RGU IIIT NUZVID

CE2102: Construction Materials & Introduction To Design

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Introduction to Construction Materials

1.1 General:

Building materials have an important role to play in this modern age of technology. Although their most important use is in construction activities, no field of engineering is conceivable without their use. Also, the building materials industry is an important contributor in our national economy as its output governs both the rate and the quality of construction work. The words building materials and construction materials are very often used interchangeably in this reading material.

The current scenario in booming "Building" or "Construction" industry has posed several challenges as well as opportunities due to the widening gap in demand and supply of building materials which are crucial inputs to the national development programs and projects, hence the national economy as mentioned earlier. There has been an intensive search and rapid strides world over for enlarging the range and production of building materials, far beyond the current availability. Besides research and development, the emphasis is on the need for standardization and regulatory mechanisms to assist in systematic growth of the industry and also to deal with emerging concerns for environmental protection and energy conservation.

These concerns reflected in the establishment of "Indian Standards Institution (ISI)" in 1947, the Department of Environment and Forests, and the subsequent enactments to tackle environmental problems. Since building and construction industry is the largest consumer of the natural resources, it is worthwhile to mention that, India is the first country which has made provisions for the protection and improvement of the environment in its constitution through 42nd amendment in 1976.

This course "Construction Materials" is designed to make the students aware of and understand the most predominantly used building materials such as concrete, bricks, steel etc. in detail with respect to their making, utilization techniques and behavior when subjected to external environment, properties & tests on materials with proper citation of relevant codes of practice.

To start with, in this module the readers will be given a brief introduction about the built environment and the functions of a building.

1.2 Built Vs Natural Environment

The natural environment consists of those surroundings which exist without interference from human beings. Notable features of the natural environment include sunshine and rain, mountains and hills, rivers and hills, rocks and soil and trees and plants. (See Fig. 1.1).

