* Paint, wall covering, and paneling in good condition
* Wood trim installed well and in good condition
* Lights and switches operate properly
* Adequate number of three pronged electrical outlets in each room
* Electrical outlets test properly (spot check)
* Heating/cooling source in each habitable room
* Evidence of adequate insulation in walls
* Fireplace: no cracking or damaged masonry, no evidence of back-drafting (staining on fireplace façade), damper operates properly, flue has been cleaned, flue is lined

**Kitchen**

* Working exhaust fan that is vented to the exterior of the building
* Ground Fault Circuit Interrupter ("GFCI") protection for electrical outlets within 6 feet of the sink(s)
* Dishwasher: drains properly, no leaks, baskets, door spring operates properly
* No leaks in pipes under sinks
* Floor in cabinet under sink solid, no stains or decay
* Water flow in sink adequate
* No excessive rust or deterioration on garbage disposal or waste pipes
* Built-in appliances operate properly
* Cabinets in good condition: doors and drawers operate properly

**Bathrooms**

* Working exhaust fan that doesn't terminate in the attic space
* Adequate flow and pressure at all fixtures
* Sink, tub and shower drain properly
* Plumbing and cabinet floor under sink in good condition
* If sink is metal, it shows no signs of rust, overflow drain doesn't leak
* Toilet operates properly
* Toilet stable, no rocking, no stains around base
* Caulking in good condition inside and outside of the tub and shower area
* Tub or shower tiles secure, wall surface solid
* No stains or evidence of past leaking around base of bath or shower

**Miscellaneous**

* Smoke and carbon monoxide detectors where required by local ordinances
* Stairway treads and risers solid
* Stair handrails where needed and in good condition
* Automatic garage door opener operates properly, stops properly for obstaclesBasement or Mechanical Room
* No evidence of moisture
* Exposed foundation; no stains no major cracks, no flaking, no efflorescence
* Visible structural wood: no sagging, no damage, no decay, no stains, no damage from insects, sills attached to foundation with anchor bolts
* Insulation at rim/band joists

**Crawl Space**

* Adequately vented to exterior
* Insulation on exposed water supply, waste and vent pipes
* Insulation between crawl space and heated areas, installed with vapor barrier towards heated area
* No evidence of insect damage
* No evidence of moisture damage

**Plumbing**

* Visible pipes: no damage, no evidence of leaks, no signs of stains on materials near pipes; drain pipes slope slightly down towards outlet to septic/sewage system
* Water heater: no signs of rust, vented properly, sized to produce adequate quantities of hot water for the number of bedrooms in the house.
* Water pump: does not short cycle
* Galvanized pipes do not restrict water flow
* Well water test is acceptable
* Hot water temperature between 47 C - 52 degrees Celsius (118 - 125 degrees Fahrenheit

**Electrical**

* Visible wiring: in good condition, no "knob-and-tube" wiring, no exposed splices, cables secured and protected
* Service panel: adequate capacity, all cables attached to panel with cable connectors; fuses or breakers are not overheating
* No aluminum cable for branch circuits

**Heating/Cooling System**

* Appears to operate well throughout (good air flow on forced hot air systems)
* Flues: no open seams, slopes up to chimney connection
* No rust around cooling unit
* No combustion gas odor
* Air filter(s) clean
* Ductwork in good condition
* No asbestos on heating pipes, water pipes or air ducts
* Separate flues for gas/oil/propane and wood/coal

The above inspection checklist is to verify the quality of visible elements of the building which suppose to give guarantee for the safety and proper functioning of the appliances/structural/building elements. However, apart from the above inspection and legal/dispute issues, the few more factors are to be considered to live happily. Sometimes the following factors that end up making the biggest impact on day-to-day experience of a house

**1. Indoor-outdoor flow**. The ease with which you can move from indoor to outdoor living areas and back again can make a huge difference in your day-to-day experience of living in a home. If this is important to you, look for French, sliding or accordion glass doors leading from the main living spaces to the outdoors.

**2. Size of rooms**. Not too big, not too small. Just right room size for individual your lifestyle. Imagine setting up your own furniture in the rooms as you walk through — bring measurements if you can.

**3. Interior layout.** Like indoor-outdoor flow, the interior layout, or floor plan, can have a big effect on your daily life. Walk through the rooms, imagining your typical day. Are there sharp corners and narrow passages to navigate, or is there an easy, natural flow from one room to the next?

