COMPLETE SET
WITHOUT QUESTION BANK

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- HISTORY & ARCHITECTURE
- URBAN PLANNING & DESIGN
- BUILDING SERVICES, CONSTRUCTION & MANAGEMENT

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By
Faculty of Architecture

GATE ARCHITECTURE
2020

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BUILDING SERVICES CONSTRUCTION & MANAGEMENT

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Introduction

As the name of this section suggests, it is meant for to recap the maximum part of the syllabus in minimum possible time. This is a part of GATE ARCHITECTURE 2018 complete set. It covers through short notes on different topics of the syllabus.

There is no limit on the discussion on the topic on General Aptitude. Scoring marks in this section depend on the intuition, clicks etc of the aspirants in the examination hall. However we have included ample examples with answer on Verbal Ability & Numerical Ability topic.

When it comes to the building services, it is essentially an engineering section. Even its topics (for example HVAC or Fire Fighting) comes from different departments. To solve a numerical from a particular topic, we need to understand the concept & theories behind it and knowledge of SI unit conversion to arrive at the precise answer. Here we have tried to introduce the topic through solved examples and derivation theories.

Contents

Section 2: Building Materials, Construction and Management

Behavioral characteristics and applications of different building materials

Timber

Introduction: The Mechanical properties and availability of wood have made it a natural material for building structures, furniture, tools, vehicles, and decorative objects. Worldwide it is used more than metal or plastic.

Wood is a natural product and when used responsibly is a sustainable resource which need not result in damage to the environment. Forests can be protected by recycling and reusing the wood, using less wood and by supporting sustainable forest management

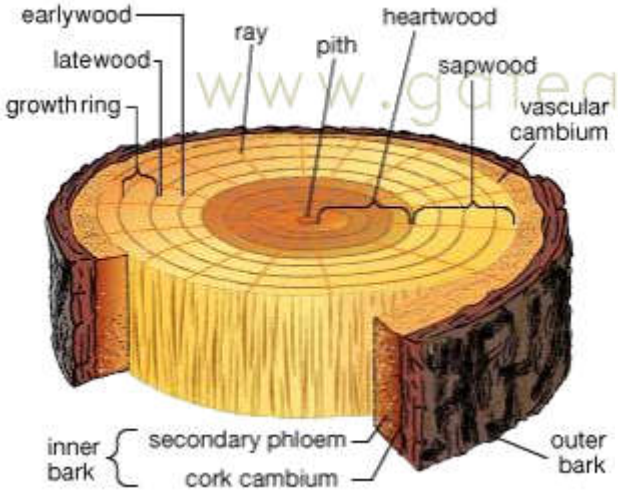
All wood is composed of cellulose, lignin, hemicelluloses, and minor amounts (5% to 10%) of extraneous materials contained in a cellular structure.

Wood comprises about 50% of cellulose which responsible for most of its mechanical properties.

Natural wood is generally composed of bundles of long fibres which are effectively water carrying tubes. These fibres are laid in the direction of the tree trunk or branch from which the wood is removed.

The strength of wood is highly dependent on the loading direction. Wood is strongest in tension along the fibres and is weakest in the radial and tangential direction. When loaded in its strongest direction (longitudinal along the grain - see figure below) wood can have a strength to weight ratio advantage relative to steel of 2:1. However when wood is loaded in other directions (radial and tangential to the grain- see figure below) this advantage disappears

To use wood to its best advantage and most effectively in engineering applications, specific characteristics or physical properties must be considered.



Softwoods are one of the botanical groups of trees that has persistent needle-like or scale-like leaves; softwoods are evergreen and have longer-length fibers than hardwoods.

Softwood trees include pines, spruces, firs , cedars.

Hardwood trees are generally broadleaved trees. These tree species are deciduous, retaining their leaves only one growing season. The designation Hardwood trees does not necessarily relate to the hardness of the wood.. Hardwood trees are also called broad leaf trees or deciduous trees.

Typical hardwood trees include ash, elms, oak, maple, walnut, hickory, mahogany, and walnut. Woods grown in tropical climates are generally hardwoods. Hardwood have shorter fibers compared to softwood. some hardwoods are evergreen.

Plywood

This is a product made from an odd number (three, five ...) of thin layers (veneers) of wood (generally hardwoods) bonded together by an adhesive. The alternate plies are at right angles thus ensuring that the resulting material hasa high uniform strength in all directions.

Plywood does not split as easily as conventional wood and has a good dimensional stability under conditions of varying moisture conditions. Plywood will not easily split if a nail is close to any edges. Plywood can be considered as a high strength construction material used for internal and external load bearing panels.

Plywood is normally supplied as 1,2m x 2,4m sheets in thickness from 3 to 25mm thickness

Chipboard

Chipboard is made from particles of wood bonded together with a synthetic resin and sometimes other binders. The panels are generally 2,4m x 1,2m with thicknesses from 3mm to 40mm. Larger sizes are available up to 5m x 1,5m. The particles are obtained from forrest thinnings sawdust and small pieces of wood unsuitable for other uses are granulated to chips. The resin used is generally urea formalehyde. Chipboard is normally only suitable for interior use in the manufacture of low cost furniture, wall panels and floor panels.

MDF (Medium Density FibreBoard)

There are different types fibreboard which differentiated by
..the size and type of wood fibres used
..the method of heating
..what type of bonding agent is used
..the method by which it is pressed into shape

Medium Density Fibreboard (MDF) is a wood substitute form which is made from fine wood fibres in a resin which is bonded under heat and pressure. It is manufactured by a dry process at a lower temperature than other fibreboards e.g hardboard. The natural glues and resins contained within the wood are not effective. MDF therefore uses artificial bonding agents / resins. The resin used is usually urea formaldehyde, but some fibreboard including exterior or marine quality board will use stronger glues such as phenol formaldehyde. MDF may be used instead of plywood or chipboard. It is dense, flat, stiff, has no knots and is easily machined. It is made up of fine particles and therefore does not have an easily recognisable surface grain

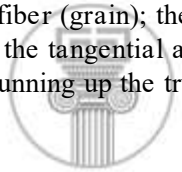
MDF can be painted to produce a smooth quality surface. Because MDF has no grain it can be cut, drilled, machined and filed without damaging the surface. MDF may be dowelled together and traditional woodwork joints may even be cut. MDF may be glued together with PVA wood glue. Oil, water-based paints and varnishes may be used on MDF. Veneers and laminates may also be used to finish MDF

Safety: It should be noted by anyone involved with MDF that there is an accepted risk that wood dust inhaled at certain level, is a carcinogen (cancercausing) and that formaldehyde is possibly carcinogenic to humans'. Exposure to formaldehyde by inhalation can cause irritation to the eyes, nose, throat and mucus membrane.formaldehyde can also cause dermatitis. A number of countries have but legal limitations on the use of MDF

Strength of wood

Wood is a natural product and its properties vary continuously throughout processing from when the tree is cut down. Green wood has high moisture content (generally) and this results in reduced strength. As it is dried it loses the moisture content and becomes stronger.

Wood may be described as an orthotropic material; that is, it has unique and independent mechanical properties in the directions of three mutually perpendicular axes: longitudinal, radial, and tangential. The longitudinal axis is assumed parallel to the fiber (grain); the radial axis is normal to the growth rings (perpendicular to the grain in the radial direction); and the tangential axis is perpendicular to the grain but tangent to the growth rings. (Think of the grain as the tree rings running up the trunk /branch - planks of wood are simply sections of the tree trunk (or branch)



FRP

Fiberglass Reinforced Plastic Panels (FRP) are modern composite materials that have become popular in the construction industry. These panels are made from a combination of glass fibers and plastics. The fibers act similar to beams in a house, reinforcing the structure of the polymer, making it more stable and strong. A fiberglass reinforced panel used in construction usually has the following components:

- A base polymer, usually, plastics like polyester
- A fiberglass reinforcement
- Other additives to improve desirable qualities like fire resistance, and opacity to UV rays
- Surface veils for a smooth finish and extra durability

Panels made from fiberglass reinforced plastics are lightweight, yet strong and flexible. They are quite superior to traditional building materials like wood and metal on several counts.

It offers the architect unlimited design flexibility due to its molded shape potential. From columns to cornices, Fiberglass (FRP) has been used around the world to add decorative dimensionality to projects while being a cost alternative to many traditional building materials.

Fiberglass reinforced polymers (FRP) is a lightweight, versatile and durable construction material for exterior architectural detailing. FRP is used to create columns, capitals, moldings, domes, decorative balustrades, pergolas, rafter tails, entablatures, pediments, rakes, brackets, quoins, window and door surrounds or any architectural feature you wish to create. Fiberglass is extremely versatile. It can be molded and produced in practically any shape. FRP parts can be made on a radius or ellipse. You can have letters preformed in the fiberglass parts to mimic the look of chiseled stone words on building facades.

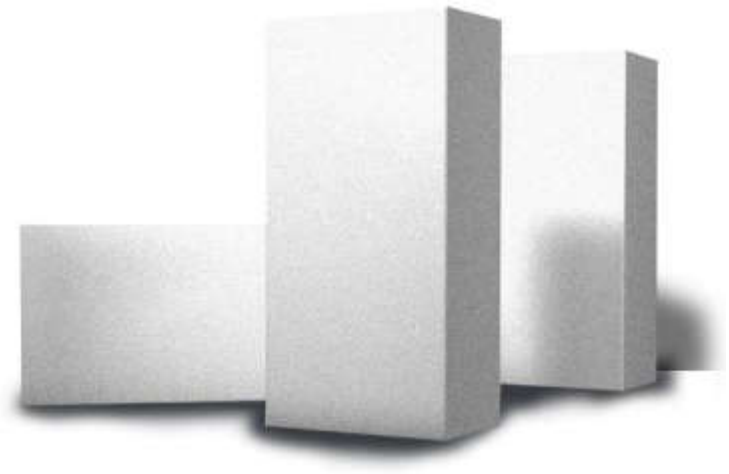
There are great advantages to specifying and installing fiberglass on your construction project. Fiberglass is lightweight with strong and durable properties. Since it is lightweight, FRP enables the building design to require less structural load requirements, thus reducing costs for the project.

FRP can be supplied several ways. For many projects, FRP is supplied unpainted. This enables the installer to attach the FRP to the structure with the ability to countersink screws, patch the screw holes with body filler and sand the screw holes flush with the fiberglass surface. The entire project is then primed and painted giving the material a uniform, finished appearance.

FRP can also be supplied with a gel coated colored finish. Almost any color can be achieved. Some projects require that the FRP arrive to the jobsite with a finished coat. When specifying a finished FRP, there are certain things to take into consideration. Firstly, there needs to be strong communication between the architect, construction manager, supplier and installer. Prefinished FRP needs to handled and installed properly to protect the finish. Screws need to be strategically installed to minimize the number of exposed areas on the surface of the material.

A third process for producing fiberglass is with a simulated stone finish. This can give the FRP the appearance of limestone and other stone finishes. The same planning and care must be followed for handling and installation the stone finished FRP as with the gel coated colored FRP.

AAC Blocks



Estimation, specification, v aluation

Cost & Estimation

Types Of Estimates

The estimates may be divided in to the following categories:-

(1) Preliminary or Approximate estimate.
(2) Rough cost estimate based on plinth area.
(3) Rough cost estimate based on cubic contents.
(4) Detailed estimate.
(5) Annual repair estimate.
(6) Special repair estimate.
(7) Revised estimate
(8) Supplementary estimate.

1. Preliminary or Approximate estimate

This estimate is prepared to decide *financial aspect* , *policy* and to give idea of the cost of the proposal to the competent sanctioning authority. It should clearly show the necessity of the proposal and how the cost has been arrived at

The calculations for approximate estimate can be done with the following data. The data can be had from a similar construction already complete in the nearby area, executed by the department.

For example: To calculate approximate estimate for a Hospital, per bed cost is calculated from the recent completed hospital and is multiplied with the number of beds required. Similarly for a house, per square metre plinth area is calculated and is multiplie d with the proposed covered area. The specifications should also be same. For a road, expenditure of per kilometer length is taken, width also plays the role.

The following documents should be attached with it.

(a) Detailed report

(b) Site plan of the proposal

(c) It should also clearly mention about the acquisition of land, Provision of

electric and water supply etc.

2. Plinth area Estimate (Based on Rough Cost)

Plinth area of a building means Length x Breadth (roofed portion only) excluding plint h offsets. The estimates are prepared on the basis of plinth areas of the various buildings proposed to be constructed. The **rates** are being arrived at the dividing the total cost of construction with its plinth area. For example if total cost of a building is

Rs. 2 lac and its plinth area is 50 sq. m. then plinth area rate =2,00,000 = Rs.4000/- per

50

sq.m. Using this rate as basis of the next construction, approximate or rough cost of the proposal can be arrived at by multiplying the plinth area of the proposed building with this plinth area rate.

The following documents are attached with the estimate.

(a) Line plan with brief specifications.
(b) Cost of various services added i.e. electric and water supply etc.
(c) North line should be shown clearly on line plan.

3. Cubic Contents Estimate (Based on Rough Cost)

The cubic contents of a building means plinth area x height of the building. The height is taken from top of floor level to top of roof.

The cubic contents of the proposed building are multiplied with cubic rates arrived at for the similar construction i.e. total cost of construction divided by cubic contents = cost per cubic metre.

4. Detailed Estimate

After getting Administrative approval on rough cost estimate, detailed estimates are prepared.

In this, the estimate is divided in to sub-heads and quantities of various items are calculated individually.

In the end of the detailed quantities, an *abstract* of *cost* giving quantities of each item and rate of every item according to the sanctioned schedule of rates shall be attached. In case of non-schedule rates i.e. rates which are not given in the sanctioned schedule of rates, proper analysis of rates shall be attached. If however the work proposed to be constructed is located in a remote place, the provision for the carriage of the material shall be added in the estimate to avoid any excess over the administratively approved estimate later on. Detailed specifications & report should also be attached with the estimate. Technical sanction is given on detailed estimate.

The detailed estimate shall also provide for the cost of approach road, water supply, electric installations and acquisition of land etc, so as to call it a comprehensive estimate.

5. Annual repair estimate

In order to keep building and roads in perfect condition, annual repairs should be carried out as follow:-

(i) In case of a building-white washing, oiling and painting of doors and windows, cement plaster repairs (inside & outside), repairs of floors etc. In no case this annual repair amount should increase more that 11/2% to 2% of the capital cost of the building.

(ii) In case of a road-filling patches, maintenance of berms etc.

6. Special repair estimate

If the work cannot be carried out of the annual repair funds due to certain reasons resulting in the genuine increase in cost, then special repairs estimate is to beprepared.

The reason of increase may be:-

(i) In case of a building-opening of new doors, change of floors, replastering walls etc.

(ii) In case of roads-if the whole surface is full of corrugation & patches, then the total surface is to be scarified. The old metal is taken out, consolidation by adding more metal is done and top surface is repainted.

7. Revised estimate

When the sanctioned estimate exceeds by 5% either due to the rate being found insufficient or due to some other reasons, a fresh estimate is prepared which is called a Revised Estimate. A comparative statement on the last page of the estimate is attached giving there in the reasons of theincrease of cost in case of each item.

8. Supplementary Estimate

This is fresh detailed estimate in addition to the original sanctioned estimate prepared when additional works are deemed necessary during the progress of a work to supplement the originalworks. The abstract of cost should show the amount of the original sanctioned estimate as well as the supplementary amount of the original sanctioned estimate as well as the supplementary amount for which sanction is required.

Methods of Taking out Estimates

The calculations of quantities of materials can be done using various methods of estimates. The application of an individual method depends upon the design and shape of the building. The different methods are as under:

1. Centre line method.
2. Crossing method.
3. Out to out and in to in method.
4. Bay method.
5. Service unit method.

PERT/CPM for Project Scheduling & Management

1. INTRODUCTION

Basically, CPM (Critical Path Method) and PERT (Programme Evaluation Review Technique) are project management techniques, which have been created out of the need of Western industrial and military establishments to plan, schedule and control complex projects.

1.1 Brief History of CPM/PERT

CPM/PERT or Network Analysis as the technique is sometimes called, developed along two parallel streams, one industrial and the other military.

CPM was the discovery of M.R.Walker of E.I.Du Pont de Nemours & Co. and J.E.Kelly of Remington Rand, circa 1957. The computation was designed for the UNIVAC-I computer. The first test was made in 1958, when CPM was applied to the construction of a new chemical plant. In March 1959, the method was applied to a maintenance shut down at the Du Pont works in Louisville, Kentucky. Unproductive time was reduced from 125 to 93 hours.

PERT was devised in 1958 for the POLARIS missile program by the Program Evaluation Branch of the Special Projects office of the U.S.Navy, helped by the Lockheed Missile Systems division and the Consultant firm ofBooz-Allen & Hamilton. The calculations were so arranged so that they could be carried out on the IBM Naval Ordinance Research Computer (NORC) at Dahlgren, Virginia.

1.2 Planning, Scheduling & Control

Planning, Scheduling (or organising) and Control are considered to be basic Managerial functions, and CPM/PERT has been rightfully accorded due importance in the literature on Operations Research and Quantitative Analysis.

Far more than the technical benefits, it was found that PERT/CPM provided a focus around which managers could brain-storm and put their ideas together. It proved to be a great communication medium by which thinkers and planners at one level could communicate their ideas, their doubts and fears to another level. Most important, it became a useful tool for evaluating the performance of individuals and teams.

There are many variations of CPM/PERT which have been useful in planning costs, scheduling manpower and machine time. CPM/PERT can answer the following important questions:

How long will the entire project take to be completed? What are the risks involved?

Which are the critical activities or tasks in the project which could delay the entire project if they were not completed on time?

Is the project on schedule, behind schedule or ahead of schedule?

If the project has to be finished earlier than planned, what is the best way to do this at the least cost?

1.3 The Framework for PERT and CPM

Essentially, there are six steps which are common to both the techniques. The procedure is listed below:

I. Define the Project and all of it's significant activities or tasks. The Project (made up of several tasks) should have only a single start activity and a single finish activity.
II. Develop the relationships among the activities. Decide which activities must precede and which must follow others.
III. Draw the "Network" connecting all the activities. Each Activity should have unique event numbers. Dummy arrows are used where required to avoid giving the same numbering to two activities.
IV. Assign time and/or cost estimates to each activity
V. Compute the longest time path through the network. This is called the critical path.
VI. Use the Network to help plan, schedule, monitor and control the project.