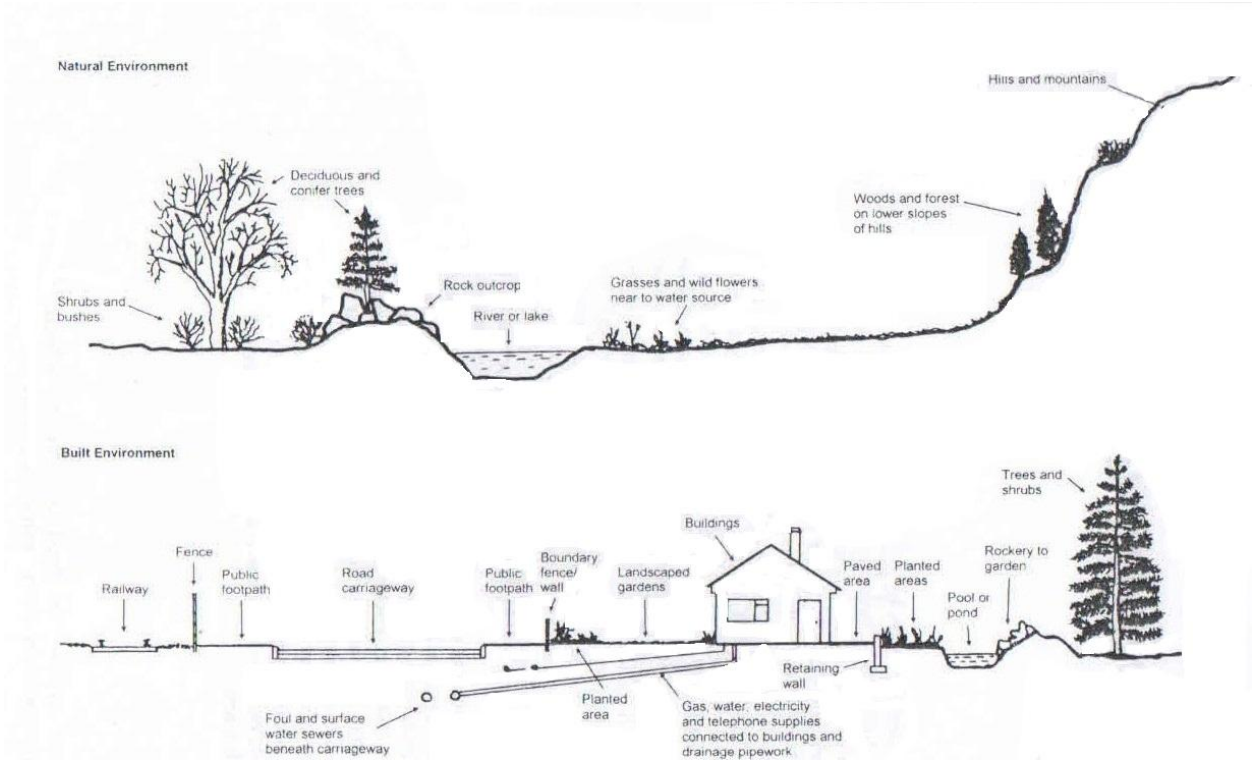


Fig 1.1 Natural Vs. Built Environmental

On the other hand the built environment is formed by the buildings and other objects that humans construct in the natural environment. In addition to the buildings in which we live and work, the built environment includes the *infrastructure* which services and connects these building (See table 1.1).

Table 1.1 Features of a built environment.

Buildings: Dwellings Shops & Offices Factories Public Buildings (Schools, Hospitals etc.)	Walls Fences Driveways Paths Gardens
Power stations Transmission lines Radio/TV masts Tele communications Pipelines Sewers Sewage works	Roads Railways Seaports Airports Canals
Mines Gravel pits Clay pits Quarries Refuse sites Landfills	Bridges Tunnels Dams Weirs Aqueducts

Buildings and towns are connected by roads, railways and communication links which in turn need bridges, tunnels, towers and cables. The built environment also includes the various features of the water supplies and electricity supplies needed by our buildings. So, every feature of the built environment, let it be a building or a bridge, has to be constructed carefully to serve its function efficiently.

1.3 Functions of a building

"The objective of a residential building is to provide shelter for its inhabitants with an indoor environment that is *safe*, *comfortable*, pleasant and healthy to reside and work in, economically." Though the function as defined here is for residential buildings alone, this can be applied to other structures also with little changes. However it should be kept in mind that the word "SAFTEY" in the definition is very important besides "COMFORT".

In general any building typically interacts with the below mentioned elements of environment (Fig 1.2). The building has to withstand and serve its function efficiently with respect to all the

elements mentioned here. Some of these elements are natural (humidity, sunlight etc.) and some are anthropogenic (noise, pollution etc.).

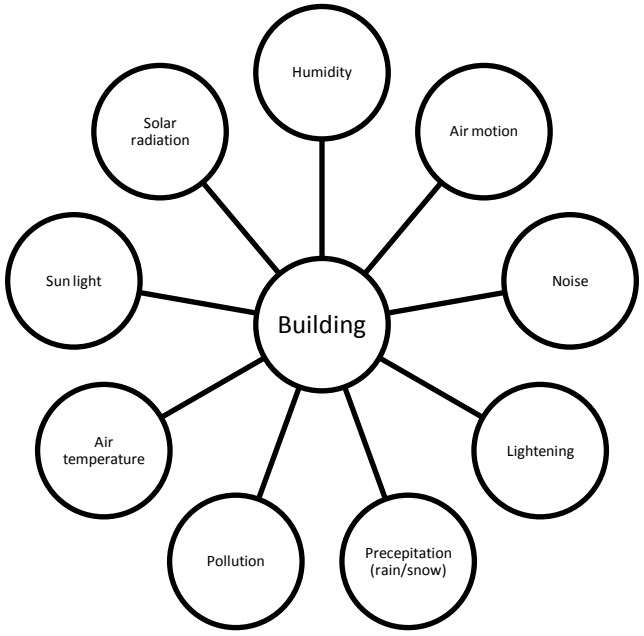


Fig 1.2 Interaction of a building

So, the buildings or structures have to be designed to serve their function (i.e. to withstand the effect of elements mentioned) and this design is broadly classified into two categories. One is with respect to *safety* and the other category is with respect to *comfort* ability. First category is termed as "Structural Design" and the second category as "Functional Design". These two design aspects will be briefly discussed in this module and the subsequent module where after we get in to the core part of this course.