**4. Lot grade.** The steepness of a lot is in some ways even more important than its size. After all, what good is an acre if it’s too steep to walk on? Think about not just what you want today but what you might want in the future. If down the road you were to decide you wanted to add a deck, an extra room or a backyard studio, would that be possible on your lot?

**5. Window size and placement**. You can of course can add and modify windows, but it’s not the cheapest change to make to a house. Ideally, look for a home with ample, well-placed windows.

**6. Amount of natural light**. This is a big one, yet it’s surprisingly easy to overlook when attending open houses. Once you have a few homes on your list that are strong contenders, make appointments to give them a second look at a different time of day. This will give you a fuller picture of what the light is like in the home.

7**. Regional weather considerations.** Live somewhere with cold winters? You may want to put an attached garage, covered entrances and an easy-to-shovel driveway on your checklist. Those in warm climates may want to focus on shaded walkways and cooling trees.

**8. House orientation on lot.** The way a house is positioned on its lot affects how much natural light it gets and can influence heating and cooling bills as well. A south-facing home will maximize natural light — though a north-facing home can be just as bright if the main living space is in the back of the home and there are ample windows all around. In hot climates a north-facing home with deep eaves may be preferable to keep your house cooler.

**9. Driveway length and width.** It seems silly to even consider this — until you buy a house and realize your car won’t fit in the ridiculously narrow driveway, or you have to shovel that extra-long driveway after a mega snow storm. (The too-narrow driveway? Yep, that happened to me.)

**10. Street parking.** Though street parking is not usually an issue in the suburbs or rural areas, some towns and cities have strange rules and regulations regarding it. In some towns, vehicles are not allowed to park overnight in front of your own house.(Combine that with the too-narrow driveway situation described above, and results in discomfort)

**11. Staircase steepness and length.** You may not have the slightest problem with stairs — but this is one of those times it’s helpful to think about the future. If you think you might ever want or need to take in an elderly relative, or you plan to age in place, a long, steep staircase may not be the best feature.

**12. Architectural details.** Great architectural details, like exposed beams, beautiful molding and mantels, will make everything else you do to your home look even better. Start with good bones.

**13. Heating and cooling systems.** While not as big an issue in temperate climates, if you live somewhere that gets very hot in summer or cold in winter (or both), good heating and cooling systems will make life much more pleasant. And because putting in central air conditioning or heating can cost a fair amount and the work is disruptive, finding a home where it’s already in place will save money and hassle.

**14. Laundry room location.** Is the laundry in a convenient spot, or is it hidden away in a dingy corner of the basement? Since this is a chore that usually needs to be done frequently, having a laundry near a main living area can make life easier.

**15. Kitchen features.** Ask whoever does most of the cooking in your household to make a wish list for the kitchen. Does he or she prefer to work on a gas stove? If so, be sure to check for one, and failing that, ask if the house is connected to a gas line so that you can add your own gas stove. Other things to consider in the kitchen could include its shape or layout, natural light, number of sinks, storage area and overall size.

**16. Number of bathrooms.** Adding a bathroom is expensive, so choose a home with enough baths to meet your family’s needs. Even if you are a household of only one or two people, an extra powder room on the main floor can be a big boon.

**17. Ceiling height.** Some basement and attic rooms have less than adequate ceiling heights. If someone in your household is tall, bring him or her along to the open house to make sure the fit in all the rooms is comfortable.

**18. Zoning and town ordinances for animals.** Have a notion that you may one day want backyard chickens or another unconventional pet? Check local ordinances before committing to a house, or you may never get the pets you have your heart set on.

**19. Closeness of neighbors.** Though the general area (city versus suburb) has much to do with how close your neighbors are, there can still be a big difference between how private one house feels over another. If privacy is important to you, be sure to check the views from every window and walk the perimeter of the property to get an idea of how close you will be to your next-door neighbors.

**20. The neighborhood.** This may be where you started your search, but have you really considered all aspects of your potential new neighborhood? School districts are of course important for families with kids, and proximity to work and family closely follows on many folks’ wish lists. But you may also want to look into how walkable (or cyclable) your neighborhood is, what community amenities (libraries, parks) are nearby and what public transportation is available.

## Aspects considered in creating buildings and infrastructure

From the above buyers’ factors, to satisfy the client needs, engineers/architects/promoters need to understand the expectations of their buyers. A clear understanding of the functional and physical requirements of a project is essential to ensure its success. A client's / owner's intent to develop a project is derived from a need, a purpose or mission, and a desired result. When the design of a facility satisfies the emotional, cognitive, and cultural needs of the people who use it and the technical requisites, the project will be successful. Requirements are also characterized by building type.