The Key Concept used by CPM/PERT is that a small set of activities, whichmake up the longest path through the activity network control the entire project. If these "critical" activities could be identified and assigned to responsible persons, management resources could be optimally used by concentrating on the few activities which determine the fate of the entire project.

Non-critical activities can be replanned, rescheduled and resources for them can be reallocated flexibly, without affecting the whole project.

Five useful questions to ask when preparing an activity network are

- Is this a Start Activity?
- Is this a Finish Activity?
- What Activity Precedes this?
- What Activity Follows this?

Introduction

to

Building Services

GATE Syllabus related to Building Services: Water supply; Sewerage and drainage systems; Sanitary fittings and fixtures; Plumbing systems; Principles of internal and external drainage system; Principles of electrification of buildings; Intelligent Buildings; Elevators and Escalators- standards and uses; Air-Conditioning systems; Firefighting Systems; Building Safety and Security systems.

Contents

This study manual is prepared from different source books & references on advance level building services. It's been trimmed down to restrict around GATE syllabus. However to maintain the coverage of topic, some discussions may have exceeded the syllabus. The aim of this manual is to introduce theconcept of derivations and basic engineering.

Some topics on building services that may not be discussed here are better discussed in question-bank. You are suggested to read this section along question-bank as complementary.

Introduction

Building Services are the electrical, plumbing, and mechanical systems in a building. For this reason they are also called MEP services, for mechanical, electrical, and plumbing.

A comprehensive list of services that could be provided in a building follows:

Mechanical Services

1. Firefighting Systems
2. Elevators & Escalators
3. HVAC Systems (heating, ventilation, and air-conditioning systems)
4. Gas Supply Systems (such as for heating and cooking in residential buildings, or oxygen and nitrogen in hospitals)
5. Compressed Air Systems used in industries

Electrical Services

1. Power Supply
2. Backup Power (such as diesel generators)
3. Emergency Power (such as battery-based uninterrupted power supply)

Plumbing Systems

1. Water Supply
2. Drainage of Wastes
3. Water Recycling Systems (these allow you to recover the water from your waste and re-use that water for low-grade applications such as flushing)
4. Rainwater Harvesting
5. Storm Water Drainage

Data based Systems or Low-Voltage Systems

1. Security Systems
2. Fire Alarm Systems
3. Building Management Systems
4. Public Address Systems
5. Cable TV Systems
6. Data Networks
7. Voice Networks

1. Heating System

Thermal resistance of materials

The thermal resistance of a slab of homogeneous material is calculated by dividing its thickness by its thermal conductivity:

$$R = \frac{l}{\lambda}$$

where R is the thermal resistance (m^2K/W), l is the thickness of the slab (m) and λ is the thermal conductivity (W/mK). Resistance to heat flow by a material depends on its thickness, density, water content and temperature. The latter two parameters result from the material's location within the structure. Insulating materials are usually protected from moisture and the possibility of physical damage as they are of low density and strength. The thermal conductivity of masonry can be found from the bulk dry density and the moisture content, which depends on whether it is exposed to the climate or is in a protected position.

Example 1.1 Find the thermal resistance of a 110 mm thickness of brickwork innerleaf.

λ=0.62 W/mK (given) and l = 0.11 m.

$$R = \frac{l}{\lambda} = \frac{0.11}{0.62} = 0.1774 \text{ m}^2\text{K/W}$$

Example 1.2 A designer wishes to replace 200 mm thick heavyweight concrete blocks in the design of a wall with fibreboard having the same thermal resistance. What thickness of fibreboard could be used?

Given, λ=1.63 W/mK for the heavyweight concrete block and λ=0.6 W/mK for the fiberboard.

R (concrete) = 0.200 / 1.63
R (fiberboard) = l / 0.06
So, for the same resistance,
0.200 / 1.63 = l / 0.06
Hence,
l = 7.4 mm Answer.

Thermal transmittance (*U* value)

Thermal transmittance is found by adding the thermal resistances of adjacent material layers, boundary layers of air and air cavities, and then taking the reciprocal. Boundary layer orsur- face film thermal resistances result from the near-stationary air layer surrounding each part of a building, with an allowance for the radiant heat transfer at the surface. Heat transmission acrosscavities depends upon their width, ventilation and surface emissivities. The external surface resistance depends upon the building's exposure.

Example 1.3 An external wall consisting of 105 mm brick, 50 mm unventilated cavity, 105 mm brick and 13 mm dense plaster has a severe exposure. Find its *U* value.

Shear Force and Bending Moment Diagram:

Introduction:

The advantage of plotting a variation of shear force F and bending moment M in a beam as a function of 'x' measured from one end of the beam is that it becomes easier to determine the maximum absolute value of shear force and bending moment.

Further, the determination of value of M as a function of 'x' becomes of paramount importance so as to determine the value of deflection of beam subjected to a given loading.

Construction of shear force and bending moment diagrams:

A shear force diagram can be constructed from the loading diagram of the beam. In order todraw this, first the reactions must be determined always. Then the vertical components of forces and reactions are successively summed from the left end of the beam to preserve the mathematical sign conventions adopted. The shear at a section is simply equal to the sum of all the vertical forces to the left of the section.

When the successive summation process is used, the shear force diagram should end up with the previously calculated shear (reaction at right end of the beam. No shear force acts throughthe beam just beyond the last vertical force or reaction. If the shear force diagram closes in this fashion, then it gives an important check on mathematical calculations.

The bending moment diagram is obtained by proceeding continuously along the length of beam from the left hand end and summing up the areas of shear force diagrams giving due regard to sign. The process of obtaining the moment diagram from the shear force diagram by summation is exactly the same as that for drawing shear force diagram from load diagram.

It may also be observed that a constant shear force produces a uniform change in the bending moment, resulting in straight line in the moment diagram. If no shear force exists along a certain portion of a beam, then it indicates that there is no change in moment takes place. It may also further observe that dm/dx= F therefore, from the fundamental theorem of calculus the maximum or minimum moment occurs where the shear is zero. In order to check the validity of the bending moment diagram, the terminal conditions for the moment must be satisfied. If the end is free or pinned, the computed sum must be equal to zero. If the end is built in, the moment computed by the summation must be equal to the one calculated initially for the reaction. These conditions must always be satisfied.

Illustrative problems:

In the following sections some illustrative problems have been discussed so as to illustrate the procedure for drawing the shear force and bending moment diagrams

1. A cantilever of length carries a concentrated load 'W' at its free end.

Draw shear force and bending moment.

Solution:

At a section a distance x from free end consider the forces to the left, then F =W (for all values of x) -ve sign means the shear force to the left of the x-section are in downward direction and therefore negative

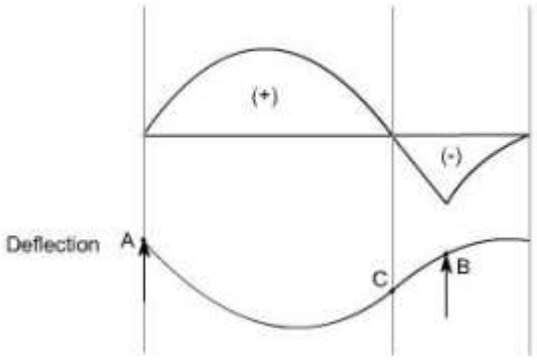
Taking moments about the section gives (obviously to the left of the section)

M = -Wx (-ve sign means that the moment on the left hand side of the portion is in the anticlockwise direction and is therefore taken as–ve according to the sign convention)

so that the maximum bending moment occurs at the fixed end i.e. M =-W l

From equilibrium consideration, the fixing moment applied at the fixed end is Wl and the reaction is W. the shear force and bending moment are shown as,

The bending moment diagram is partly positive and partly negative.If we plot the deflected shape of the beam just below the bending moment



Common Relationships

Load	0	Constant	Linear
Shear	Constant	Linear	Parabolic
Moment	Linear	Parabolic	Cubic

This diagram shows that L.H.S of the beam 'sags' while the R.H.S of the beam 'hogs'

The Relationship Between Load, Shear and Bending Moment

$$w(x) = \text{the load function}$$

$$V(x) = \int w(x)dx$$

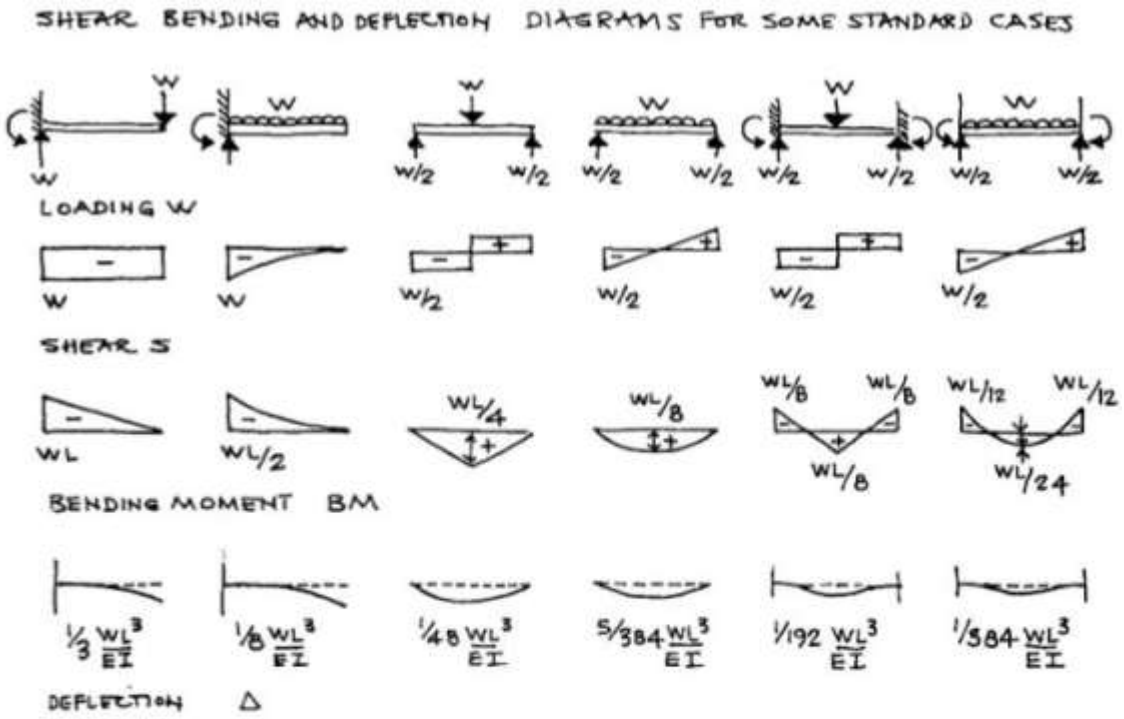
$$M(x) = \int V(x)dx$$

The point C on the beam where the curvature changes from sagging to hogging is a point of contraflexure.

OR

It corresponds to a point where the bending moment changes the sign, hence in order to find the point of contraflexures obviously the B.M would change its sign when it cuts the X-axis therefore to get the points of contraflexure equate the bending moment equation equal to zero.The fibre stress is zero at such sections

Note: there can be more than one point of contraflexure.



GATE SYLLABUS2018: General Aptitude (15 marks)

Numerical Ability: Numerical computation, numerical estimation, numerical reasoning and data interpretation.

Verbal Ability: English grammar, sentence completion, verbal analogies, word groups, instructions, critical reasoning and verbal deduction.

Numerical Ability Questions:

In the exams, you may encounter challenging numerical reasoning questions. Such challenging numerical reasoning questions require problem-sloving heuristics (set of rules) in addition to the four basic operations (addition, subtraction, multiplication and division). Below are the 11 useful heuristics you can adopt to solve difficult questions.

1. Use Diagrams / Models
2. Act it Out
3. Use Before & After
4. Use Systematic Listing
5. Look for Patterns
6. Work Backwards
7. Use Guess & Check
8. Simplify the Problem
9. Make Supposition
10. Solve Part of the Problem
11. Paraphrase the Problem

---

1. In the first 10 overs of a cricket game, the run rate was only 3.2. What should be the run rate in the remaining 40 overs to reach the target of 282 runs?

A.6.25 B.6.5
C.6.75 D.7

Answer: Option **A**
Explanation:

Required run rate = $\frac{282 - (3.2 \times 10)}{40} = \frac{250}{40} = 6.25$

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2. The captain of a cricket team of 11 members is 26 years old and the wicket keeper is 3 years older. If the ages of these two are excluded, the average age of the remaining players is one year less than the average age of the whole team. What is the average age of the team?

A. 23 years B. 24 years
C. 25 years D. None of these

Answer: Option **A**

Explanation: Let the average age of the whole team by x years.

$\therefore 11x - (26 + 29) = 9(x - 1)$
$\Rightarrow 11x - 9x = 46$
$\Rightarrow 2x = 46$
$\Rightarrow x = 23.$
So, average age of the team is 23years.

---

3. The average age of husband, wife and their child 3 years ago was 27 years and that of wife and the child 5 years ago was 20 years. The present age of the husband is:

A. 35 years B. 40 years
C. 50 years D. None of these
Answer: Option **B**

Explanation: Sum of the present ages of husband, wife and child = (27 x 3 + 3 x 3) years = 90 years.

URBAN PLANNING & DESIGN

GATE ARCHITECTURE 2020

By
Faculty of Architecture

gatearchitecture.com

Introduction

One of major reasons to score low in GATE exam for B.Arch students is that few are fully aware that GATE AR is for both of B.Arch & B.Plan. So, a quite well number of questions would be asked in exam covering B. Planning section.

This is a reason you have this booklet. Please note that we have covered in depth the section about town planners, theories and their contribution in Question-Bank itself. Therefore we have minimized those sections here.

Urban planning and design more of theories, stories, concepts etc. We have randomly selected topics from the syllabus and put into concise and bullet form as far as possible.

You should read this booklet as a complementary to the complete set.

GATE SYLLABUS 2018 [Contents covered in this section are highlighted]

Section 5: Urban Design Concepts and theories of urban design; Public Perception; Townscape; Public Realm; Urban design interventions for sustainable development and transportation; Historical and modern examples of urban design; Public spaces, character, spatial qualities and Sense of Place; Elements of urban built environment – urban form, spaces, structure, pattern, fabric, texture, grain etc; Principles, tools and techniques of urban design; Urban renewal and conservation; Site planning; Landscape design; Development controls – FAR, densities and building byelaws.

Section 6: Urban Planning and Housing Planning process; Types of plans - Master Plan, City Development Plan, Structure Plan, Zonal Plan, Action Area Plan, Town Planning Scheme, Regional Plan; Salient concepts, theories and principles of urban planning; Sustainable urban development; Emerging concepts of cities - Eco-City, Smart City, Transit Oriented Development (TOD), SEZ, SRZ etc.

City Planning

Housing; Concepts, principles and examples of neighbourhood; Housing typologies; Slums; Affordable Housing; Housing for special areas and needs; Residential densities; Standards for housing and community facilities; National Housing Policies, Programs and Schemes

Urban Design

What is urban design?

Unfortunately, there are no hard and fast rules related to urban design. A structural beam in a building must meet certain requirements for that building to stand. A road must be built in a certain way to avoid future potholes.

Urban design, however, is not a series of rulesand standards. Rather, it is a group of concepts that, once understood, can lead to a fresh way of perceiving streets, buildings, and spaces-- and insights into why certain places are appealing and others are not. With urban design concepts in mind you should be able to better question architectural presentations and consider the impact of development proposals on your town's character.

Introduction to urban design

When walking down the street you see a place that appears interesting and inviting. Across the street you glance at another area but it looks unappealing and uncomfortable. Which place would you rather be? That's easy to answer. The more difficult question is: Why? What is it that creates a place that people like and use? Understanding some ofthe ideas of urban design can help us better answer this question. Urban design does not have to be a mystery. Knowing a few important concepts can make it easier for you to observe what works– and what doesn't – as you stroll through your town, or as you review a project application.

Urban design is concerned with the arrangement, appearance and function of our suburbs, towns and cities. It is both a process and an outcome of creating localities in which people live, engage with each other, and engage with the physical place around them.

Urban design involves many different disciplines including planning, development, architecture, landscape architecture, engineering, economics, law and finance, among others.

We can also say, Urban design is the art of making places for people. It includes the way places work and matters such as community safety, as well as how they look. Itconcerns the connections between people and places, movement and urban form, nature and the built fabric, and the processes for ensuring successful villages, towns and cities.

Urban design operates at many scales, from the macro scale of the urban structure (planning, zoning, transport and infrastructure networks) to the micro scale of street furniture and lighting. When fully integratedinto policy and planning systems, urban design can be used to inform land use planning, infrastructure, built form and even the socio-demographic mix of a place.

	Architecture	**Urban Design**	**Urban Planning**
Scale	Individual building	Space between buildings: Street, park, transit shop	Whole neighborhood, districts & cities
Orientation	Aesthetic and functional	Aesthetic and functional	Unity
Treatment of space	2D & 3D	3D	Predominantly 2D
Time frame	No definite time frame	Short Term (< 5 years)	Long term (5 to 20 years)

Concepts of urban design

Key urban design concepts are:

- Physical comfort
- Circulation and accessibility
- Transitions and boundaries
- The connection between street and building
- Scale
- Detail, variety, and complexity
- Cohesiveness

Figure: **Physical Comfort:** A Market Street is designed to offer places to sit

Physical Comfort

Physical comfort is the basic concept in urban design for people to feel comfortable in a public place. There are basic needs like a good walking surface and some garbage bins, but a good environment also offers places to sit, some shade on a hot day, shelter from the rain, readily accessible public toilets, and decent lighting at night. It is also possible to physically design areas in a way that may help to deter crime.

Circulation and Accessibility

There should be a peaceful coexistence between the pedestrian and the car. Comprehending and feeling comfortable in the urban environment means that separation between pedestrian use, driving lanes, and parking must be easy to see and interpret. In many developments it will be important to reassert the priority of the pedestrian when looking at circulation.

Figure: **Circulation and Accessibility:** Providing an adequate buffer strip and sidewalks can help people walkthrough easily.