The structural design deals with size detailing while the functional design deals with overall dimensions of the structure/building in question. For example, when we are planning for construction of a national highway, assuming it as two lane and each lane of width 7 m with a divider of 1 m width in the middle, the overall width of the highway comes around 7+1+7 = 15 meters which is a conclusion arrived through functional design. The depth of pavement to sustain the load due to passage of vehicles, camber (transverse slope for drain out of water on the surface of road at times), type of pavement (rigid / flexible) etc. are arrived at from structural design. Similarly, when we are planning for construction of a residential building, the overall dimensions

are arrived at with respect to no. of rooms required, circulation space, relative proximity, scope for future expansion, orientation etc. which comes under functional design where as the dimensions of structural components (beams, columns, slab etc.) in detail comes under structural design.

1.5 Structural design

The structure or building has to be designed against various external / natural forces and also internal / manmade forces. We have already studied that force is action of one body on another body and civil engineering structures have to withstand these forces and hence loads safely. The design of the structures in detail is dealt in other subjects such as Structural Analysis in detail. However it is discussed in brief for the sake of understanding the structural design in comparison with the functional design.

The forces are regarded as loads and the structures are designed to safely withstand these loads without any sort of disturbance to purpose of the structure. The types of loads may be classified in many ways, but a very limited discussion is given in this module.

1.5.1. Load classification w.r.t. time

With respect to time the loads may be classified into three types. They are,

i. Steady loads

ii. Quasi study loads

iii. Transitory / Dynamic loads

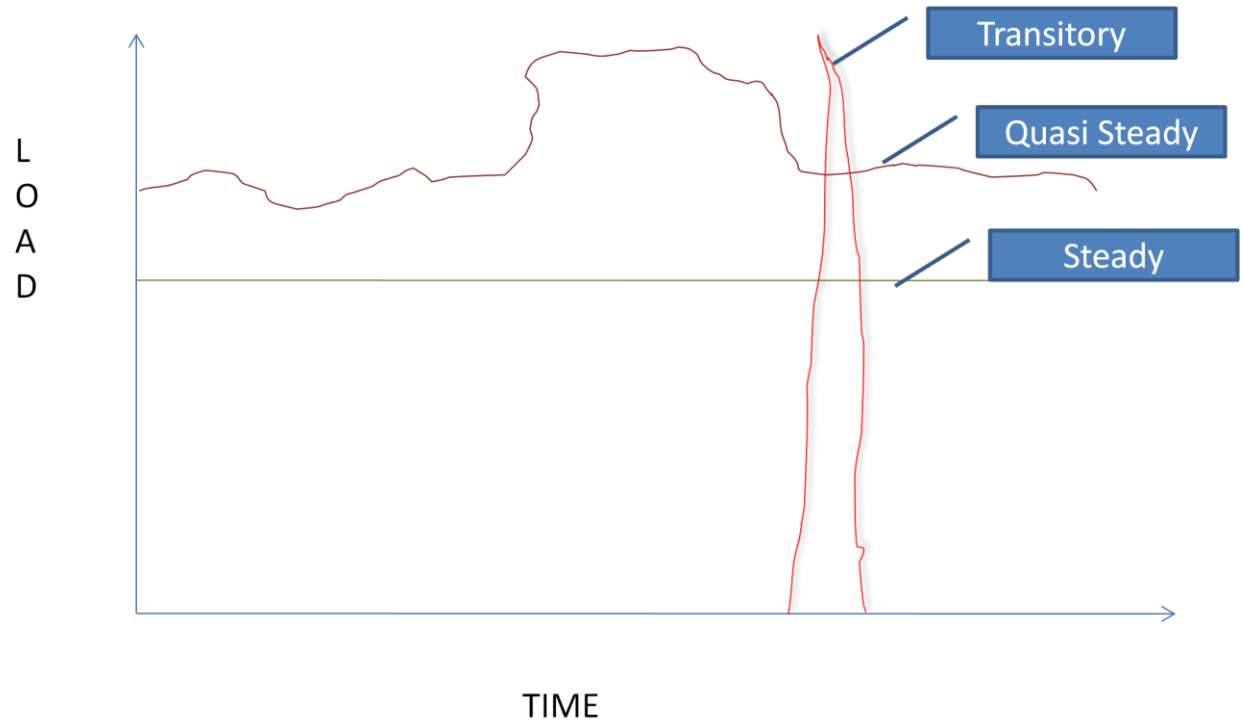


Fig 1.3 Classification of loads w.r.t. time.