Special functional requirements of the proposed project, such as auditoriums, laboratories, or computer spaces, may require that special investigations be made of humidity; waste treatment, radiation shielding, and power supply. Only when all necessary information has been gathered and collated, the project may be approved by both client and architect. All these aspects and factors that are likely to influence are to be considered for designing the building/infrastructure.

For the purpose of clear understanding, we can categorize them in the following categories:

* Functional/Aesthetic Requirements
* Safety/strength/stability Requirements
* Durability Requirements
* Maintenance/operational requirements
* Economic Sustainability requirements
* Environmental/Social requirements

**Functional/Aesthetic Requirements**

Functional Requirements for building are that a building which constructed for intended purposes:

1. Protective – Need to protect from outside heat and cold, sun, wind, rain, etc. It also gives protection to children and old people who need special care.
2. Economic – Need to provide a kidchen and other space for preparing food and income generating activities like pickle or papad making or any other similar activity. Families also save money by staying together and sharing everything available. The money thus saved can be more effectively utilized elsewhere.
3. Religious – Need to arrange a room for a number of religious activities. You celebrate various festivals while staying in a home.
4. Educative –Need to provide a room for study. Child’s basic education starts from the home, which helps in the development of personality.
5. Social –Need to space for meeting with other people and promotes social interaction,
6. Affectional –Need to provide space where all family members stay together with love and affection.
7. Status/Aesthetic -Need to promote a status in the society
8. Special functional requirements that to be met for clients.

Thus an architect’s/Engineer’s role is to design an environment (inside & outside), which caters to human needs, both physical and psychological, human comforts and luxuries.

There are code book such as

* National Building code of India (NBC India – Totally 10 parts) ,
* Bureau of Indian Stardard, Special Publication 41 – 1987 [IS SP 41-1987 - Handbook on Functional Requirements of Buildings (Other than Industrial Buildings)],
* Bureau of Indian Stardard, Special Publication 32 – 1986 [IS SP 32-1986 - Handbook on Functional Requirements of Industrial Buildings (Lighting and Ventilation)].

These codes give guidelines to provide proper provisions for ventilation, heat/cold insulation, lighting, safe electrical, plumbing installation.

Once functional requirements are known, based on site condition, an architect/Engineer will have to plan the building to meet the functional requirements.

**EXAMPLE for functional requirements**

As an example, a railway station can be designed as follows :

1. As regards passenger handling, it should be remembered that there are four categories of people. The first one belongs to those who come for boarding, the second one for those who arrive by some train and depart by some other train by changing platform, the third one for those who arrive and disperse and the fourth for the friends and relatives of passengers who come to receive or see off the passengers. Taking cue from airports, it should be possible to separate and streamline the movements of arrival, departure and transit passengers in designing major station.
2. The circulating area should cater for different kinds of vehicles, viz., cars, taxis, autorickshaws, buses, etc. Vehicular movements into/out of paid parking areas should be isolated from free access lanes.
3. The main entrance hall or foyer is a large area, enough to accommodate hundreds of people, who form a permanently mobile crowd. Most of the people are directly concerned with the purchase of tickets, thus making it important to locate ticket and enquiry windows as close as possible to the foyer. Notice boards, train schedules, enquiry counters, etc., are always part and parcel of this foyer. This ensures that other than travellers, outsiders do not penetrate the interior, thus increasing congestion inside the station.
4. Separate access and infrastructure are provided for accepting parcels for trains. A road leads directly from the outside to the parcel office. However, parcel booking of accompanied baggage by the passengers should be catered for, near the foyer.
5. Entries and exits should be so provided so as to be controlled by ticket checking staff. Station manager should be so located that people can meet him without the need to purchase platform ticket and also that access exists for Station Manager to enter main platform.
6. The foyer opens out into platforms with a foot overbridge located close by. All trains which have a heavy daily commuter traffic, berth on the platform which is closest to the foyer. By doing this large crowds crossing from one platform to the other is avoided. Through trains, which stop for short time periods, with less number of arriving and departing passengers berth on the subsequent platform. Therefore, by proper use of platforms, human traffic and the walking distances are effectively reduced.
7. Goods trains have separate goods sheds, offices, loading and unloading yards. This should have proper road access and facilities for agents, commercial organization and labourers.
8. Toilets, drinking water facilities and tea stalls are located in positions which are central and have maximum and easy accessibility. Providing small toilet blocks at various locations instead of large central one, reduces cross circulation of people. Railway’s own facilities not directly related to train operation, such as Signal & Telecom stores, rest rooms, motor trolley sheds, trade union office, etc should not be located in platforms. Number of stalls on platforms should be kept to the minimum. Pictograms for passenger guidance and signages should be adequately used. On careful observation, one realizes that the smooth functioning of a public place like a railway station largely depends on the circulation within the station and is a study in itself.