Transitions and Boundaries

Most people feel a deep need to know where one neighborhood or district ends and another begins. A logical world with good spatial definition orients us and gives us information to help us make decisions about where to go and what to do. Elements such as the shape of buildings, doorway design, paving materials, curbs, landscaping, street furniture, changes in the elevation of the ground, and signage let us know where one category of uses gives way to another. The transitions and boundaries of the urban world tell us when we enter and leave the town, what is public and what is someone's private space, where to sit and meet people, where to stroll, where to shop, and where to drive or park. Using urban design to clearly show these transitions and boundaries can be the difference between comfort and confusion; and between feeling invited and feeling unwelcome.

Figure: **Transitions and Boundaries**: these can be effective in helping orient visitors where to go. Better with signage.

Figure: **Scale:** The varied rhythm of storefronts in towns helps establish a pedestrian-oriented scale.

PLANNING PROCESS:

All stages of actions from defining the objectives till implementation and review of any planning project in the planning process. In plan preparation, the physical planning should associate with the socio-economical, geographical, political factors, for achieving the objective in desired direction.
The various stages of planning process is as follows:

1. Identification and definition of problems
2. Defining the objectives
3. Studies and survey
4. Analysis of data and preparation of study maps
5. Fore-casting
6. Design
7. Fixation of priorities
8. Implementation
9. Review, evaluation and feedback

MULTILEVEL PLANNING IN INDIA

The concept of multi level planning incorporates the principle that proper decision making is possible at any level if the strategy at each level is determined after a careful consideration of the potentials, needs and limitation at the next higher as well as the next lower levels of planning
Multi level planning is two-way approach, requiring many preparatory efforts from both ends. The higher level gives macro framework indicators and guideline for planning. The lower levels must feed the higher level with information and has to prepare from below. The various processes involved in multi-level planning are

- Determination of approach levels of decision making with reference to various activities
- Organizing interaction between different levels in terms of exchange of information and interactive consultations of different stages of plan formulation and appraisal
- 'Nesting of plans' at different levels and integrating them into a unified frame work. Nesting implies securing both the balances within the plans drawn up for different levels and also their harmonization. Securing integration within plans at different levels implies achieving balance at three levels i.e. sectoral, spatial and operational

COMPREHENSIVE COMMUNITY PLANNING

The purpose of community planning is to anticipate the physical environment that will best serve the needs of the people living and working in an urban area, and then to make plans for achieving this environment. It is continuing process of developing a comprehensive programme to guide urban growth and renewal. There are six minimum planning requirements, which are backbone of any programme.

1. *The Land use plan*
2. *The thoroughfare plan*
3. *The community facilities plan*
4. *The public Improvement programme*
5. *The zoning ordinance and map*
6. *The subdivision regulations*

CENTRAL PLACE THEORY by CHRISTELLER Comprehensive approach of the system

Basic elements are

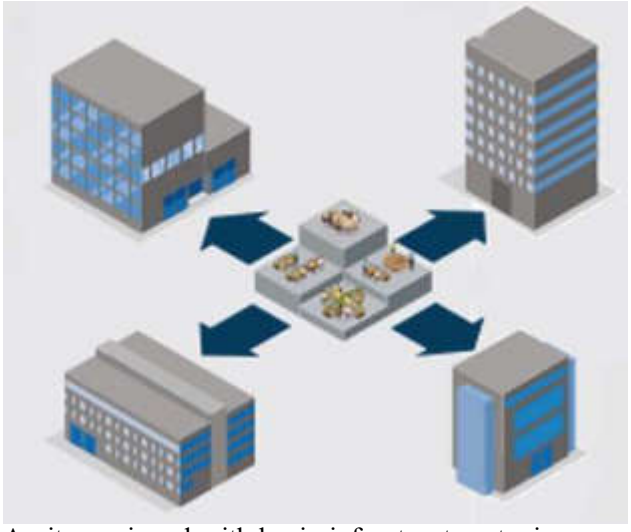
A central good
A central place
A complimentary region

1. A region can be served by goods of various types if central places producing different ranges of goods are evenly distributed

Smart Cities in India

The concept of Smart City to public came after PM Modi had announced his vision to set up 100 smart cities across the country soon after his government was sworn into power mid last year. Since then a race has been on among cities to land on the list that the ministry of urban development is compiling. The 100 smart cities mission intends to promote adoption of smart solutions for efficient use of available assets, resources and infrastructure. Following are illustrations show how the concept of smart city has evolved:
(Source: http://timesofindia.indiatimes.com/what -is-a-smart-city-and-how-it-will-work/listshow/47128930.cms)

1..What is a smart city



A city equipped with basic infrastructure togive a decent quality of life, a clean and sustainable environment through application of some smart solutions.

2.. Basic infrastructure

Assured water and electricity supply, sanitation and solid waste management, efficient urban mobility and public transport, robust IT connectivity, e-governance and citizen participation, safety and security of citizens.

3.. Smart solutions

Public information, grievance redressal, electronic service delivery, citizens' engagement, waste to energy & fuel, waste to compost, 100% treatment of waste water, smart meters & management, monitoring water quality, renewable source of energy, efficient energy and green building, smart parking, intelligent traffic management system.

4.. What's the next step?

The next step is identification of the 100 cities and for this a city challenge competition to be conducted by Bloomberg Philanthropies is envisaged. The current plan looks to select 20 cities this year followed by 40 each in the next two years.

5.. Smart Cities Council India has been formed

It is part of the US-based Smart Cities Council, which is a consortium of smart city practitioners and experts, with a 100-plus member and advisor organizations operating in over 140 countries.

6.. All states willget at least one smart city

A Special Purpose Vehicle will be created for each city to implement Smart City action plan. The SPV will be signed with the urban local body, state government and the Centre for implementation of the project.

7.. How it will work

After government announces the guidelines, states will be asked to nominate names of cities for a 'City Challenge Competition' and the chosen ones will get Central fund of Rs 100 crore each year for 5 years.

8.. The basic criteria for selection of a city/municipal area

9.. Area-based development

1. **Retrofitting 500 acres:** Planning in an existing built-up area in a municipal ward, preparing plan with citizen participation (example: Connaught Place in Delhi, Bhendi Bazar in Mumbai).
2. **Greenfield 250 acres:** Introduce smart solutions in a vacant area using innovative planning (example: land pooling/land reconstitution in Oute r Delhi, GIFT city in Gujarat).
3. **Redevelopement 50 acres:** Replacement of existing built-up area and preparing a new layout plan with enhanced infrastructure by way of mixed land use (example: Kidwai Nagar in Delhi).

Eco City

The term 'eco-cities' is synonymous with urban areas that, at scale, promote environmental preservation. However, decorating cities with boulevards and green buildings, as well as adopting energy- and waste-efficient technologies, are merely small parts of the modern eco-city.

The concept of making cities environmentally sustainable is nothing new. In Europe and the US, the Garden City movement of the 1890s and the post-World War II New Town phenomenon were based on the idea of creating urban areas that merged contemporary and spacious housing with modern infrastructure and greenery. Both were seen as attempts to reinvent the city in the post-industrial era.

The term 'eco-city' surfaced in the 1970s, when a US-based movement known as Urban Ecology first used it. Founded in California, the group launched the journal, The Urban Ecologist. "An eco-city is an ecologically healthy city. That also means the city design is strongly informed by knowledge of ecology and its design principles,"

Image: *One of the principles of eco-cities is a modal shift of private car usage to public transportation. Promoting cycling for short-distance trips can help to encourage that shift.*
Image © Dylan Passmore.

However, many claim the term today depicts a city that adheres to the three core pillars of sustainability: environmental stewardship, social equality and economic prosperity.

Today we know much more about designing and building eco-cities than we did in the 1990s. At that time sustainability was more or less about being environmentally sustainable. Today, however, sustainability is much more recognised and mainstream."

"We have come to recognise that sustainability has three dimensions: environment and resources; social and cultural cohesion; and economic and financial dimension. We have also realised that we should aim for creating cities for people – cities that are designed and built for the human scale and are vibrant," he adds.

Eco-cities come in all shapes and sizes. Research conducted in 2011 by the International Eco-Cities Initiative claims there are more than 170 such places globally, with this number set to rise over the next decade. Furthermore, the size, scale and types of eco-cities vary widely. In the developing world, for instance, purpose-built eco-cities are being built at breakneck pace, whereas in the West, urban regeneration is more common.

"Greenfield development and retrofitting both have their advantages and disadvantages. In the developed world of Europe, the US and Japan, greenfield is becoming rarer, so in these regions it is more about retrofitting. In the developing world of Asia and Latin America, greenfield development is happening in many places,".

The urbanist names the IBA Hamburg project in Germany and Masdar City in the UAE. It is said that the former exemplifies a hybrid model that mixes retrofitting with building on new land, while the latter demonstrates the ability to build a sustainable city in a harsh desert climate

Drivers of today's eco-cities

It is widely accepted among urbanists that in order to be referred to as an eco-city, cities must embrace the three core pillars of sustainability.

However, behind these principals, a host of other factors influence the modern eco-city. Affordability and demand on the parts of the general public and government policymakers are two notable factors, as are energy-and resource-efficiency and land conservation.

"People want eco-cities only if they can choose freely and can afford to pay for them. Wise politicians and business people listen to their constituents and clientele, and strive to deliver what the people want. As energy prices go up eco-cities will become more competitive. In addition, land scarcity is also driving up prices on building rights, making the densification process unavoidable," .

2. Shopping facilities

Level of shopping	Population served	No. of shops per 1000 persons	Average area per shop in sq.m.	Area of influence in km.
Neighbourhood and convenience centre	3000 - 20,000	3	10 - 15	0.5 - 0.75
Community centre (district level)	50,000 - 75,000	2 - 3	20	1.5 - 3
City centre	1,50,000 & above	3 -4	25	Entire city
Total for the city	Entire city	8 - 10	20	Entire city

3. Parks, playgrounds and open spaces

Category	Population per unit	Area in hectares
Tot - lot	500	0.05
Children's park	2,000	0.2
Neighbourhood playground	1,000	0.2
Neighbourhood park	5,000	0.8
District park	25,000	5.0
Regional park	1,00,000	40.0
Crematorium	5,00,000	0.2
Burial ground	10,000	0.4
Total area required for parks, playgrounds and open spaces	1,000	1.5

4. Water supply consumption

Population range	Break up per capita consumption in litres per day					
	Domestic use	Public use	Ind. and commerce	Agriculture	Waste	Total
Less than 1000	25	---	---	---	---	25
1,000 to 5,000	45	10	5	---	10	70
5,000 to 20,000	45	10	15	15	10	95
20,000 to 50,000	45	35	15	10	10	115
50,000 to 2,00,000	70 - 90	45 -65	20	10	20	165
Above 2,00,000	---	---	---	---	---	165 - 300

5. Desirable land use pattern (percentage)

Particulars	Population range		
	1,50,000 and above	50,000 to 1,50,000	Less than 50,000
Residential	40	45	50
Industrial	8	7	6
Commercial	3.5	3	3
Parks, playgrounds and open spaces	10	10	8
Transportation and communication	24	22	22
Public and semi-public	10	9	8
Others	4.5	4	3
Total	100	100	100

HISTORY & ARCHITECTURE

By
Faculty of Architecture

GATE ARCHITECTURE
2020

gatearchitecture.com

Introduction

This is a part of GATE ARCHITECTURE 2018complete set. It covers the topic onhistory & architecture.
The section on history of architecture plays a significant role in scoring a good marks and so this dedicated section is included. It has three broad topics. Indian history of architecture, world history of architecture & contribution of architects & planners. If you remember of the compilation of Sir Banister Fletcher, you mayaware that how vast this topic is itself. Here we have tailored the coverage to the syllabus and questions asked in GATE exams in past years. The topics that are extensively covered through the Question Bank, are escaped here. However, some common topics are discussed here to complement the syllabus.

Contents

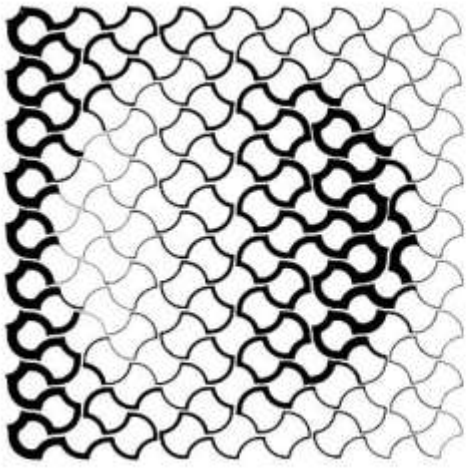
Elements & Principles of Art Design

Elements of design are the parts. They structure and carry the work.
Principles of design are concepts. They affect content and message.

Elements of Design: Line, Form, Space, Texture , Shape, Color, Value
Principles of Design: Emphasis, Movement, Unity, Rhythm, Contrast, Variety

Order and Composition

Composition is the organization of the elements of design into a unified whole. "It is the organization of the whole out of its parts - the conception of single elements, the interrelating of these elements, and the relating of them to the total form. It means 'putting together', and can apply to any work of art, from music to writing to architecture, that is arranged or put together using conscious thought."



It basically refers to the placement or arrangement of conceptual elements (point, line, plane, volume, form, shape, space) and visual elements (color, texture, size and shape) in a work of art according to some (consciously or unconsciously used) compositional principles. "In the visual arts, composition is often used interchangeably with various terms such as design, form, visual ordering, or formal structure, depending on the context."

In architectural design, the architect creates an ordered expression through the process of composition by using the raw materials of architectural form, which are basically the mass and the space. In this process, the material forms (masses) and spaces are arranged into the final composition, of the definitive design. At this stage each element ends up in its proper place according to the principles of composition. Without this ordering process the result would be chaos. The method of ordering and the concept employed ultimately dictate the character, appearance and style of a design."

Frank Lloyd Wright, Johnson and Wax Building

Some compositional principles might be used (such as unity, balance, hierarchy, scale, dominance, similarity, contrast, rhythm, repetition, symmetry) to create this order. The way the formal and spatial elements are arranged though these principles creates the order of composition in architecture.

These organizational principles of composition are like the grammar of a language. The use of these principles over the visual and conceptual elements of design is like using a visual grammar. It is like speaking and writing in the language of architectural design. Visual and conceptual elements are the materials (words) of design and the principles are the ways to work with and arrange the elements (grammar). However it is also truethat there is not such a thing that these principles should be obeyed.

Principles of visual composition

1. Important factor to be considered in Urban Design – Arrangement of spaces
   Good composition
   Orderly and pleasing
   Pleasure follows order
2. principles of composition –

Unity –

- Oneness and brings harmony with the surroundings.
- Similar forms give coherence to the parts and integrity to the whole.
- An urban form so planned and created will create a single picture of unity.
- Dissimilar forms, texture, color lack unity.

Segregation –

- Composition should form an independent unit by separating from others by enclosing masses.
- It can be made up neutral forms, average textures or subdued colors of building masses.

Coherence –

- Complicated compositions lack coherence.
- Too many sorts of buildings, elements, and accessories result in lack of coherence.

Balance –

- **Symmetrical balance – Balance** means equality and it can be easily obtained by symmetrical type of plants or features on either side of the central axis of composition. Balance should be dynamic, vital hence it should be rhythmic.
- **Asymmetrical or Occult balance –** Too unequal masses on either side of the central axis form asymmetrical balance. Meticulously arranged occult balance adds softness and freedom to the composition.

Scale –

- The building or group of buildings must be in scale with its surroundings.
- The parts of the composition in relation to each other should exhibit their true size.

Rhythm and reputation –

- It is a devise to give continuity to the design.
- It develops rhythmic sequence producing a coherent effect.
- Use distinctive elements for a rhythmic arrangement (columns, openings like windows), to hold together and carry the eye from part to the other.

Color –

- Select paints for long color effects.
- A feeling of coherence in design is achieved by color as well or by simple repetition of the same color at regular intervals.

Texture –

- It is the surface quality which give a textile sensation when touched, such as soft cum ha rd, smooth, rough etc.,
- Sandstone – course.
- Marble – translucent and soft

Light and Shade –

- Occasional Shades cast by large openings produce a pictorial effect.
- Columns and arcades throw shadows in the morning and evening producing a constant change of li ght and shade.
- Quality of color also changes according to the intensity of light.

3. Visual aspect of plan arrangement –
   - View: is a scene observed from a given place.
   - Vista: is a confined view to a dominant feature. Each vista has a viewing station. A wel conceived vista has the balance and rhythm.
   - Axis: is a linear element connecting two or more elements such as a drive, a street or a park way. It is directional, orderly, dominating.

4. Color theory –

Primary hues - RED, YELLOW, BLUE
Complementary colors: Red and Green
Harmonizing colors – hues adjacent on the color wheel.
Hue – (first dimension), by definition it is pure color, containing no white, black or grey.

Timeline: Indian History of Architecture

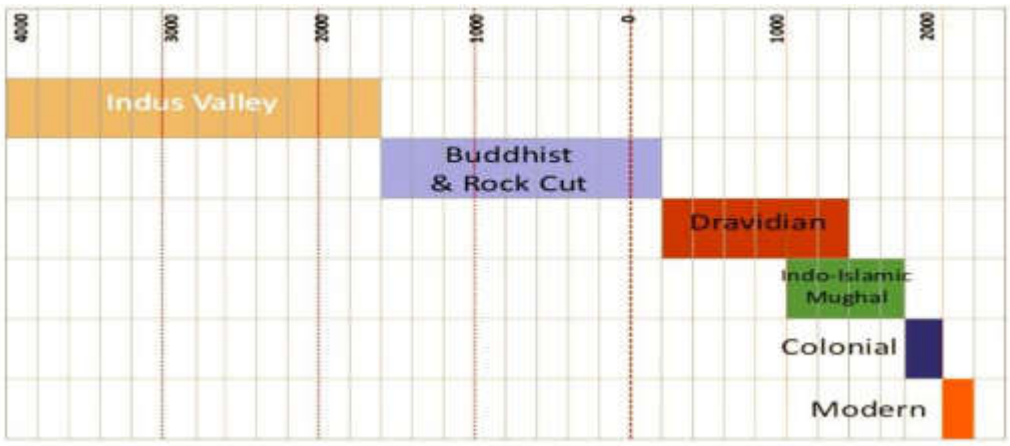


Figure: Architecture timeline

Indus Valley Civilization

Introduction

- A bronze age civilization- Also known as harappan civilization (2600-1900 BC)
- Thrived in the basins of Indus river profiting from the fertility of the land
- Had a population of 5 million at its peak
- People were mostly tradesmen or artisans
- Known for
  - futuristic urban planning
  - astonishing architecture
  - remarkable handicrafts
  - work in the field of metallurgy

Figure: Excavations at Mohenjo-Daro

Regional Spread

Figure: Spread of Indus Valley Civilization

- Sites cover most of the modern Pakistan and northwestern India
- Area covered is about 1.3 million square miles
- The largest among the old world civilizations
- Over 1050 sites; scattered across the area.