Steady loads are those which does not change with respect to time and are deterministic. In the graph, the horizontal line (green in colour) represents this load.

E.g. Self weight of the structure itself (also Dead Load)

Quasi study loads are deterministic in nature but they change with respect to time. In the graph the zig-zag line brown in colour represents this load.

E.g. Furniture weight.(also Live load)

Transitory loads are dynamic in nature and practically not possible to determine them precisely as they last for a very short period of time as shown by the curve red in colour in the graph.

E.g. Seismic load and Wind load

1.5.2. Load classification w.r.t. direction

The loads are broadly classified as vertical loads, horizontal loads and longitudinal loads. The vertical loads consist of dead load, live load and impact load. The horizontal loads comprises of wind load and earthquake load. The longitudinal loads i.e. tractive and braking forces are considered in special case of design of bridges, gantry girders etc.

Dead load:

Dead loads are permanent or stationary loads which are transferred to structure throughout the life span. Dead load is primarily due to self weight of structural members, permanent partition walls, fixed permanent equipments and weight of different materials.

Imposed loads or live loads:

Live loads are either movable or moving loads without any acceleration or impact. There are assumed to be produced by the intended use or occupancy of the building including weights of movable partitions or furniture etc. The floor slabs have to be designed to carry either uniformly distributed loads or concentrated loads whichever produce greater stresses in the part under consideration. Since it is unlikely that any one particular time all floors will not be simultaneously carrying maximum loading, the code permits some reduction in imposed loads in designing columns, load bearing walls, piers supports and foundations.

Impact loads:

Impact load is caused by vibration or impact or acceleration. Thus, impact load is equal to imposed load incremented by some percentage called impact factor or impact allowance depending upon the intensity of impact.

Wind loads:

Wind load is primarily horizontal load caused by the movement of air relative to earth. Wind load is required to be considered in design especially when the height of the building exceeds two times the dimensions transverse to the exposed wind surface. It is an equivalent static load

depends on design wind speed computed from basic wind speed for 50 years of return period at the location.

For low rise building say up to four to five storey, the wind load is not critical because the moment of resistance provided by the continuity of floor system to column connection and walls provided between columns are sufficient to accommodate the effect of these forces. Further in limit state method the factor for design load is reduced to 1.2 (DL+LL+WL) when wind is considered as against the factor of 1.5(DL+LL) when wind is not considered. IS 1893 (part 3) code book is to be used for design purpose.

Earthquake load:

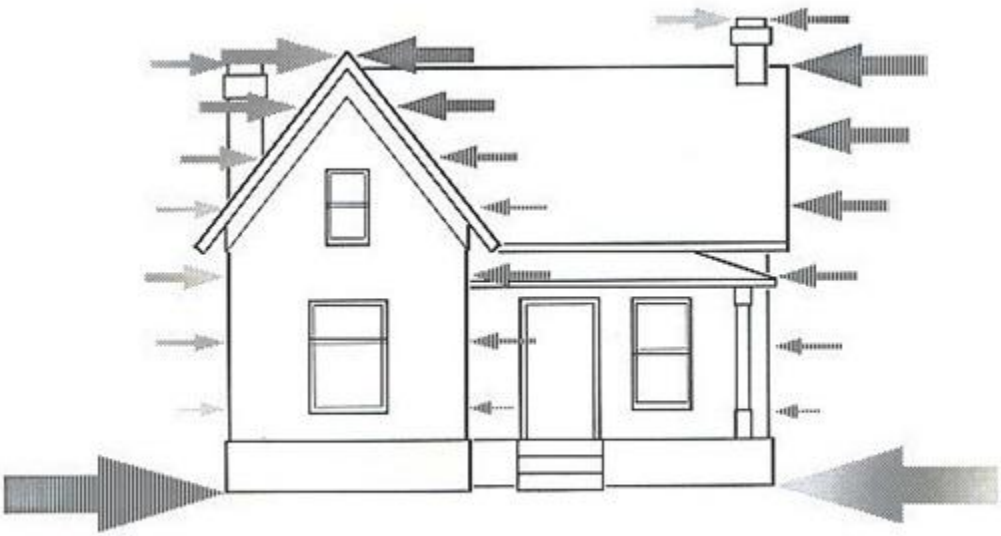


Fig. 1.4 Earthquake load

Earthquake loads are horizontal loads caused by the earthquake and shall be computed in accordance with IS 1893. For monolithic reinforced concrete structures located in the seismic zone 2, and 3 without more than 5 storey high and importance factor less than 1, the seismic forces are not critical.

1.5.3 Design Loads

Precise computation of actual load that a structure is likely to encounter in service is difficult to determine. However improper consideration of the loads might be catastrophic. So somehow the impact of all the loads has to be taken into account while designing any civil engineering structure. To do this we have to rely on experience and scientific knowledge. Loads decided on the basis of experience and currently acceptable scientific knowledge are put down in ***code of practice***.

Building codes of practice is nothing but legal documentation setting out requirements to protect public health and safety, and outlining standards of good practice with regard to the construction and occupancy of buildings. In India, Bureau of Indian Standards is the organization which develops these codes of practice, Indian Standard (IS) codes of practice. So, the design loads which will be used for design calculation of structures have to be taken from the IS codes (See table 1.2)

Table 1.2 IS codes of practice for design load calculation

TYPE OF LOAD	Code of Practice
Dead Loads	IS 875 Part-I
Imposed Loads	IS 875 Part-II
Wind Loads	IS 875 Part-III
Snow Loads	IS 875 Part-IV
Earth quake Loads	IS 1893
Special Loads & Load combinations	IS 875 Part-V

Loads due to temperature effects (contraction and expansion), shrinkage, moisture, seepage, fire resistance, soil pressure, load during construction, fatigue, creep etc. are regarded as special loads. The probability of all the loads acting at their worst case is very less. However, the structure has to be designed to be competent with combination of loads.

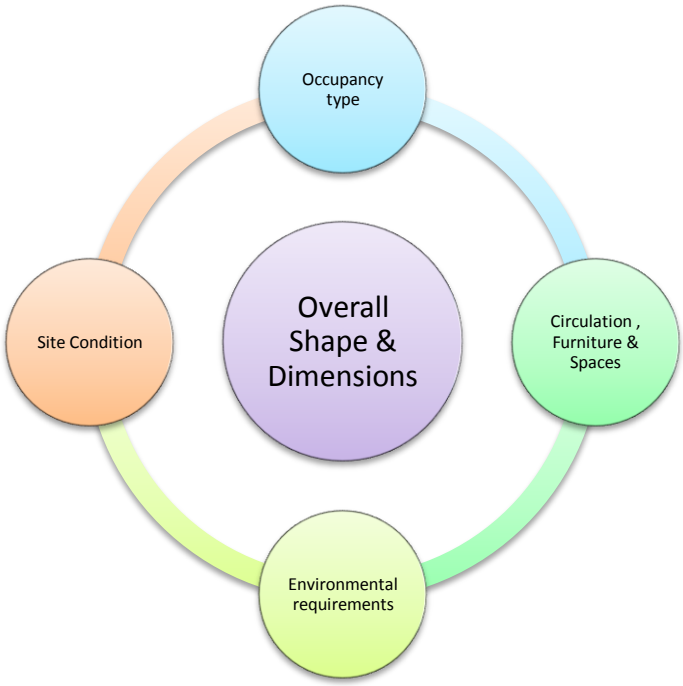
Another aspect of structural design which is worth mentioning at this point is ***factor of safety.*** In structural engineering, a design coefficient utilized to ensure that structural members are never overloaded is called as factor of safety and is calculated as the maximum load that an element

can withstand divided by the calculated design or allowable load. This brings our discussion on structural design of buildings or structures to an end.

1.6 Functional Design

Functional design of building is based on the functional use and "comfort" conditions of the occupants. To start with, any building project is planned based on the occupancy type and its functional use, that is whether residential or industrial or commercial etc. Once this is decided by the owner of the building, the circulation space and furniture will be planned. Circulation space is a stair or corridor or gangway space within a building along which people, goods etc. can move or be moved from place to place.