Outcome of the above process, that satisfying the functional requirements, will be layout design and building orientation.

**Safety/Strength requirements of buildings/infrastructure**

Apart from the above primary functional requirements, each and every building element should serve its functions without failure/collapse.

Structures must be designed to satisfy:.

1. Stability to prevent collapse
2. Strength to prevent breaking
3. Stiffness to prevent excessive deformation
4. Serviceability conditions

Structural engineering is, mostly, considered as a subset of civil engineering dealing with the design and analysis of buildings and large non-building structures to withstand both the gravity and wind loads as well as natural disasters. Besides, it may also cover design of machinery, medical equipment, vehicles or any other objects where structural functionality or safety are involved. Structural engineers must ensure their designs satisfy building codes.

In a practical sense, structural engineering is largely the application of Newtonian mechanics to the design of structural elements and systems that support buildings, bridges, walls (including retaining walls), dams, tunnels, etc.

Structural engineers ensure that their designs satisfy safety/strength requirements(i.e. structures do not collapse/break) and on serviceability (i.e. floor vibration and deformation do not result in occupants criteria discomfort). Typically, entry-level engineers may design simple beams, columns, and floors of a new building, including calculating the loads on each member and the load capacity of various building materials (steel, timber, masonry, concrete).

The fundamental core subjects for structural engineering are engineering mechanics, solid mechanics, strength of materials, material science, basic structural design. Reinforced concrete, and structural steel designs. The structural analysis courses are required to design complex/huge structures. At the final year, prestressed concrete design, space frame design for building, structure rehabilitation and other advanced structural engineering specializations will be usually introduced.

Engineers who are good knowledge in the above subjects will be able to design size of individual structural members with suitable construction materials. Design Engineers consider design of concrete structures to mean assessing:

1. The size and strength of structural components and concrete strength grade to meet safety and serviceability limits.
2. The amount, size and distribution of reinforcements for strength and control cracks to an acceptable size.

Outcome, that meets the safety/strength requirements, are structural detailed design. With these details, now architect refines final draft of plan and elevation of the building.

**Durability Requirements**

A long service life is considered synonymous with durability. Since durability under one set of conditions does not necessarily mean durability under another, it is customary to include a general reference to the environment when defining durability. No material is inherently durable; as a result of environmental interactions the microstructure and, consequently, the properties of materials change with time. A material is assumed to reach the end of service life when its properties under given conditions of use have deteriorated to an extent that the continuing use of the material is ruled either unsafe or uneconomical.

Materials Related Failures:

Concrete Deterioration can be caused by: 1. The use of inappropriate materials. 2. Poor construction practices.

Environmental Related Causes of Concrete Durability Problems

Environmental factors affect durability of structures. Hundreds of bridges and structures are collapsing or showing signs of deterioration with corroding reinforcement — all within 25 years of construction. It is, therefore, necessary for the designer to develop a feel for the problem and design the structures to satisfy safety, serviceability and durability requirements (structural and non-structural loads caused by environment).

The following environmental condition can affect the concrete durability:

* -Temperature.
* -Moisture.
* -Physical factors.
* -Chemical factors.
* -Biological factors.

The above factors introduce small cracks in the materials like concrete/walls etc over the period of time. In the presence of cracks/pores, these factors quickly deteriorate the materials.

1. Permeability is the key to durability[ Compacted Dense concrete will have less permeability]
2. Corrosion of embedded steel [Providing sufficient cover and anti-corrosive coating will retard corrosion]

Avoiding the natures is difficult, however, reducing the permeability (less porous) and by provide suitable covers for reinforcements, durability can be increased.

**Maintenance/operational requirements**

There is no such thing as a maintenance-free building. All building materials decay to different extents due to sunlight, rain, and wind. Whether historic or not, all buildings need regular maintenance.

The Maintenance Plan

Regular inspections will detect problems. If these are dealt with at an early stage, it will minimise the need for major and expensive repair work. As it is easy to forget to carry out routine maintenance tasks, it is useful to have a maintenance plan for the building. This will remind you of the tasks that need to be done and the parts of the building that should be inspected. It will also help you to make decisions and to control what happens to the building, rather than just reacting to faults as they arise. A maintenance plan can be used to plan short, medium, and long-term maintenance and repair programmes and to budget accordingly. The plan should be checked and updated every year to identify and document changes and potential problems.