Architecture

- The cities are build on numerous mounds (elevated grounds)
- Advanced architecture
  - Impressive dockyards
  - Graineries
  - Warehouses
- Walled city (protection from flood water)
- Well planned streets
- Proper sanitation and drainage system
- Baked brick houses

Figure: The drain

Mahabodhi Temple, Bodh Gaya, Bihar

Figure: Mahabodhi Temple, Bodh Gaya .

The magnificient **Maha Bodhi temple** in Bodhgaya is an architectural amalgamation of many cultures. Originally believed to be small shrine erected by Emperor Asoka in the 3rd century B.C, temple was later restored in the 11th and 18th centuries. The temple bears the stamp of the architecture of the Gupta Dynasty and subsequent ages. On the walls of the temple, one sees Buddha carved in different aspects, and in the sanctum sanctorum, a colossal Buddha, is seen touching the ground, which has mythological significance in the Buddhist lores. The temple has a 54 meters high pyramidical spire and an ornamental arch way at the entrance. The temple carries inscriptions recording the visits of pilgrims from Sri Lanka, China and Mayanmar in the 7th and 10th Centuries A.D. Hieun Tsang, the Chinese traveller, also visited the temple in the 7th Century.

The Mahabodhi temple has a 150 feet high tower, and it contains a gilded image of Buddha. The original shrine here is believed to have been raised by Emperor Ashoka. The temple has a beautiful stone railing around it. Depicted on the walls of the temple are scenes from Buddha's life. A museum in the vicinity has gold, bronze and stone images of Buddha.

Figure: Mahabodhi Temple Inside Picture

The Vajrasana-platform where Buddha performed his penance is located below the Bodhi tree, and this spot is described as the center of the Universe. The spots where he spent seven weeks have seven shrines, built by devout Buddhists from several countries.

Several Buddhist relics have been unearthed in this area. Other places of interest here include the Tibetian, Japanese and Burmese monasteries. The Tibetian monastery houses the massive Dharma Chakra or the wheel of law. Millions visit Buddha Gaya from all over the world.

The basement of the present temple is 15m square, 15m in length as well as in breadth andts height is 52m which rises in the form of a slender pyramid tapering off from a square platform. On its four corners four towers gracefully rise to some height. The whole architectural plan gives pose and balance to the observers.

Inside the temple there is a colossal image of the Buddha in the "touching the ground pose", bhumisparsha mudra. This image is said to be 1700 years old and is facing east exactly at the place where the Buddha in meditation with his back to the Bodhi tree was enlightened.

Figure: The Bodhi Tree of Mahabodhi Temple

Bodhi Tree

The original **'Bodhi tree'** or Pipal (Ficus religiosa) - the tree of awakening; was said to have been destroyed by Mauryan emperor

Modern Architecture In India

No doubt we have a great architectural heritage of temples, mosques, palaces and forts. So much so that whenever architecture is thought of in conjunction with India, images of the Taj Mahal, Fatehpur Sikri and South Indian temples are conjured up in our minds.

Do we have anything today as representative of Modern Architecture which could be compared with our old buildings? Or in even simpler terms - 'what represents Modern Architecture in India'?

The question which is difficult to answer - demands more than skin deep analysis of modern architecture in the context of India.

The answer to this question also depends on the spirit behind it. If the curiosity behind the question concerns the quantum of construction done in post -independence years, the answer can be one impressive list of statistical figures, a fine achievement for building science and technology.

But, if on the other hand the questioning mind is concerned about new architectural and planning thought generated in the same post-independence years, which have resulted in buildings and cities suited to our socio-economic, cultural and climatical circumstances, our achievements are not very impressive so far. But considering the fact that formation of thoughts and ideas, in this relatively young field, has been going for only the last quarter of century and with the limited resources that we have, it is evident that we are on the verge of making a breakthrough.

Figure: **Chhatrapati Shivaji Terminus, formerly Victoria Terminus, is a UNESCO World Heritage Site and historic railway station which serves as the headquarters of the Central Railways in Mumbai.**

It is not out of context here to go into details how things have been happening in the field of architecture in years preceeding the following independence.

Architecture traditionally, i.e., before the arrival of British on the Indian soil, was from the social point of view, a creation of spectacular sculptural forms hewn out of stone. Architectural material was stone; tools, chisel and hammer, and the aim was glorification. In contrast, the every-day needs of a common man were ruthlessly neglected. Then the British arrived on the scene, it was through them that the first introduction to elementary modern building construction and planning was introduced into India. Their aim, however, was to house their organisations, and their people and whatever was necessary to control an empire as big as India. Apart from self-serving military cantonments and civil lines, they also left the basic problems well alone. It was no intention of the British to educate Indians in the art and science of architecture. Consequently Indian minds, during the British reign, were completely out of touch with the progressive thinking taking place in the rest of the world. The most significant architectural phenomenon that took place during the first half of this century in this country was building of Imperial Delhi. This was an anachronism of the highest order, because, while at that time contemporary Europeans were engaged in most progressive thinking in architecture, Sir Edward Lutyen's was a masterpiece in high renaissance architecture, the result of a way of thinking typical of the early nineteenth century in Europe. It is interesting to note that at the same time as the construction of Delhi, Europe was having "Heroic period of modern architecture" in such schools of thought as "Bauhaus".

Independence woke us to a changed situation. "Time had moved on. In place of religion or royal concern with architectural immortality, this situation demanded attention to those problems that had so far been ruthlessly neglected. The ordinary man, his environment and needs became the centre of attention. Demand for low cost housing became urgent.

URBAN PLANNING & DESIGN

GATE ARCHITECTURE 2020

By
Faculty of Architecture

gatearchitecture.com

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Section 6: Urban Planning and Housing Planning process; Types of plans - Master Plan, City Development Plan, Structure Plan, Zonal Plan, Action Area Plan, Town Planning Scheme, Regional Plan; Salient concepts, theories and principles of urban planning; Sustainable urban development; Emerging concepts of cities - Eco-City, Smart City, Transit Oriented Development (TOD), SEZ, SRZ etc.

City Planning

Housing; Concepts, principles and examples of neighbourhood; Housing typologies; Slums; Affordable Housing; Housing for special areas and needs; Residential densities; Standards for housing and community facilities; National Housing Policies, Programs and Schemes

Urban Design

What is urban design?

Unfortunately, there are no hard and fast rules related to urban design. A structural beam in a building must meet certain requirements for that building to stand. A road must be built in a certain way to avoid future potholes.

Urban design, however, is not a series of rulesand standards. Rather, it is a group of concepts that, once understood, can lead to a fresh way of perceiving streets, buildings, and spaces-- and insights into why certain places are appealing and others are not. With urban design concepts in mind you should be able to better question architectural presentations and consider the impact of development proposals on your town's character.

Introduction to urban design

When walking down the street you see a place that appears interesting and inviting. Across the street you glance at another area but it looks unappealing and uncomfortable. Which place would you rather be? That's easy to answer. The more difficult question is: Why? What is it that creates a place that people like and use? Understanding some ofthe ideas of urban design can help us better answer this question. Urban design does not have to be a mystery. Knowing a few important concepts can make it easier for you to observe what works– and what doesn't – as you stroll through your town, or as you review a project application.

Urban design is concerned with the arrangement, appearance and function of our suburbs, towns and cities. It is both a process and an outcome of creating localities in which people live, engage with each other, and engage with the physical place around them.

Urban design involves many different disciplines including planning, development, architecture, landscape architecture, engineering, economics, law and finance, among others.

We can also say, Urban design is the art of making places for people. It includes the way places work and matters such as community safety, as well as how they look. Itconcerns the connections between people and places, movement and urban form, nature and the built fabric, and the processes for ensuring successful villages, towns and cities.

Urban design operates at many scales, from the macro scale of the urban structure (planning, zoning, transport and infrastructure networks) to the micro scale of street furniture and lighting. When fully integratedinto policy and planning systems, urban design can be used to inform land use planning, infrastructure, built form and even the socio-demographic mix of a place.

	Architecture	**Urban Design**	**Urban Planning**
Scale	Individual building	Space between buildings: Street, park, transit shop	Whole neighborhood, districts & cities
Orientation	Aesthetic and functional	Aesthetic and functional	Unity
Treatment of space	2D & 3D	3D	Predominantly 2D
Time frame	No definite time frame	Short Term (< 5 years)	Long term (5 to 20 years)

Concepts of urban design

Key urban design concepts are:

- Physical comfort
- Circulation and accessibility
- Transitions and boundaries
- The connection between street and building
- Scale
- Detail, variety, and complexity
- Cohesiveness

Figure: **Physical Comfort:** A Market Street is designed to offer places to sit

Physical Comfort

Physical comfort is the basic concept in urban design for people to feel comfortable in a public place. There are basic needs like a good walking surface and some garbage bins, but a good environment also offers places to sit, some shade on a hot day, shelter from the rain, readily accessible public toilets, and decent lighting at night. It is also possible to physically design areas in a way that may help to deter crime.

Circulation and Accessibility

There should be a peaceful coexistence between the pedestrian and the car. Comprehending and feeling comfortable in the urban environment means that separation between pedestrian use, driving lanes, and parking must be easy to see and interpret. In many developments it will be important to reassert the priority of the pedestrian when looking at circulation.

Figure: **Circulation and Accessibility:** Providing an adequate buffer strip and sidewalks can help people walkthrough easily.

Transitions and Boundaries

Most people feel a deep need to know where one neighborhood or district ends and another begins. A logical world with good spatial definition orients us and gives us information to help us make decisions about where to go and what to do. Elements such as the shape of buildings, doorway design, paving materials, curbs, landscaping, street furniture, changes in the elevation of the ground, and signage let us know where one category of uses gives way to another. The transitions and boundaries of the urban world tell us when we enter and leave the town, what is public and what is someone's private space, where to sit and meet people, where to stroll, where to shop, and where to drive or park. Using urban design to clearly show these transitions and boundaries can be the difference between comfort and confusion; and between feeling invited and feeling unwelcome.

Figure: **Transitions and Boundaries**: these can be effective in helping orient visitors where to go. Better with signage.

Figure: **Scale:** The varied rhythm of storefronts in towns helps establish a pedestrian-oriented scale.

PLANNING PROCESS:

All stages of actions from defining the objectives till implementation and review of any planning project in the planning process. In plan preparation, the physical planning should associate with the socio-economical, geographical, political factors, for achieving the objective in desired direction.
The various stages of planning process is as follows:

1. Identification and definition of problems
2. Defining the objectives
3. Studies and survey
4. Analysis of data and preparation of study maps
5. Fore-casting
6. Design
7. Fixation of priorities
8. Implementation
9. Review, evaluation and feedback

MULTILEVEL PLANNING IN INDIA

The concept of multi level planning incorporates the principle that proper decision making is possible at any level if the strategy at each level is determined after a careful consideration of the potentials, needs and limitation at the next higher as well as the next lower levels of planning
Multi level planning is two-way approach, requiring many preparatory efforts from both ends. The higher level gives macro framework indicators and guideline for planning. The lower levels must feed the higher level with information and has to prepare from below. The various processes involved in multi-level planning are

- Determination of approach levels of decision making with reference to various activities
- Organizing interaction between different levels in terms of exchange of information and interactive consultations of different stages of plan formulation and appraisal
- 'Nesting of plans' at different levels and integrating them into a unified frame work. Nesting implies securing both the balances within the plans drawn up for different levels and also their harmonization. Securing integration within plans at different levels implies achieving balance at three levels i.e. sectoral, spatial and operational

COMPREHENSIVE COMMUNITY PLANNING

The purpose of community planning is to anticipate the physical environment that will best serve the needs of the people living and working in an urban area, and then to make plans for achieving this environment. It is continuing process of developing a comprehensive programme to guide urban growth and renewal. There are six minimum planning requirements, which are backbone of any programme.

1. *The Land use plan*
2. *The thoroughfare plan*
3. *The community facilities plan*
4. *The public Improvement programme*
5. *The zoning ordinance and map*
6. *The subdivision regulations*

CENTRAL PLACE THEORY by CHRISTELLER Comprehensive approach of the system

Basic elements are

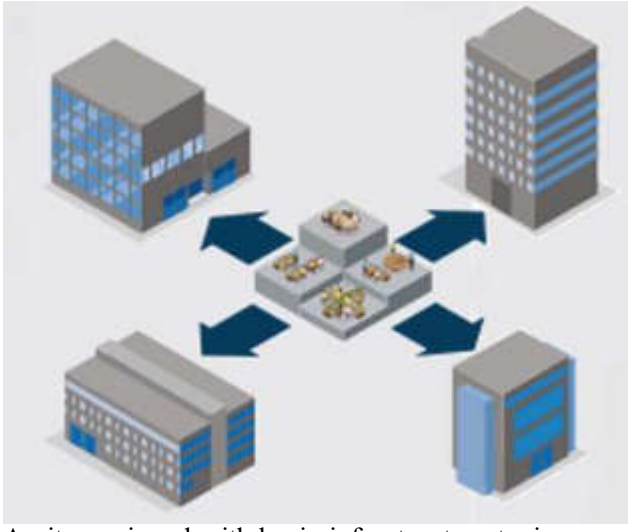
A central good
A central place
A complimentary region

1. A region can be served by goods of various types if central places producing different ranges of goods are evenly distributed

Smart Cities in India

The concept of Smart City to public came after PM Modi had announced his vision to set up 100 smart cities across the country soon after his government was sworn into power mid last year. Since then a race has been on among cities to land on the list that the ministry of urban development is compiling. The 100 smart cities mission intends to promote adoption of smart solutions for efficient use of available assets, resources and infrastructure. Following are illustrations show how the concept of smart city has evolved:
(Source: http://timesofindia.indiatimes.com/what -is-a-smart-city-and-how-it-will-work/listshow/47128930.cms)

1..What is a smart city



A city equipped with basic infrastructure togive a decent quality of life, a clean and sustainable environment through application of some smart solutions.

2.. Basic infrastructure

Assured water and electricity supply, sanitation and solid waste management, efficient urban mobility and public transport, robust IT connectivity, e-governance and citizen participation, safety and security of citizens.

3.. Smart solutions

Public information, grievance redressal, electronic service delivery, citizens' engagement, waste to energy & fuel, waste to compost, 100% treatment of waste water, smart meters & management, monitoring water quality, renewable source of energy, efficient energy and green building, smart parking, intelligent traffic management system.

4.. What's the next step?

The next step is identification of the 100 cities and for this a city challenge competition to be conducted by Bloomberg Philanthropies is envisaged. The current plan looks to select 20 cities this year followed by 40 each in the next two years.

5.. Smart Cities Council India has been formed

It is part of the US-based Smart Cities Council, which is a consortium of smart city practitioners and experts, with a 100-plus member and advisor organizations operating in over 140 countries.

6.. All states willget at least one smart city

A Special Purpose Vehicle will be created for each city to implement Smart City action plan. The SPV will be signed with the urban local body, state government and the Centre for implementation of the project.

7.. How it will work

After government announces the guidelines, states will be asked to nominate names of cities for a 'City Challenge Competition' and the chosen ones will get Central fund of Rs 100 crore each year for 5 years.

8.. The basic criteria for selection of a city/municipal area

9.. Area-based development

1. **Retrofitting 500 acres:** Planning in an existing built-up area in a municipal ward, preparing plan with citizen participation (example: Connaught Place in Delhi, Bhendi Bazar in Mumbai).
2. **Greenfield 250 acres:** Introduce smart solutions in a vacant area using innovative planning (example: land pooling/land reconstitution in Oute r Delhi, GIFT city in Gujarat).
3. **Redevelopement 50 acres:** Replacement of existing built-up area and preparing a new layout plan with enhanced infrastructure by way of mixed land use (example: Kidwai Nagar in Delhi).

Eco City

The term 'eco-cities' is synonymous with urban areas that, at scale, promote environmental preservation. However, decorating cities with boulevards and green buildings, as well as adopting energy- and waste-efficient technologies, are merely small parts of the modern eco-city.

The concept of making cities environmentally sustainable is nothing new. In Europe and the US, the Garden City movement of the 1890s and the post-World War II New Town phenomenon were based on the idea of creating urban areas that merged contemporary and spacious housing with modern infrastructure and greenery. Both were seen as attempts to reinvent the city in the post-industrial era.

The term 'eco-city' surfaced in the 1970s, when a US-based movement known as Urban Ecology first used it. Founded in California, the group launched the journal, The Urban Ecologist. "An eco-city is an ecologically healthy city. That also means the city design is strongly informed by knowledge of ecology and its design principles,"

Image: *One of the principles of eco-cities is a modal shift of private car usage to public transportation. Promoting cycling for short-distance trips can help to encourage that shift.*
Image © Dylan Passmore.

However, many claim the term today depicts a city that adheres to the three core pillars of sustainability: environmental stewardship, social equality and economic prosperity.

Today we know much more about designing and building eco-cities than we did in the 1990s. At that time sustainability was more or less about being environmentally sustainable. Today, however, sustainability is much more recognised and mainstream."

"We have come to recognise that sustainability has three dimensions: environment and resources; social and cultural cohesion; and economic and financial dimension. We have also realised that we should aim for creating cities for people – cities that are designed and built for the human scale and are vibrant," he adds.

Eco-cities come in all shapes and sizes. Research conducted in 2011 by the International Eco-Cities Initiative claims there are more than 170 such places globally, with this number set to rise over the next decade. Furthermore, the size, scale and types of eco-cities vary widely. In the developing world, for instance, purpose-built eco-cities are being built at breakneck pace, whereas in the West, urban regeneration is more common.

"Greenfield development and retrofitting both have their advantages and disadvantages. In the developed world of Europe, the US and Japan, greenfield is becoming rarer, so in these regions it is more about retrofitting. In the developing world of Asia and Latin America, greenfield development is happening in many places,".

The urbanist names the IBA Hamburg project in Germany and Masdar City in the UAE. It is said that the former exemplifies a hybrid model that mixes retrofitting with building on new land, while the latter demonstrates the ability to build a sustainable city in a harsh desert climate

Drivers of today's eco-cities

It is widely accepted among urbanists that in order to be referred to as an eco-city, cities must embrace the three core pillars of sustainability.