Depending upon the occupancy type and circulation of the building, the relative proximity of the spaces is planned. For example, when we are planning for a residential building the bed room, kitchen, bath rooms, dining hall etc. are all spaces. Similarly, when we are planning for a residential campus such as RGU IIIT the class room complexes, dining facilities, workshops, laboratories etc. are all treated to be spaces. Proximity is nothing but nearness, for example the dining hall should be in proximity to kitchen rather than bed rooms for a residential building.



Beside the above factors, we should also consider the site conditions, environmental requirements, aesthetics etc. for arriving at the overall dimensions of the building.

1.6.1 General Functions of a Building & Comfort conditions

The general functions of a building can be explained in terms of comfort conditions of the occupants. The comfort aspect of a building may consist of the fallowing factors (See fig 1.5).

a) Thermal comfort
b) Air quality
c) Sound
d) Lighting

Thermal Comfort: The thermal comfort conditions of humans depend on factors that vary from person to person (i.e. body chemistry, body size, age, gender, type of activity and clothing etc.). The heat energy produced by food energy in the body has to be lost at a best rate to keep the body at a constant temperature. The rate at which the body exchanges heat with its surroundings depends on the air temperature, temperature of the surrounding surfaces, air movement and moisture in the air. Air temperature & Relative Humidity are the measures in determining thermal comfort. So, the building envelop has to be designed to accommodate adequate air temperature & relative humidity in terms of proper fenestration (deliberately made openings such as windows) design and appropriate material selection.

Air Quality: As humans we need certain qualities of air for preserving life and for comfort. Breathing requires a minimum supply of oxygen, and more importantly the removal of carbon dioxide. However, long before there is any danger to life we will object to uncomfortable temperatures, odours and contaminants in the air from activities like smoking, cooking and washing. Proper ventilation system maintains air quality by removing stale air and replacing it with fresh air. Open windows are a common form of natural ventilation. We can also have mechanical ventilation systems such as exhaust fans if required. No. of air changes is the measure for the ventilation.

Sound: Comfortable surroundings of sound and noise, which may also be called aural comfort, are affected by habits and preferences of individual people. Environmentally noise is defined as unwanted sound. Acoustics is concerned with noise within a room or enclosed space and deals