Access

To make the job of regular inspection safer and easier, consider providing a permanent means of access to the areas that will need regular inspection. For example, where possible, provide ladders or folding staircases to attic spaces, provide lighting within roof spaces and access hatches to allow inspection of, and works to, areas such as valley gutters. Externally, duckboards fitted on lead roofs and gutters will avoid damage by foot traffic. Permanent ladders to access roofs will need to meet relevant health and safety standards and should be installed so as not to damage the part of the building they are fixed to.

Maintenance Manuals And Maintenance Routines

Maintenance manuals can be invaluable in ensuring the proper conservation of a building. Depending on the nature of the particular building, they can be complex and sophisticated documents. They may also take a considerable amount of time and expertise to compile. A maintenance manual can be used to establish a maintenance routine for the building. It can also include a checklist specific to the building, outlining the tasks required.

Maintenance of building services has been now emerging as area that requires more attention in the design of a building. Failure to maintain building services will affect building performance whereas improved maintenance will bring long-term benefit to our buildings.

In the process of planning sustainable buildings, the design team should also consider the integration of services within the building envelope and structure through coordination meetings. The planning process should also include maintenance engineers in the project team. All designers should consider the following needs when planning a sustainable building.

* Ensuring that replacement or refurbishment is possible with adequate space and access and, without breaking the structure or building enclosure housing the services (this will save resources and also reduce waste)
* Checking whether any plant and equipment provided may become obsolescent before the end of design life.

**Economic Sustainability requirements**

The building site and the structures constructed on the land are economic assets. In addition to the cost of the land there are three interrelated costs to consider. The first is the initial cost, the cost of designing and erecting the building. This is usually the primary and sometimes the only concern of clients and developers. It covers professional fees and associated costs involved in land acquisition and permissions, the capital cost of materials and components and the labour costs associated with carrying out the work.

The second cost to consider is the cost of the building in use, i.e. the costs associated with routine maintenance and replacement and the costs associated with heating and servicing the building over its life. These costs can be reduced by sensitive design and detailing, for example designing a building to use zero energy and to be easy to maintain will carry significant cost benefits over the longer term (not to mention benefits to the environment). All materials and components have a specified design life and should also have a specified service life. Designers and contractors need to be aware of these factors before starting work, thus helping to reduce defects and maintenance requirements before construction commences.

The third cost is the cost of materials recovery at the end of the life of the building, i.e. the cost of demolition, recycling and disposal. All three areas of cost associated with building should be considered within a whole life cost model, from which decisions can be made about the type of materials and components to be used and the manner in which they are

**Environmental/Social requirements**

There is an extensive literature concerning the environmental impact of building materials, products and components, construction activities and the use (and misuse) of buildings during their lifetime. We know that we must do more to respect our planet and build in a way that has a positive impact on our environment. From a construction perspective consideration should be given to the method of construction, maintenance and repair, future adaptability of the structure and the recycling of materials as and when the building is demolished or substantially remodelled. This is particularly important at the detailing and specification stage when materials and components are selected. There are many ways in which we can improve the relationship between our artificial environment and our natural one. For example, detailing buildings so as to reduce unnecessary waste during production not only helps to reduce landfill, it also saves time and money. Similarly, detailing and constructing a building in such a way as to make it easy to disassemble at the end of its service life will enable precious components and materials to be recovered with minimal damage, and hence minimal waste.

Energy efficiency and environmental performance

The environmental performance of buildings has long been a cause for concern, but it is an area in which it is difficult for the building owner to get reliable information. Designers and builders must make a greater effort to provide buildings with:

❑ Lower running costs

❑ Enhanced air quality and natural daylight

❑ Use of low-allergy materials

❑ Use of environmentally friendly materials

❑ Water efficiency (and recycling) measures

❑ Ease of adaption and alteration

❑ Future proofing (easy upgrading of energy-efficient technologies)

If these (and related) factors are addressed at the conceptual and detailed design phases then the initial cost of the construction is likely to be similar to a project that is less energy efficient and less environmentally friendly. Add to this the considerable cost savings over the life of the building and it is difficult to understand why buildings are still being constructed with such scant regard for the whole life performance of the constructed works.

**CONSTRUCTION MATERIALS USED ?**