However, behind these principals, a host of other factors influence the modern eco-city. Affordability and demand on the parts of the general public and government policymakers are two notable factors, as are energy-and resource-efficiency and land conservation.

"People want eco-cities only if they can choose freely and can afford to pay for them. Wise politicians and business people listen to their constituents and clientele, and strive to deliver what the people want. As energy prices go up eco-cities will become more competitive. In addition, land scarcity is also driving up prices on building rights, making the densification process unavoidable," .

2. Shopping facilities

Level of shopping	Population served	No. of shops per 1000 persons	Average area per shop in sq.m.	Area of influence in km.
Neighbourhood and convenience centre	3000 - 20,000	3	10 - 15	0.5 - 0.75
Community centre (district level)	50,000 - 75,000	2 - 3	20	1.5 - 3
City centre	1,50,000 & above	3 -4	25	Entire city
Total for the city	Entire city	8 - 10	20	Entire city

3. Parks, playgrounds and open spaces

Category	Population per unit	Area in hectares
Tot - lot	500	0.05
Children's park	2,000	0.2
Neighbourhood playground	1,000	0.2
Neighbourhood park	5,000	0.8
District park	25,000	5.0
Regional park	1,00,000	40.0
Crematorium	5,00,000	0.2
Burial ground	10,000	0.4
Total area required for parks, playgrounds and open spaces	1,000	1.5

4. Water supply consumption

Population range	Break up per capita consumption in litres per day					
	Domestic use	Public use	Ind. and commerce	Agriculture	Waste	Total
Less than 1000	25	---	---	---	---	25
1,000 to 5,000	45	10	5	---	10	70
5,000 to 20,000	45	10	15	15	10	95
20,000 to 50,000	45	35	15	10	10	115
50,000 to 2,00,000	70 - 90	45 -65	20	10	20	165
Above 2,00,000	---	---	---	---	---	165 - 300

5. Desirable land use pattern (percentage)

Particulars	Population range		
	1,50,000 and above	50,000 to 1,50,000	Less than 50,000
Residential	40	45	50
Industrial	8	7	6
Commercial	3.5	3	3
Parks, playgrounds and open spaces	10	10	8
Transportation and communication	24	22	22
Public and semi-public	10	9	8
Others	4.5	4	3
Total	100	100	100

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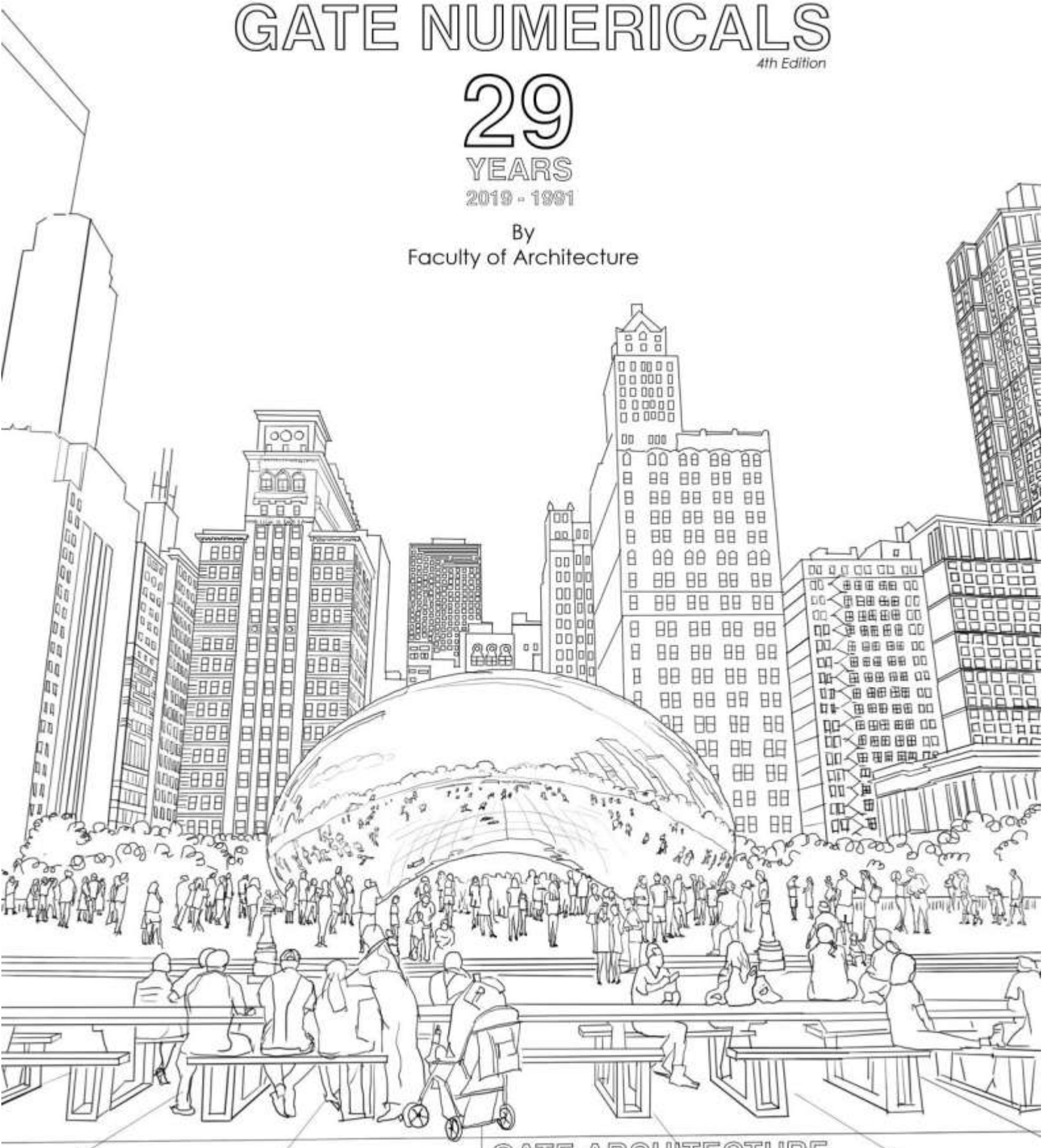

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Preface

If you have already prepared for the exam, this book would be fruitful to you. This book is m eant for last stage of preparation and add an edge to your preparation by reviewing sets of numerical questions asked in previous years. In past few years, the pattern of numerical question has changed. It is observed that upto 40% marks are of numerical questions. There would be approx. 7 numerical question of 1 or 2 marks of which no option would be given. You have to answer the question by using keypad displayed on the screen. (Use of keyboard is prohibited. Touching any key would lock your monitor screen and you may not able to answer any further question!)

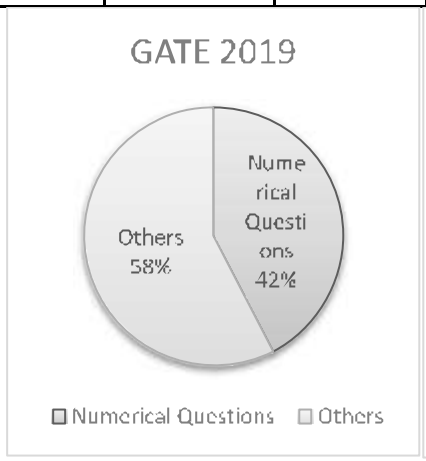
So, for such question pattern, you need through practice. We are hopeful that this book would meet the requirement.

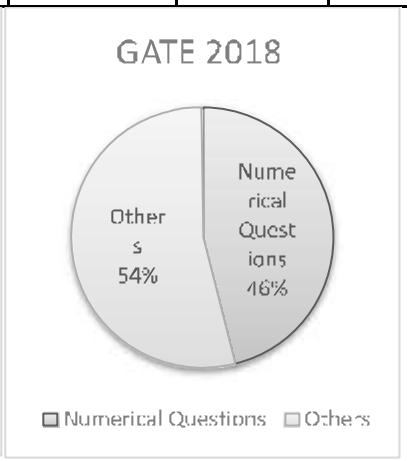
Answering an objective question has its own rule to follow when you have a doubt in choosing the right answer. For so, we have also attached expert opinion for handling objective question well.

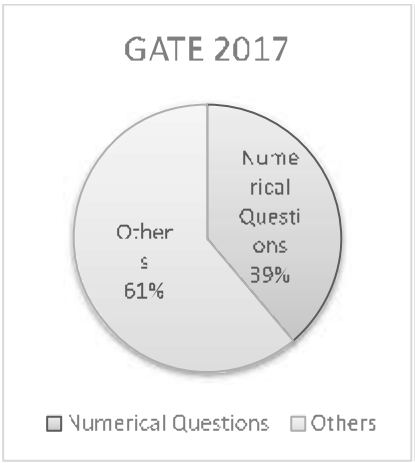
In this book, we have also provided basics of theories which are very essential before you solve a question.

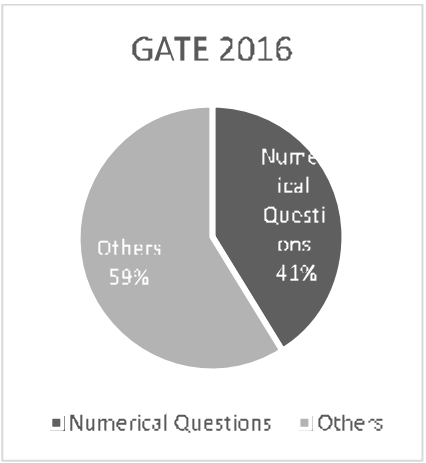
(GATE 2016 AR trend):

No. of students applied (Approx.)	No. of students appeared (Approx.)	No. of students qualified	Highest marks obtained	Lowest mark obtained	Cut-off Mark	Average marks obtained	Standard deviation
6300	5900	1240	75.67	26.00	38.90	43.37	8.32









Most of the questions has been solved. You are always welcome for your valuable suggestion and feedback about this book. If you find better contents or alternative solution, send us to gatearchitecture@gmail.com

We may add contents or solution by you in next reprint or edition!

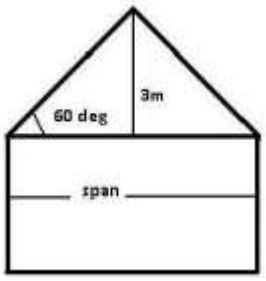
We wish you all the best for GATE 2020.

Tips & Tricks

Followings are tips & tricks for handling multiple choice questions suggested by experts from open source online resources. Please note that following insights are not only for Numerical Questions b ut also for all topics. Some of following are for paper bound exam (not online). You should skip those.

Tips for solving numerical problems:

- **Drawing the picture of theproblem** is very important! The correct picture of a numerical problem is more than 80 % of success.

  Example (GATE 2013): If the slope of a hipped roof is 60º and height of the roof is 3 m, span of the room, in m, would be _____
  Solution: Span of the room = 2 * (3/tan60 º) = 3.46 answer.

- **Having the same units for all variables in the proble m**. You must ensure that you solve the problem in the same unit. For example, in a given question, force may be given 40 Newton (N) and length of the beam would be *l*= 50 centimetre. For easy and correct solution, you should change the length in meter (*l*= 0.5m). Tip: If the option is given as follows: (A) 50Pa (B) 5Pa (C) 10Pa (D) 100Pa. For this type of question, you must recheck your solution before you choose an answer.

- **Checking the dimensionality of analytical expressions**. To arrive at correct answer, you should always write the numerical value with it's unit.

  Example: Area of tense steel per meter width of a reinforced concrete slab is 335 sq mm. If 8 mm rods are used as reinforcement, then centre to centre spacing of the reinforcement in mm is

  Solution: Total area of steel is 335 sq mm. (which is spread in 1m of width)
  Area of 8 mm rod = Πr^2 = 3.14 x 4mm x 4mm = 50.24 sq mm { *8mm rod means it has diameter of 8mm*

  So, total no. of rods spread in 1m of width = $\frac{335 sqmm}{50.24 sqmm}$ = 335 /50.24 = 6.67 { *When 'sqmm' is divided by 'sqmm', it becomes a dimensionless quantity. So, the result is a just number without any unit. Here, we want to calculate 'no. of rods', which does not have any dimension. So, our calculation is in right direction .*

  So, distance between two rods will be 1m/6.67 = 1000 mm/6.67 = 150 mm Answer { *Here, please note that we are dividing 1000mm /6.67 and not 1 m/6.67. In the question "per meter" is mentioned. But for correct answer we need to convert 1m to 1000mm.*

Taking Multiple Choice Exams *(Source:1)*

Studying for a multiple choice exam requires a special method of preparation distinctly different from an essay exam. Multiple choice exams ask a student to recognize a correct answer among a set of options that include 3 wrong answers (called *distracters)*, rather than asking the student to produce a correct answer entirely from his/her own mind.

For many reasons, **students commonly consider multiple choice exams easier than essay exams**. Perhaps the most obvious reasons are that:

- The correct answer is *guaranteed* to be among the possible responses. A student can score points with a lucky guess.
- Many multiple choice exams tend to emphasize basic definitions or simple comparisons, rather than asking students to analyze new information or apply theories to new situations.
- Because multiple choice exams usually contain many more questions than essay exams, each question has a lower point value and thus offers less risk.

Important Topics

Acoustics

Sound is such a common part of everyday life that we rarely appreciate all of its functions. It provides enjoyable experiences such as listening to music or to the singing of birds.

Yet, too often in our modern society, sound annoys us. Many sounds are unpleasant or unwanted - these are called noise. However, the level of annoyance depends not only on the quality of the sound, but also our attitude towards it. For example the type of music enjoyed by some people could be regarded as noise by others, especially if it is loud.

The branch of science which deals with the planning of a building to provide the best quality audible sound to audience is termed as architectural acoustics or acoustics of the building.

Intensity Level (dB)

Bel & Decibell:

Whenever the intensity of sound increases by a factor of 10, the increase in the intens ity is said to be 1 bel *(A unit named after Alexander Graham Bell, the inventor of telephone)*

Therefore dynamic range of audibility of the human ear is 12 bels or 120 dB. When the intensity increases by a factor of $10^{0.1}$, the increase in intensity is 0.1 bel or 1dB.

$\therefore$ in decibel

$$L = 10 \log_{10} \left(\frac{I}{I_0}\right)$$

I_0: base intensity (10^{-16} W/cm^2, hearing threshold)
I: intensity (W/cm^2)

For the intensity level change = 1 dB

$$1 = 10 \log_{10} \left(\frac{I}{I_0}\right)$$

$$\therefore \frac{I}{I_0} = 1.26 \quad \ldots(1.4)$$

If $I = I_0$,

$$L = 10 \log 1 = 0$$

This represents the threshold of audibility.
It means that intensity level alters by 1dB when intensity of sound changes by 26%

Intensity levels of different sounds

Sr. No.	Sound	Intensity level (in db)
(1)	Threshold of hearing	0
(2)	Rustle of leaves	10
(3)	Whisper	15 – 20
(4)	Normal conversation	60 – 65
(5)	Heavy traffic	70 – 80

Illumination

Terms

Visible Light Transmission (VLT)
The percentage of visible light that is transmitted through the glazing assembly. This is the essential characteristic for daylighting calculations. A perfectly clear window would have a VLT of 100 percent. Most practical assemblies for architectural use are between 35 and 80 percent.

Solar Heat Gain Coefficient (SHGC)
The percentage of total solar radiant energy that is transmitted through the assembly. This is the essential characteristic for solar gain calculations. For ordinary windows without special coatings, the SHGC and the VLT are the same and sometimes called the shading coefficient (SC). However, with modern coated windows, the SHGC is almost always lower than the VLT. Such window systems are generically referred to as *low-emissivity* or *lowE* and are used in most commercial construction.

Candela

The candela (unit cd) has its origin in the brightness of a "standard candle", but it has received a more precise definition in the International System of Units (SI) — and at that time the unit was also renamed from "candle" to "candela".

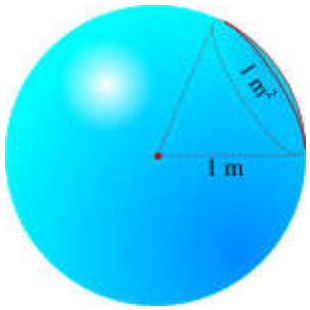


Figure: Creation of a solid angle.

The candela measures the amount of light emitted in the range of a (three-dimensional) angular span. Since the luminou s intensity is described in terms of an angle, the distance at which you measure this intensity is irrelevant. For ease of illustration, in the picture at the right the three dimensions have been flattened to two. In this picture, screen B would catch exactly the same amount of light rays (emitted from the light source) as screen A—provided that screen A were removed to not obscure screen B. This is because screen B covers the same angle as screen A.

The angular span for candela is expressed in steradian, a measure without unit (like radian for angles in a two-dimensional space). One steradian on a sphere with a radius of one metre gives a surface of one m^2. A full sphere measures 4π steradians.

Figure: The candela measures the amount of light emitted in the range of a (three-dimensional) angular span. The luminous intensity is described in terms of an angle.

Lumen

If you look at LEDs, especially high-brightness LEDs, you may notice that the LEDs with a high luminous intensity (in candela or milli - candela, mcd) typically have a narrow apex angle. Similarly, LEDs with a wide apex angle typically have a relatively low luminous intensity. The same is true for halogen spots with reflector: those with a narrow -beam reflector have a higher rating in candela than the "floodlight" spots of the same power.

The cause for this relation is the total energy produced by the LED. LEDs of a specific class (for example, "high flux") all produce roughly the same amount of luminous energy. However, when a LED emits its total energy in a beam with a narrow angle, the intensity will be greater (in the direction of tha t angle) than when *the same* energy had been emitted over a wide angle.

The lumen (unit lm) gives the total luminous flux of a light source by multiplying the intensity (in candela) by the angular span over which the light is emitted. With the symbol Φv for lumen, Iv for candela and Ω for the angular span in steradian, the relation is:

$\Phi v = Iv \cdot \Omega$

CPM/PERT

Introduction

Basically, CPM (Critical Path Method) and PERT (Programme Evaluation Review Technique) are project management techniques, which have been created out of the need of Western industrial and military establishments to plan, schedule and control complex projects.

Brief History of CPM/PERT

CPM/PERT or Network Analysis as the technique is sometimes called, developed along two parallel streams, one industrial and the other military.