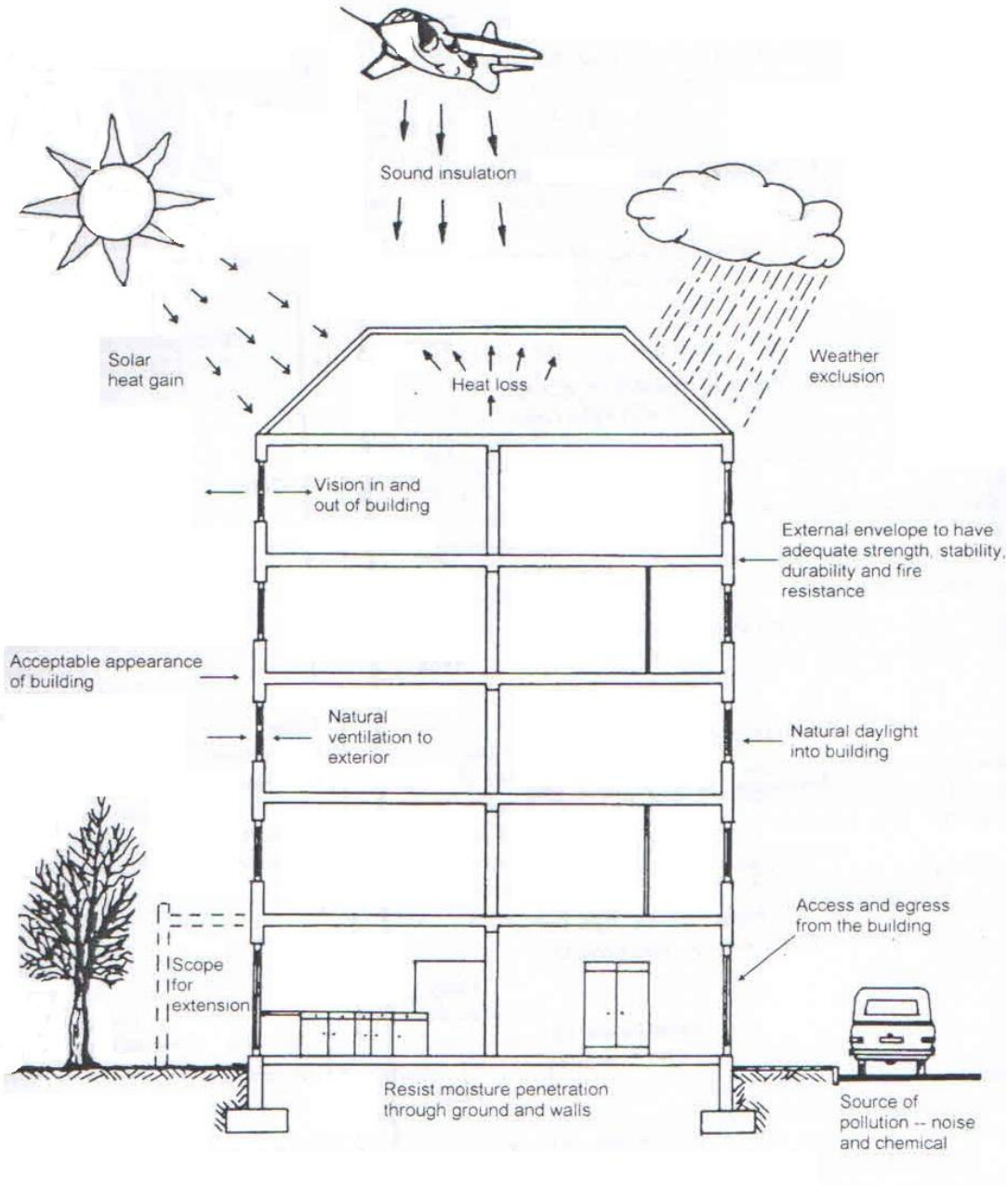


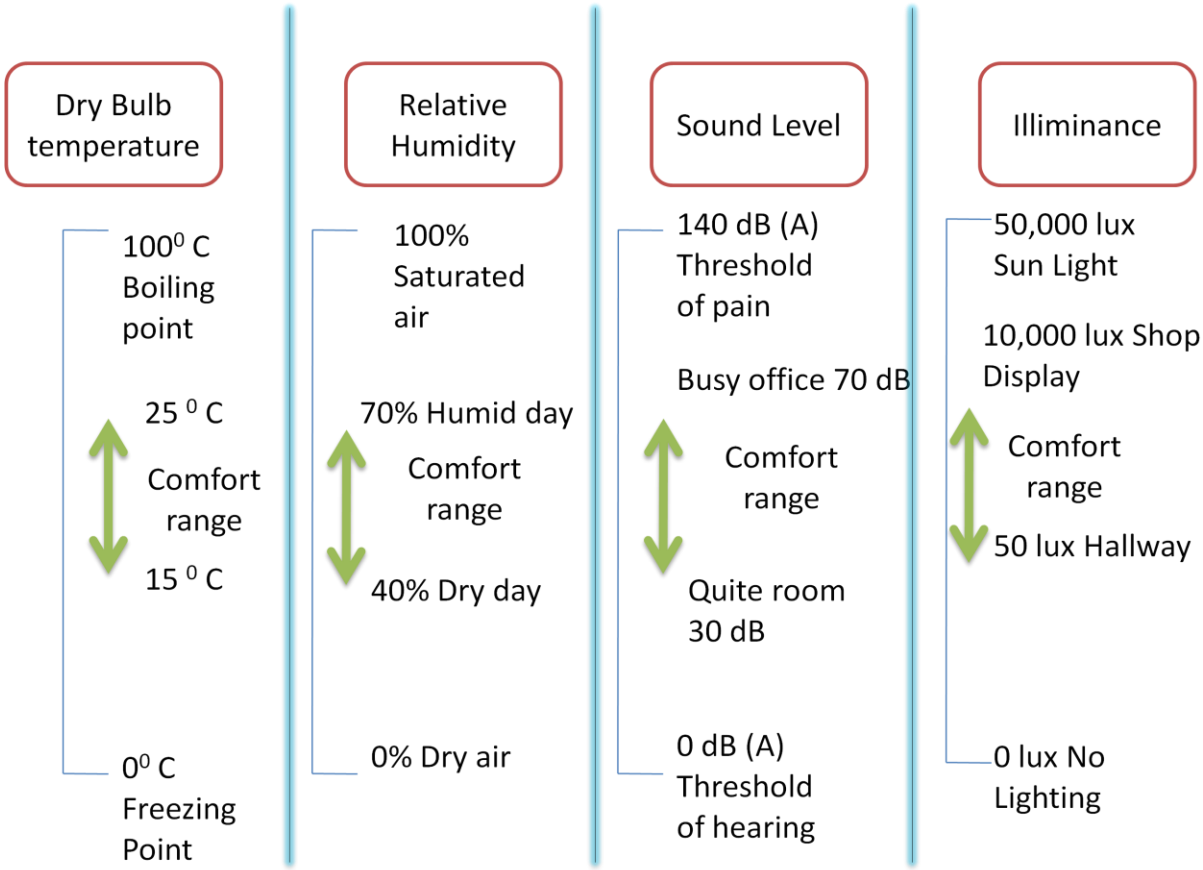
Fig 1.5 General functions of a building

with qualities such as clarity, evenness and fullness. A building, especially theatre should be acoustically sound. Buildings should be designed with sound insulations so that excessive

amounts of sounds should not enter the building. This is achieved by selecting materials which acts as 'noise barriers'. Sound is measured in "Decibels".

Lighting: The primary consideration is the lighting design is the quantity of light on a certain surface, such as a table or floor. The concentration of light is specified by illuminance and is measured in units of 'lux'. Adequate lighting has to be provided depending upon the functional use of the buildings.

Summary of comfort measurements a building should provide



1.6.2 Building Services

The building services are also a part of functional design of buildings. The main features of building services are as fallows.

- Fire protection through zoning, planning, fire rated element design and provisions for evacuation & fire fighting.
- Plumbing, electrical and communication services through proper planning & control.
- Lifts and other services through design.
- Protection against moisture ingress and rain penetration through design, detailing construction practice and; damp proofing & water proofing.
- Maintenance of the building during service.

1.6.3 Need for Byelaws

Building by-laws are locally varying regulations controlling the construction and erection of buildings administered by local authorities on the basis of model by-laws provided by government. They typical features of building byelaws may be stated as below.