CPM was the discovery of M.R.Walker of E.I.Du Pont de Nemours & Co. and J.E.Kelly of Remington Rand, circa 1957. The computation was designed for the UNIVAC-I computer. The first testwas made in 1958, when CPM was applied to the construction of a new chemical plant. In March 1959, the method was applied to a maintenance shut-down at the Du Pont works in Louisville, Kentucky. Unproductive time was reduced from 125 to 93 hours.

PERT was devised in 1958 for the POLARIS missile program by the Program Evaluation Branch of the Special Projects office of the U.S.Navy, helped by the Lockheed Missile Systems division and the Consultant firm of Booz Allen & Hamilton. The calculations were so arranged so that they could be carried out on the IBM Naval Ordinance Research Computer (NORC) at Dahlgren, Virginia.

The Framework for PERT and CPM

Essentially, there are six steps which are common to both the techniques. The procedure is listed below:

1. Define the Project and all of it's significant activities or tasks. The Project (made up of several tasks) should have only a single start activity and a single finish activity.
2. Develop the relationships among the activities. Decide which activities must precede and which must follow others.
3. Draw the "Network" connecting all the activities. Each Activity should have unique event numbers. Dummy arrows are used where required to avoid giving the same numbering to two activities.
4. Assign time and/or cost estimates to each activity
5. Compute the longest time path through the network. This is called the critical path.
6. Use the Network to help plan, schedule, monitor and control the project.

The Key Concept used by CPM/PERT is that a small set of activities, which make up the longest path through the activity network control the entire project. If these "critical" activities could be identified and assigned to responsible persons, management resources could be optimally used by concentrating on the few activities which determine the fate of the entire project.

Non-critical activities can be replanned, rescheduled and resources for them can be reallocated flexibly, without affecting the whole project.

Five useful questions to ask when preparing an activity network are:

- Is this a Start Activity?
- Is this a Finish Activity?
- What Activity Precedes this?
- What Activity Follows this?
- What Activity is Concurrent with this?

Some activities are serially linked. The second activity can begin only after the first activity is completed. In certain cases, the activities are concurrent, because they are independent of each other and can start simultaneously. This is especially the case in organisations which have supervisory resources so that work can be delegated to various departments which will be responsible for the activities and their completion as planned.

When work is delegated like this, the need for constant feedback and coordination becomes an important senior management pre-occupation.

Heat

Understanding fundamental heat flows from conduction, convection, and radiation is key to creating energy efficient buildings. Moisture flows are also important because moisture holds energy as "latent heat."

Sensible vs. Latent Heat Flows

There are of two forms of heat flows: **sensible heat** and **latent heat**. Sensible heat flow results in a change in temperature. Latent heat flow results in a change in moisture content (often humidity of the air). Total heat flow is the sum of sensible and latent flows. Human comfortdepends on providing acceptable levels of both temperature (sensible heat) and humidity (latent heat).

Sensible heat: The heat associated with change in temperature of a substance/

Latent heat: The release or storage of heat associated with change in phase of a substance, without a change in the substance's temperature. In building design, this is often heat required to add/remove moisture content (humidity) in the air. Hot dry air is actually less uncomfortable than hot humid air, because moisture holdsenergy as latent heat.

Whenever an object is at a temperature different from its surroundings, heat flows from hot to cold. Likewise, moisture flows from areas of greater concentration to areas of lower concentration.

Conduction, Convection, and Radiation

Buildings lose sensible heat to the environment (or gain sensible heat from it) in three principal ways:

1) Conduction: The transfer of heat between substances which are in direct contact with each other. Conduction occurs when heat flows through a solid.

2) Convection: The movement of gasses and liquids caused by heat transfer. As a gas or liquid is heated, it warms, expands and rises because it is less dense resulting in natural convection.

3) Radiation: When electromagnetic waves travel through space, it is called radiation. When these waves (from the sun, for example) hit an object, they transfer their heat to that object.

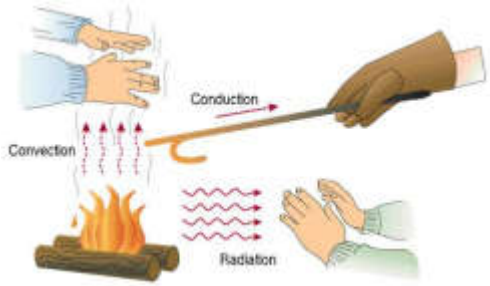


Figure: The way that you experience the heat from a fire is a good example of conduction, convection, and radiation. Heat conducts through materials placed in the fire, like a metal poker. You can stop theconduction to your hand by using an insulating pad Heat (and smoke) travels away from the fire through the air. The direction it travels depends on the wind and pressure differences (convection).Heat radiates from the fire to where you are. You can avoidthe radiation by putting a material between you and the fire, or stepping away.

GATE QUESTION PAPERS

GATE 2019

Q.1 The radius as well as the height of a circular cone increases by 10%. The percentage increase in its volume is ___.
(A) 17.1 (B) 21.0 (C) 33.1 (D) 72.8

Q.2 Five numbers 10, 7, 5, 4 and 2 are to be arranged in a sequence from left to right following the directions given below:
1. No two odd or even numbers are next to each other.
2.The second number from the left is exactly half of the left-most number.
3.The middle number is exactly twice the right-most number.

Which is the second number from the right?
(A) 2 (B) 4 (C) 7 (D) 10

Q.3 In a country of 1400 million population, 70% own mobile phones. Among the mobile phone owners, only 294 million access the Internet. Among these Internet users, only half buy goods from e-commerce portals. What is the percentage of these buyers in the country?
(A) 10.50 (B) 14.70 (C) 15.00 (D) 50.00

Q.4 Two trains started at 7AM from the same point. The first train travelled north at a speed of 80km/h and the second train travelled south at a speed of 100 km/h. The time at which they were540 km apart is_____ AM.
(A) 9 (B) 10 (C) 11 (D) 11.30

Q.5 The illumination level of a room is 300 lux and the efficacy of the lamps is 60. The Light Power Density (LPD) of the room in Watt/m^2 is _____.

Q.6 The load on a RCC column is 150 kN. The soil bearing capacity is 80 kN/m^2. Assuming a factor of safety of 1.2, the side of the square column footing is _____ meter *(rounded off to one decimal place).*

Q.7 A room is separated by a partition wall. The averageintensities of sound in the source and receiving sides across the partition are 10^{-4} W/m^2 and 10^{-7} W/m^2 respectively. The transmission loss (TL) of the partition wall is _____ dB.

Q.8 If the purchase price of 2BHK flat rises by 10 percent, the demand for such flats is observed to decrease by 8 percent. The price elasticity of the housing demand for 2BHK flats is _____ *(rounded off to one decimal place*).

Q.9 Threshold of enclosure created by vertical surfaces or series of vertical elements in an urban plaza, represented by the ratio of height and distance, is given by an angle of _____ degrees *(rounded off to one decimal place).*

Q.10 A colony of 50 people is served by a septic tank. The rate of water supply is 90 lpcd in the colony and 40% of it is going to the septic tank. The retention period of the tank is 24 hours. The length of the septic tank is_____ meter (*rounded off to two decimal places*).
Assume, storage capacity/person = 0.085m^3 (3 years)
Space for digestion = 0.0425 m^3/person
Depth of tank = 1.4 m
Length: Width = 2:1

Q.11 A cone, with a base of 10 cm diameter and axis of 12 cm, is lying on Horizontal Plane (HP) along its generator. The internal angle which the base of the cone makes with the HP is _____degrees.

Q.12 A public utility building of 5000 $m^2$was constructed 5 years before, on a site of 1 hectare. The present value of open land in that location is Rs. 100/$m^2$and present construction cost of such building is Rs. 2500/m^2. If the value of the

GATE 2009

Q1. A simply supported beam of length L carries a concentrated load of intensity P at its centre. The bending moment of the centre of the beam will be (A) PL/2 (B) PL/4 (C) PL/6 (D) PL/8

Q2. As per IS:456-2000, the maximum area of tension reinforcement in a RCC beam shall not exceed x% of its cross-sectional area, where x is equal to
(A) 2 (B) 4 (C) 6 (D) 8

Q3. A commercial plot measures 100 m x80 m. if the permissible Floor Space Index (FSI) is 3.0, and 50% of the ground is covered, then the maximum number of floors that can be built is (A) 3 (B) 4 (C) 6 (D) 12

Q4. A microwave oven of 3 kW rating is operated for 30 minutes, a hot water geyser of 1 kW rating is operated for 15 minutes, and 5 fluorescent lamps of 60 W are operated for 6 hours. The total power consumed (in kWh) will be
(A) 1.80 (B) 3.55 (C) 18.01 (D) 35.50

Q5. A site has 6 contour lines and length of the line joining the midpoints of the highest contour and lowest contour is 300 m. If the slope of the line is 1 in 10, then the contour interval (in m) is (A) 5 (B) 6 (C) 50 (D) 60

Q6. A neighborhood with a total of 200 hectares has a gross density of 300 persons per hectare (pph). If the residential area is 60% of the total area, then net density in (pph) of the neighborhood is
(A) 300 (B) 450 (C) 500 (D) 750

Q7. A town with a population of 50000 has an average household size of 5.0. The number of occupied dwelling units is 8400 of which 10% are in dilapidated condition. The housing demand of the town is
(A) 760 (B) 1600 (C) 2440 (D) 10840

Q8. A building has a rooftop area of 300 sq. m. If the average annual rainfall in the region is 700 mm and the runoff Coefficient of the rooftop is 0.8, then the maximum amount of rainfall than can be harvested from the rooftop (in litres) is
(A) 168 (B) 262 (C) 168000 (D) 262500

Common Data Questions
Common Data Questions 10 and 11:

A construction project has the following data:

Activity	Duration (days)	Predecessors
P	4	-
Q	3	P
R	7	P
S	2	P
T	4	Q
U	6	S
V	4	R,T,U

Q9. The normal project duration (in days) is
(A) 14 (B) 15 (C) 16 (D) 17

Q10.The critical activities of the project are
(A) P, Q, R, V (B)P, R, S, U (C)P, Q, T, V (D)P, S, U, V

Common Data for Questions 12 and 13:
A seminar hall has a volume of 2000 cu.m, and the total absorption of all acoustic materials without any audience is 80 m^2-sabines.

Q11. The reverberation time of the empty hall (in seconds) will be(A) 1.0 (B) 4.0 (C) 8.0 (D) 12.0

Q12. When the same seminar hall is filled with audience, the reverberation time is recorded as 2.0 seconds. Then the total absorption of all acoustic materials (in m^2-sabines) will be
(A) 40 (B) 80 (C) 160 (D) 320

Q4. An investor has a capital of Rs. 15 lacs from which he expects a return of 14.5%. He intends to purchase a small workshop from which the net annual income is expected to be Rs. 5 lacs. Calculate the maximum price which the investor can invest for the workshop if money can be borrowed in mortgage at 16% interest for 8 years.

Q5. A studio has dimensions 10m x 8 m x 5m. The ceiling of studio is provided with acoustical tiles having absorption coefficient = 0.40. Curtains in heavy folds (absorption coefficient = 0.50) are provided on one short wall. The absorption power of other surfaces of the studio may be taken as 8 sq.m. sabines. What will be extra absorption units required to make reverberation time t = 0.75 sec.?

Q6. A property has been sold by the Housing Board on a conditional sale. The Board is to receive Rs. 24,000 at the end of every year for 10 years, and further, the Board is to receive Rs. 200,000 at the end of 10 years. A period of 4 years has already lapsed. Estimate the current value of the property (Interest rate for Years Purchase is 8%)

Q7. The distance between two points in a map on 1:100,000 is 2 cm. Distance between the same two points in an aerial photograph is 10 cm. The camera of the aerial photograph was flown with a focal length of 6 inches. Find out the scale of the photograph and calculate the flying height.

GATE 1996

1. If 'a' is the optimistic time, 'b' is the pessimistic time and 'm' is the most likely time of an activity, the expected time of the activity is

(A) $\frac{a+5m+b}{6}$ (B) $\frac{a-4m+b}{6}$ (C) $\frac{a+2m+b}{6}$ (D) $\frac{a+m-b}{6}$

2. As per Indian Road Congress the 'Width of formation' of highway in plain land is
(A) 6.0 m (B) 12.0 m (C) 18.0 m (D) 21.0 m

3. In a lecture auditorium the seating pattern from the speaker should fall within maximum angle of
(A) 70° (B) 90° (C) 120° (D) 140°

4. When two pigments of contrasting value are mixed, the most striking change observed is in
(A) Hue dimension (B) Occult rhythm (C) Occult balance (D) None of the above

5. Number of common clay bricks required to make one cubic meter of brick masonry is
(A) 350 (B) 420 (C) 500 (D) 550

6. Sinking fund refers to
(A) Reserve fund (B) Fund loss due to damage (C) Bad debts (D) Fund for underground construction

7. BASIC is a
(A) Compiler (B) Hardware item (C) Interpreter (D) Plotter type

8. Minimum strength of cement mortar used in load bearing brick masonry is
(A) 50 N/cm^2 (B) 60 N/cm^2 (C) 80 N/cm^2 (D) 100 N/cm^2

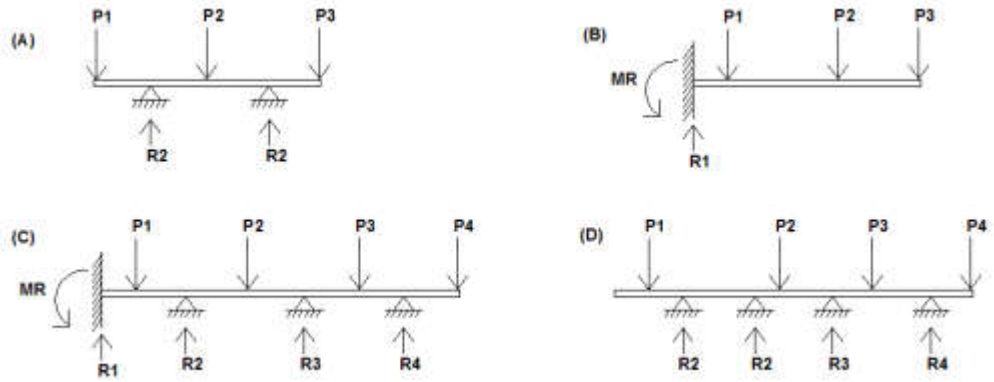
9. If 'P' denotes the total population, the age-dependency ratio is expressed as
(A) $[P_{(60+)}] / [P_{(0-59)}]$
(B) $[P_{(0-14)}] / [P_{(15-59)}]$
(C) $[P_{(60+)} + P_{(0-14)}] / [P_{(0-59)}]$
(D) $[P_{(60+)} + P_{(0-14)}] / [P_{(15-59)}]$

10. Compute the capacity and workout the dimension of a septic tank for a small colony of 500 persons with average daily sewage flow of 75 litres per head. Detention period is 36 hours. Cleaning interval is six months. Assume rate of deposited sludge as 25 litres per capita per year.

11. Compute the thermal transmittance (U) value for a 230 mm brick wall with 12.5 mm thick cement plaster on both sides (value of thermal conductivity for brick wall and cement plaster are 69 and 80 respectively in K cal cm/ m^2h deg C. Thermal conductance of outside and inside walls are 0.05 and 0.16 respectively.)

12. A newly built property fetches an annual rent of Rs. 18,00. As per agreement tenant is liable to pay outgoing equivalent to 18% of the annual rent. Calculate the present value of the property. (Assume rate of interest as 8.5%)

13. Determine which of the following are determinate or indeterminate structures.



14. A reinforced concrete slab (having balanced section) has an overall depth of 100 mm. The effective cover is 20mm. If the stresses in concrete and steel are not to exceed 5N.mm2 and 140N/mm2. Find the safe uniformly distributed load which can be placed on the slab. The slab is supported on beams at 3.0m c/c on both sides. The maximum bending moment for a meter strip of slab may be taken as Wl2/12. Take the moment of resistance of the balanced section as equal to 0.85 bd^2Nmm.

15. The time estimate of various activities of a project in the following Table. Determine the standard deviation of the critical path.

Activity	Optimistic Time (Weeks)	Most Likely Time (Weeks)	Pessimistic Time (Weeks)
1-2	8	12	22
1-3	6	12	18
2-4	1	4	7
3-4	5	9.5	11
2-5	9	15	21
4-5	3	4	5

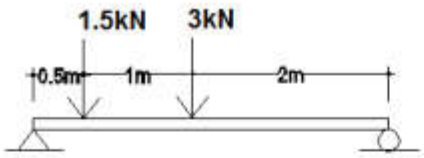
16. A main sewer is tobe designed to receive a flow from 2 sq. Km. Area of a community, where the population density is 250 persons/hectare. The average sewage flow is 120 litres per capita per day. What will be the design flow of the main sewer? Assume peak factor as 3.

17. a) Explain the concept of relief displacement on aerial photography.

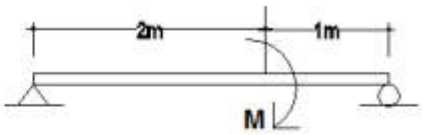
17. b) A flat area is photographed in a scale of 1:10,000 with a camera of 15 cm focal length. The bottom of a chimney stack is found to lie at a distance of 12.01 cm from the principle point of the photograph and the top at a distance of 12.22 cm. Find the height of the chimney stack.

18. Explain the significance of 'Z' score in the statistical analysis and mention its properties.

(i)



(ii)



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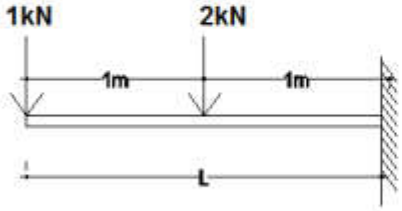

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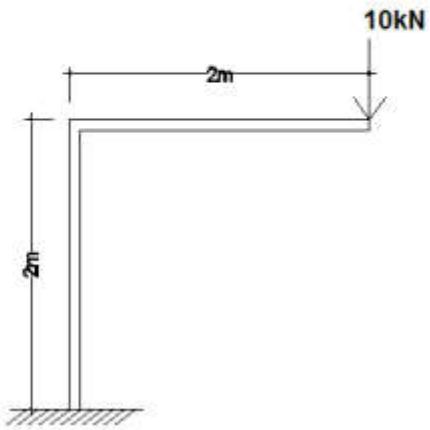


Q3. Draw the CPM network and determine the critical path from the following data:

Serial No.	Activity	Duration (days)	Preceding activity
1	A	4	-
2	B	10	-
3	C	6	-
4	D	6	A
5	E	8	B
6	F	3	C
7	G	7	D
8	H	2	E, F

GATE 1991

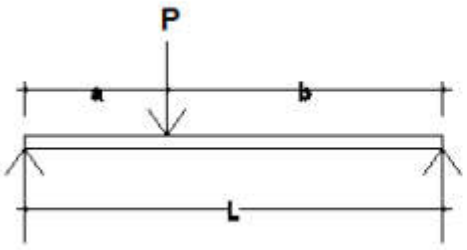
Q1. Ratio 'Golden Mean' is:

(A) 1:2.261 (B) 1 : 1.618 (C) 1: 1.15 (D) 1: 1.44

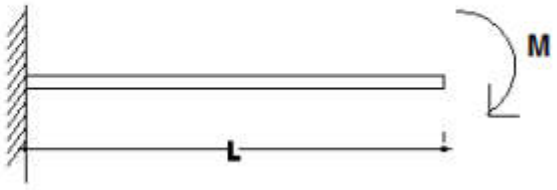
Q2. An urban area with a population of 2,15,000 is having housing stock of 39,000 and average household size of 5.0 . The city is expected to have 2,70,000 by 2001 with an average family size of 4.5, Estimate the housing demand of the city by 2001assuming there will be depletion of existing housing stock by 3,500 during this period.

Q3. Draw the bending moment and shear force diagrams for thefollowing:

(i)



(ii)



Q4. The residential landuse of an urban area accounts for 50% of the developed land of the city. Thevacant undeveloped land is about 30% of the total urban area, which amounts to 2,400 hectares of land. Estimate the quantum of land put to residential uses and also the overall density of the urban area if the population is of 2,00,000 size.

Q5. Sketch the bending moment and shear force diagrams (values not required)

GATE Solution, Explanation & Notes

GATE 2019

Q.1 Answer (C) 33.1 **The increase in volume of circular cone is 33.1 %**

We know for volume of a (right circular) cone is $\frac{1}{3}\pi r^2 h$

Original volume (V_o)

$(V_o) = \frac{1}{3}\pi r_1^2 h_1$

Now we know radius and height both are increased by 10%. So, after increase, the new volume will be:

$(V_n) = \frac{1}{3}\pi(1.1r_1)^2(1.1)h_1 = 1.331*(\frac{1}{3}\pi r_1^2 h_1) = 1.331 *(V_o)$

% change in volume = $\frac{Vn-Vo}{Vo}$ x 100% = $\frac{1.331Vo-Vo}{Vo}$ x 100% = 33.1% Answer

Q.2 Answer (C) 7 **According to given data, the only possible arrangement is:**

10 5 4 7 2

So, second from right will be 7.

Q.3 Answer (A) 10.50 **Total population = 1400 million**

Number of people who having own mobile phones

= 70% of 1400 = 0.7 x 1400 = 980 million

Number of people who have access of internet = 294 million

Number of people who buy goods from e-commercial portals = half of interest users

= $\frac{294}{2}$ = 147 million

Percentage buyers = $\frac{147\ million}{1400\ million}$ x 100% = 10.5%

Q.4 Answer (B) 10 **The time at which they were 540 km apart is 10 AM.**

According to the concept of relative sped in opposite direction, speed should be added:

Time of activity = Sum of distance/ Sum of speeds = 540/(100+80) = 540/180 = 3 hours from 7 am = 10 am Answer.

Q.5 The Light Power Density (LPD) of the room is 5 Watt/m^2.

Illumination, E = 300 lux = 300 lumen/sqm

Efficacy = 60 lumen/watt

LPD = Illumination / Efficacy = (300 lumen/sqm) / (60 lumen/Watt) = 5 Watt/sqm Answer

Tips: Please solve this type of question with numerical value and unit attached.

Q.6 The side of the square column footing is 1.5 meter

Load on column = 150 kN

Design load consisting factor of safety = 150 * 1.2 = 180 kN

Soil bearing capacity = 80kN/m^2

Let side of the square column footing be S

So, area of the column = S^2

So, total load on column = 80kN/m^2 * S^2

As per question,

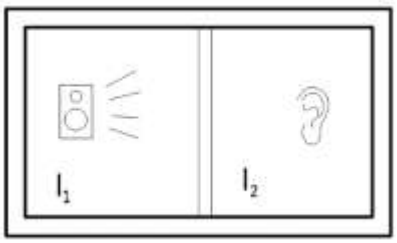
80kN/m^2 * S^2 = 180kN

- ⇨ S^2 = 2.25
- ⇨ S = 1.5 m Answer.

(GATE official answer range: 0.75 to 0.85)

Q.7 The transmission loss (TL) of the partition wall is 30 dB.

Here I_1 = 10^{-4} W/m^2 and I_2 = 10^{-7} W/m^2



We simply cannot subtract intensities I_1 and I_2. We have to take *log* value.

Also the required answer is in dB.
Sound level at source side = 10 log (10^{-4} / 10^{-12}) = 80 dB
Sound level at receiver side = 10 log (10^{-7} / 10^{-12}) = 50 dB
So, transmission loss = 80 – 50 = 30dB Answer.

Q.8 The price elasticity of the housing demand for 2BHK flats is 0.8
Price elasticity of demand = Change in quantity / Change in demand = 8% / 10% = 0.8 Answer

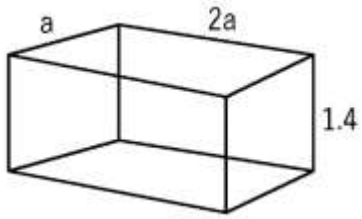
Q.9 Ratio of height and distance for 'Threshold of enclosure' = ½
Tan 0 – ½
So, 0 – 26.5° Answer

Q.10 The length of the septic tank is 3.42 meters

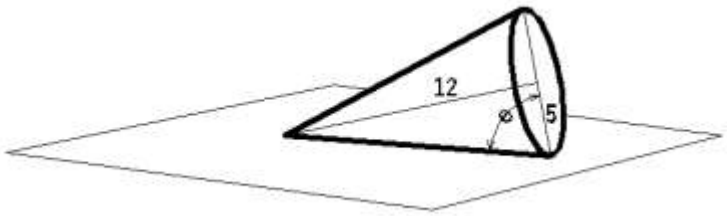
Volume of water in septic tank	40% * 50* 90	1.8 cum
Storage volume of septic tank	0.085 * 50	4.25 cum
Digestion volume of septic tank	0.0425 * 50	2.125 cum
Total volume		**8.175 cu.m**

Volume of septic tank V = a*2a*1.4 = 8.175
- ⇨ $2.8a^2 = 8.175$
- ⇨ a2 = 2.919
- ⇨ a = 1.708

So, length of septic tank = 2a = 2*1.708 = 3.42 Answer



Q.11 The internal angle which the base of the cone makes with the HP is 67.38 degrees.



Tan0 height/ base = 12/5
- ⇨ Θ – Tan^{-1}(12/5) = 67.38 degree Answer

Q.12 The present value of the property using 'Valuation by Cost Method' is 91.738 Lakhs
Present land value = Rs. 100/m^2*1 hectare = Rs. 100/m^2*100m x 100m = Rs. 10 Lakh
Value of new construction = 5000 m^2 * Rs. 2500/m^2 = 125 Lakh
Depreciating rate = 6% per annum
Value after depreciation of construction in 5 years = 125 $(1-r)^n$ = 125*$(1-0.06)^5$ = 91.738 Lakh
Present value of property = 91.738 Lakhs **Answer**

Q.13 The net residential density of the area in personsper hectare is 159.48
Plot area = 20 Ha

Type	Area per plot (sqm)	Number	Total area (type)
A	500	100	50000
B	300	120	36000
C	200	150	30000
Total		**370**	**116000**

Population = 370 x 5 = 1850 person
Net residential density = population / net area = 1850 / 11.6 = 159.48 pph Answer

Q.14 The velocity of the shock wave generated is 10 km/h.

Speed of the shock-wave = Q_2-Q_1/K_2-K_1

Q1 = Flow before Jam = 1000 V/h

Q2 = Flow after jam = 0 (because V= 0)

K1 = Density before jam = 1000 / 20 = 50 V/km

K2 = 150 Vehicle / Km (Jam density)

Therefore, Speed of the shock-wave = Q_2-Q_1/K_2-K_1 = 0-1000 / 150-50 = -10 km/h

So, the answer in absolute value is 10 km/h Answer

Q.15 The maximum built-up area for the residential building will be 450m^2.

As per question, 16 mm width of road = 4m = 4000 mm

So, 1 mm = 250 mm or scale is 1:250

Therefore, actual dimension of the plot would be,

Length = 150 mm * 250 = 375000 mm = 37.5 m

Width = 40 mm * 250 = 10000 mm = 10 m

So, the area of site = 37.5*10 = 375 m^2

So built-up area = 375*FAR = 375*1.2 = 450 m^2 Answer

Q.16 If all the doors and windows of the room are kept fully open, the reverberation time will be0.956 seconds

Consider the uniform absorption coefficient = a

Using, R_T = 0.16V/A

- ⇨ 1.2 = 0.16 * 400/360a (Total surface area of the room is 360 m^2)
- ⇨ 360a = 400*0.16/1.2
- ⇨ A = 0.148

New RT = 0.16 * 400/ (344*0.148 + 16*1) = 0.956 Answer

Note: Out of 360m^2 of room area, 344m^2 has absorption coefficient of 0.148 and rest 15m^2 area has absorption coefficient of 1 because opened door orwindow has absorption coefficient of 1 as it would absorb all sound)

Q.17 Using prismoidal method, the volume of the earth needed to fill the land depression is66 m^3.

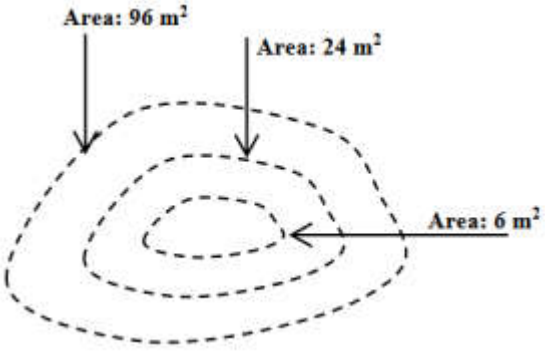
Prismoidal method is used in calculation of earthwork quantities. It states that the volume of any prismoid is equal to one-sixth it's length multiplied by the sum of the two end-areas plus four times the mid-area.

So, volume of earth fill = d/3 (A_1 + 4A_{odd}+ 2A_{even} + A_n)

Depth of depression, d = 1m

Volume of earth-fill = 1/3 (96 + 4*24 + 2*0 + 6) = 198/6

= 66 Answer



Notes: In many construction projects, earthwork involve the excavation, removal and dumping of earth, therefore it is required to make good estimate of volume of earthwork. Volume computation are also required to determine the capacity of reservoirs.

Computing of areas and volumes is an important part of the office work involved in surveying. For computation of the volume of earthwork, the sectional area of the crosssection which are taken to the longitudinal section durin g profile leveling are first calculated.

After calculating the cross-sectional areas, the volume of earth work is calculated by:

- *The Trapezoidal Rule*
- *The Prismoidal Rule.*

Computation of Volume:

Trapezoidal Rule

Volume (Cutting or Filling) V= d/2 [A1 + An − 2 (A2 + A3 + ……An-1)

i.e. Volume = Common Distance/2 x [First section area + Last section area + 2 (sum of areas of other sections)

Prismoidal Formula

Volume,V= d/3* [A1 + An + 4 (A2 + A4 + An-1) + 2 (A3 A5 ….. An-2)]

i.e. Volume =Common Distance/3* [Area of First Section + Area of Last Section + 4 (Sum of areas of even Section) + 2 (Sum of Area of Odd Sections)]

The Prismoidal formula is applicable when there are odd number of sections. If the number of sections are even, the end section is treated separately and the area is calculated according to the trapezoidal rule. The volume of the remaining section is calculated in the usual manner by the prismoidal formula. Then both the result are added to obtain the total volume.

Prismoidal Correction

The prismoidal rule gives the correct volume directly. The trapezoidal rule does not give the correct volume. Prismoidal correction should be applied for this purpose.

This correction is always subtractive.

Prismoidal Correction for the section

$Cp = (L (h_1 - h_2)^2 * S) / 6$

Side Slope= S:1

Considering traverse Slope = 1 in n

Example: An embankment of width 10 m and side slope 1 ½ : 1 is required to be made on a ground which is level in a direction traverse to centre line. The centralheight at 20 m intervals are as follows:

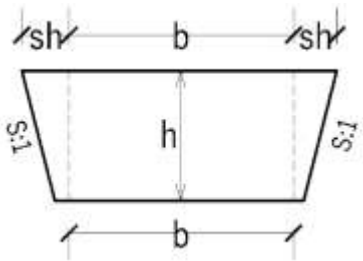
0.8, 1.2, 2.25, 2.6, 1.9,1.4 and 0.9

Calculate the volume of earth work according to:

(1) The trapezoidal formula

(2) The prismoidal formula

Solution: Level Section : Ground is level along the traverse direction



Here, b = 10 m, s = 1.5, interval = 20 m

The cross-Sectional Area are calculated by equation: Area= (b + sh) h

$A1 = (10 + 1.5 \times 0.8) \times 0.8 = 8.96\ m^2$

$A2 = (10 + 1.5 \times 1.2) \times 1.2 = 14.16\ m^2$

$A3 = (10 + 1.5 \times 2.25) \times 2.25 = 30.09\ m^2$

$A4 = (10 + 1.5 \times 2.6) \times 2.6 = 36.14\ m^2$

$A5 = (10 + 1.5 \times 1.9) \times 1.9 = 24.42\ m^2$

$A6 = (10 + 1.5 \times 1.4) \times 1.4 = 16.94\ m^2$

$A7 = (10 + 1.5 \times 0.9) \times 0.9 = 10.22\ m^2$

Volume according to Trapezoidal Rule,

V = 20/2* [8.96 + 10.22 + 2 (14.16 + 30.09 + 36.14 + 24.42 + 16.94)]

= 10 [19.18 + 242.10]

= 2612.80 m^3

Volume according to Prismoidal Formula,

V = 20/3* [8.96 + 10.22 + 4 (14.16 + 36.14 + 16.94) + 2 (30.09 + 24.42)]

= 20 x (19.18 + 268.96 + 109.02) /3

= 2647.73 m^3

Example: Calculate the volume of earthwork in an embankment for which the Cross-Sectional areas at 20 m interval are as follows:

Distance	0	20	40	60	80	100	120
Cross-section area (m^2)	38	62	74	18	22	28	13

V= d/3 (A1 + A7 + 4 (A2 + A4 + A6) + 2 (A3 + A5)]
= 20/3* [38 + 13 + 4 (62 + 18 + 28) + 2 (74 + 22)]
= 20/3 [51 + 4 (108) + 2 (96)]
= 20/3 [51 + 432 + 192]
= 20 x 675 3
= 4500 m^3

Capacity of Reservoir: The plane containing any contour represents a horizontal plane and the area bounded by a contour is treated as the area of the cross-section. The contour interval is the vertical distance between any two adjacent crosssectional bounded by the contours. The area bounded by the contour is measured by a planimeter.
Reservoir are made for water supply, irrigation, hydropoweretc. A contour map is very useful to study the possible location of a reservoir and the volume of water to be confined. All the contours are closed lines within the reservoir area.
The area A1, A2, A3,..... An between successive contour lines can be determined by a planimeter and if h is the contour interval, the capacity of the reservoir can be estimated either by the prismoidal formulaor by the trapezoidal formula. In practice, the capacity of a reservoir is measured in terms of volume of water stored upto full reservoir level (FRL) which is the level of water at its full capacity.

Example: From a contour plan of a proposed reservoir area, the following data were found:

Contour (m)	100	105	110	115	120	125
Area of contour (ha)	3	8	13	17	23	29

The capacity of the reservoir if the FRL is 125 m. The volume below the contour of 100 may be ignored.

Solution: Prismoidal formula can be used when odd number of section are there So, the volume up to the contour 120 m is:
V_{120} = d/3 [(A1 + A5 + 4 (A2 + A4) + 2 (A3)] 3
= 5 [(3 + 23) + 4 (8 + 17) + 2 x 13)]
= 5/3 [26 + 100 + 26]
= 255.33 ha.m
And by trapezoidal formula, the volume, the formula, the volume between 120 and 125 m is
$V_{120\text{-}125} = h *(A_5 + A_6) / 2 = 5 \text{ x } (23 + 29) / 2 = 130$ ha.m

Total Volume, $V= V_{120} + V_{120\text{-}125} = 253.33 + 130 = 383.33$ ha.m

Volume by the trapezoidal formula:
V= h/2* [First Area + Last Area + 2 (Sum of area of other section)]
= 5/2* [3 + 29 + 2 (8 + 13 + 17 + 23)]
=5/2 * (32 +122) = 385 ha -m

Example: The area enclosed by the contour in a reservoir are as follows:

Contour (m)	175	180	185	190	195
Area (m^2)	460	750	2500	3500	3950

The top water level is 195 m and the lowest point in the reservoir is 175 m. Find the volume of water (reservoir capacity) between 175 m and 195 m by:

- Trapezoidal formula
- Prismoidal formula

Contour Interval = 5 m
Volume according to trapezoidal formula, V= h/2* [A1 + A5 + 2 (A2 + A3+ A4)] = 5/2* [460 + 3950 + 2(750 + 2500 + 3500)] = 44775 m^3
Volume according to Prismoidal formula, V= h/3 [A1 + A5 + 4 (A2 + A4) + 2 (A3)] = 5/3* [(460 + 3950) + 4 (750 + 3500) + 2 (2500)] = 5/3 [4410 + 1700 + 5000] = 44016. 66 m^3

Source: "Surveying and Leveling" Vol- I Kanetkar and Kulkarni (2011) "Surveying and Leveling" N.N.Basak
https://www.slideshare.net/gauravhtandon1/volume -28486423

Q.18 As per theproposal, 28.5 kWh solar power will be generated daily.