- Zoning and Land use control [E.g. Industrial zone vs. Residential zone]
- Unobstructed air movement & sun light [Buildings in urban areas have to leave a min. of 8’ towards the buildings beside and back side]
- Control of microclimate
- Fire fighting provisions
- Protection against earthquake
- Traffic movement & traffic privacy of neighborhood.

1.7 Conclusion

The broad objectives or functions which the individual aspects of the building design and construction should set out to achieve are often referred to as functional requirements and are expressed in terms of what is reasonable, appropriate, or adequate. These objectives can be achieved by proper selection of building construction material and products.

Self Assessment: REVIEW QUESTIONS

1. Compare the built environment and natural environment (features).
2. What is the function of a building?
3. Compare structural design with functional design.
4. Elaborate on the different loading conditions a building or a structure undergo in its lifetime.
5. What are "Design loads"?
6. What are comfort conditions?
7. Explain the role of building with respect to comfort conditions?
8. What is the need for byelaws?
9. What are the features of building services?

Selected references:

- Hore, A.V, Kehoe, J.G., McMullan, R., Penton, M.R., " Construction 2 Environment Science Materials Technology", MACMILLAN PRESS LTD, Hampshire, 1997.
- Koenigsberger, O.H., Ingersoll, T.G., Mayhew, A., Szokolay,S.V., "Climatic Design - Manual of Tropical Housing and Building", Orient Longman Private Ltd. Chennai, India, 2006.
- Gambhir, M.L. and Neha, J., " Building Materials – Products, Properties and Systems", Tata McGraw Hill Education Private Ltd, New Delhi, India, 2011.