Given data				*Data calculation*	
Orientation	No. of Panels	Average daily solar radiation in W/m2	Average solar hours per day	*Total electricity generation*	*At 75% efficiency*
South	10	400	4	*10*400W/m^2*2m^2*4hours = 32 kWh*	*0.75*32 kWh = 24kWh*
West	5	300	2	*5*300W/m^2*2m^2*2hours = 6 kWh*	*0.75*6 kWh = 4.5 kWh*

Total energy generation = 24 + 4.5 = 28.5 kWh Answer
GATE official answer range: 28.4 to 28.6

Q.19 The amount of soil excavated by the power shovel per day is 720 m^3.

Total working hour = 6 hrs (given)
Time wasted = 10 minutes per hour. So, total time wasted = 10 minutes * 6 = 1 hour
Therefore, effective working hours = 5 hours = 300 minutes = 18000 seconds

As it takes 45 seconds for 1 excavation.
So, no. of excavations in 18000 seconds = 18000/45 = 400 excavations

As 1.8m^3 of soil is excavated in 1 excavation.
So, in 400 excavations, amount of soil excavated would e = 1.8m^3 * 400 = 720 m^3 Answer
GATE official answer range: 719.75 to 720.25

Q.20 The capacity of the air-conditioner for the room will be 1.5 Ton.
General formula to be used is $Q = msΔT$ for energy Q required to raise the temperature by $ΔT$ of material of mass m with specific heat of s. This formula is for solid material but equally holds good for gaseous item like air.

In this question, m will be volume of air.
Volume of air = 3* volume of room ….. *(Room volume is multiplied by 3 as there are three air changes per hour.)*
= 3* (12 x 10 x 3.5) = 1260 m^3

In this question, s will be 1250 J/m^3 °C and $ΔT$ would be 12°C
Therefore, Q = msΔT = 1260 m^3 * 1250 J/m^3 °C * 12°C = 18900000 Joule and this much energy is required per hour.

So, rate of energy flow = Q/Time = 18900000 Joule / 36000 Seconds = 5250 Joule per second = 5250 Watt = 5250 W = 5.25 kW

As per question, 3.5 kW = 1 Ton (given)
So, 5.25 kW = 5.25/3.5 Ton = 1.5 Ton Answer.

The angle covered 2πr/l 2π (5/13) 10π/13 Answer.

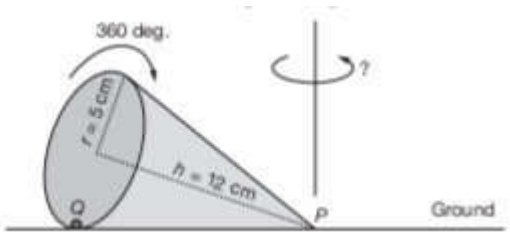


Figure: Cone with radius 5cm and height 12 cm

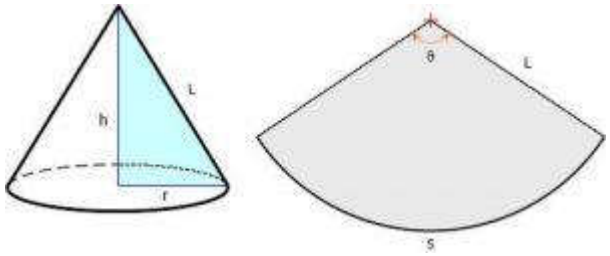


Figure: The right circular cone is unfolded

Alternative solution: This problem can also be replicated as below.
Given, h = 12 & r = 5
First, let us focus on unfolded cone.
By symmetry,
(2π/2πL) (0/S)
So, θ – S/L (Answer)
Now, let us find S and L.
L = Square root of (12^2 + 5^2) = Square root of (144+25) Square root of 169 = 13
S = 2πr = 10π
Therefore, θ – S/L – 10π/13 Answer (D)

Q16. If S has 1 or 2 cars both Q and R would be right. If S has 3 or more both P and R would be right. Therefore, S has 0 cars. Only Q is right. Hence, the correct option is (A) i.e. zero.

Q17. The paragraph clearly states that Stuart was reprimanded (criticized), by his superiors (commander-in-cheif), for fighting for his Sepoy's right to wear their caste-marks. He then resorts by saying that, he has never come across a better example of European prejudice than this instance. Further more, the last phrase 'it had no effect' shows that the commander-in-chief had not been moved by Stuart's retort or fight. Hence, option A can be eliminated. Option B is negated in the given stanza. Option D is inapt as the commander-in-chief believed in the European prejudice and he is- as understood from the stanza-very much a part of it. Only option C which can be clearly understood from the stanza is accurate.
Hence, the correct option is (C).

Q18. Mark and Steve are brothers who play for the same country. When James replied to Mark saying that he is the best player in his own family, James took a dig (make sarcastic or critical remarks) at Mark for teasing him. What he meant by that statement is that Steve is a better player than Mark. Or rather that Mark is not the best player in his own family. Hence, the correct option is (B)

Q19. 5% of x = 10000 So, value of x = 2 lakh

Q20. Maximum buildable area = FAR * Site Area = 2.5 * 60750 = 151870 sq.m
Actual buildable area = Site Area * Ground Coverage * No. of floors = 60750 * 45% * 5 floors = 60750 * 0.45 * 5 = 136687 sq.m.
(Please note that, *actual buildable area* is always less than the *maximum buildable area*. Height of the building given is 15m and the floor height is 3m, so no. of floors = 15/3 = 5 floors)
According to question, HIG units owns 30% of the buildable area. So, 30% of 136687sq.m. = 0.3 * 136687 = 41006 sq.m. Answer.

Q21. The salary distribution is given below. The salary is in thousands of rupees.

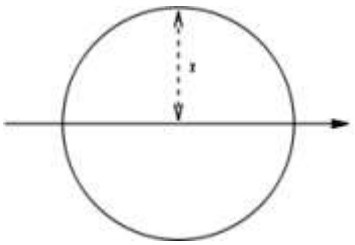
Salary	20	30	40	60	150
Number	45	25	20	8	2

The median is 30,000. Half the staff earns 30,000 or less. The other half earns 30,000 or more.
Hence, the correct option is (B).

Q22. The correct answer is 40 (This answer was challenged, earlier it was 0.4)
Pigment Volume Concentration (PVC)
% PVC = 100 * $V_{pigment}$ / ($V_{pigment}$ + $V_{non\text{-}volatile\ binder}$)
$V_{pigment}$ = pigment volume

neutral axis to the most extreme fiber. It is also often used to determine the yield moment (My) such that My S ‹ σy, where σy is the yield strength of the material.

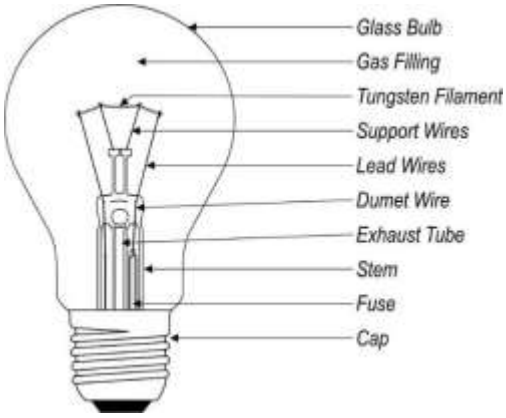
(Source: https://www.engineersedge.com/material_science/section_modulus_12893.htm)



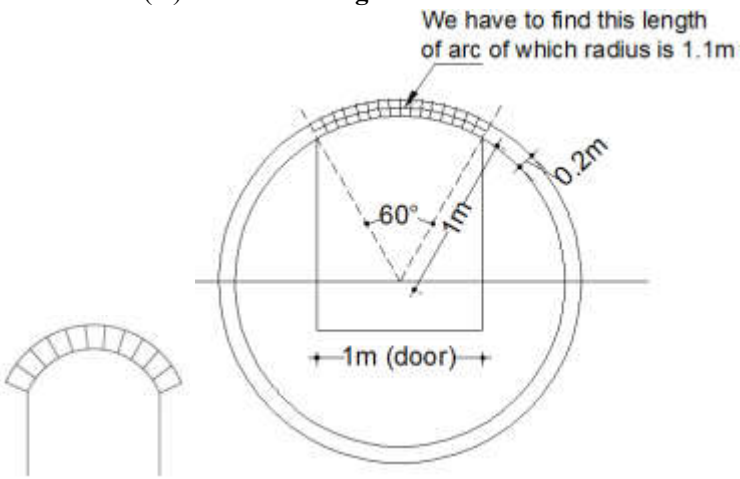
$$S = \frac{\pi r^3}{4} = \frac{\pi d^3}{32}$$ (Section Modulus)

15. Answer (A) **For incandescent lamps the distribution of total energy emission is 5% light & 95% heat.**

An **incandescent lamp** is an electric light with a wire filament heated to such a high temperature that it glows with visible light (incandescence). The filament, heated by passing an electric current through it, is protected from oxidation with a glass or fused quartz bulb that is filled with inert gas or evacuated.



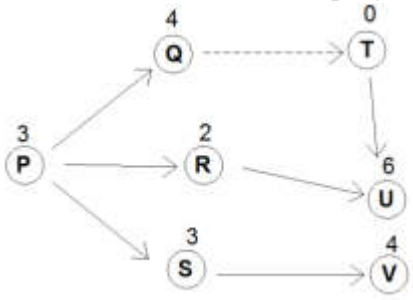
16. Answer (B) **The mean length of the arch is 1.15 meters.**



Length of arc $= \frac{60^c}{360^\circ}(2\pi r) - \frac{1}{6}(2\pi r) = \frac{1}{6}(2\pi 1.1) = 1.15\text{m}$

17. Not Answered

18. Answer (C) **The normal project time for the given network is 13 days.**



next largest city and more than twice as significant." A primate city is number one in its country in most aspects, like politics, economy, media, culture and universities.

Significance: Not all countries have primate cities, but in those that do, the rest of the country depends on it for cultural, economic, political, and major transportation needs. On the other hand the primate city depends on the rest of the country as paying consumers of the cultural, economic, political and other services produced in the city.

The presence of a primate city in a country may indicate an imbalance in development usually a progressive core, and a lagging periphery, on which the city depends for labor and other resources. However, the urban structure is not directly dependent on a country's level of economic development.

Examples: Among the best known examples of primate cities are alpha world cities London and Paris. Budapest and Vienna have also been described as primate cities.

Figure: Lux meter

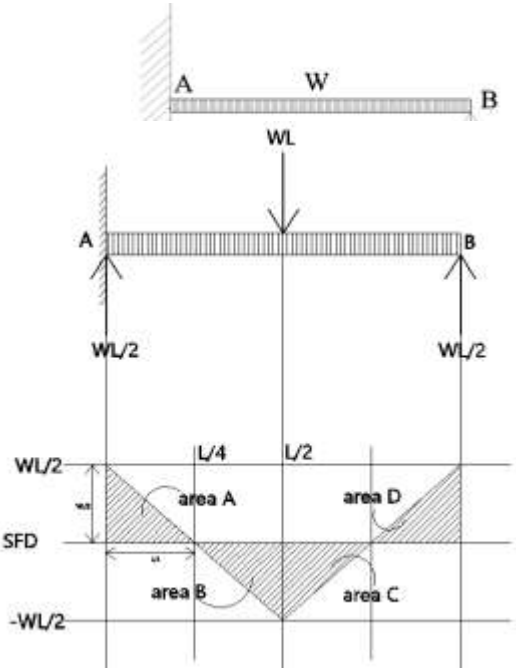
Rank-size usually indicates a country wherein all of the people have access to services because there are many cities of the differing sizes needed to spread services equally. A primate city can indicate and LDC wherein the people away from that city do not have access to services. Note: This rule is not always true and you need to think about whether or not this applies.

Q8. Unanswered

Q9. Answer (B) **110 cars can be parked in 400m stretch along the kerb?**
Thumb rule for car space of 2.5m*5m:
30◦ parking: , L = 0.58+5N
45◦ parking: L = 3.54 N + 1.77
60◦ parking: L = 2.89N+2.16

Q10. Answer (C) **Moment at the fixed end 'A' of the beam is $-WL^2/8$**
Let's start from the basic. Unit of Moment is Newton-meter. In the question, W is UDL (uniformly distributed load). So, its unit is Newton /meter. Unit of length L is meter.
Now, unit of WL is (W Newton/meter)*(L meter) = WL Newton (which is essentially a force. So WL/16 is also a force, not a moment. Therefor options (B) and (D) are incorrect).

Now, you are left with options (A) and (D). You should try your luck. If not, you should know that the area in SFD (Shear Force Diagram) is actually a value of moment.
Here, Moment at A should be sum of area of triangle A & B.
Moment at A = Area (ΔA + ΔB) = Area [(1/2*WL/2*L/4) + (1/2*WL/2*L/4)] = $WL^2/8$ Answer



Q11. Answer (B) **30 m should be spacing between the lamps if the desired average lux on the pathway is 6**
Area of the road to be illuminated = 300m x 6m = 1800sq.m.
We have,
E = (N x F x UF x MF) / A
Where, E = average illuminance over the horizontal working plane
N = number of luminaire

GATE 1994

1. Answer (D) **Density control of residential area is expressed in terms of Floor Area Ratio**

F.A.R. Perhaps the best way to define an FAR is to give an example. An FAR of 1.0 means that the developer is allowed to build the equivalent of a one-story building over her entire lot, or a 2-story over half the lot. An FAR of 2.0 means the developer is allowed to build the equivalent of a two-story building over her entire lot, or a 4-story over half the lot.
F.A.R. is the ratio of total building floor area to the area of the plot.

Why FAR is used:

- Various tools are used by for regulating or guiding the development of our urban areas. The primary objective of using such tools is the optimal utilization of precious land considering its use, reuse, misuse, disuse and abuse . Among various development regulations adopted, Floor Area Ratio (F.A.R.) is one of the most important one, which regulates he bulk of the built space. Higher the F.A.R. value, more will be floor area within the same plot, and higher the pressure on land for infrastructure. Carrying capacity and development priorities assigned by the plan to each locality are the major factors which decide F.A.R. that can be permitted i n an area.
- F.A.R. values mainly determine the density or intensity of development of an area. Hence different F.A.R. values are prescribed for different locations in development plans.
- In brief; the permissible F.A.R. values are decided in relation to different inter-related aspects such as adequacy of water supply, sewerage system, solid waste disposal, road capacity, land availability, harmony with surrounding developments and other facilities, amenities and services.

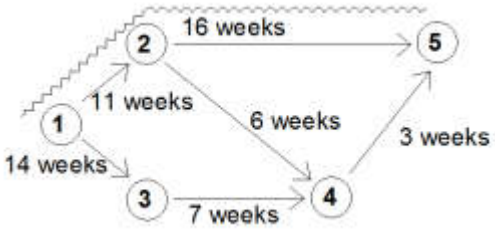
2. Unanswered

3. Answer (C) **The permissible height of a building on a plot is determined by abutting road width and floor area ratio**

4. Unanswered

5. Balanced Compositions in a square frame of 6 cm x 6cm as required:

6. Solution: 1 > 2 > 5 is the longest path and it should be given prime importance.

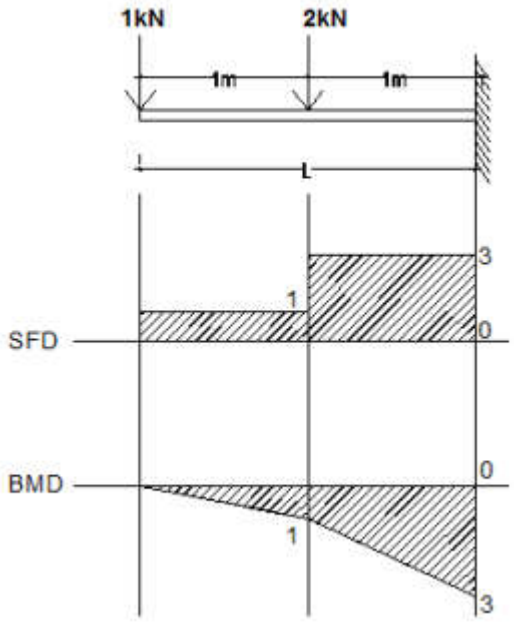


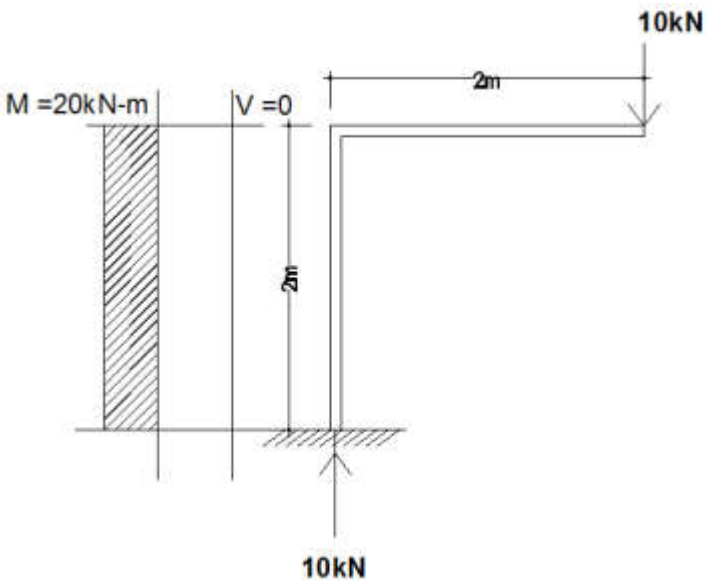
8. Volume of RCC slab = Slab area* Thickness = (3.5 m x 5.0 m) * (0.12 m) = 2.1 m^3
So, Quantity of steel = 0.8% of 2.1m^3*Density of steel = 0.0168m^3 *
Density of steel = 0.0168 m^3*7850 kg/m^3 = 132kg

Quantity of cement required = 2.1*6.2 bags = 13 bags
Quantity of sand required = 2.1*434 litres = 911.4 litres
Quantity of stone aggregates = 2.1*868 litres = 1822.8 litres

9. Unanswered

10. (a) The scale of the aerial photograph is 1:100000
(b) The total area of the settlement is 40000 hectares





Q3. B > E > H is the critical path.

GATE 1991

Q1. Answer (B) **Ratio 'Golden Mean' is 1 : 1.618.**

Q2. Current Demand = Population / Household size = 2,15,000 / 5 = 43,000 Houses
Housing Demand in 2001 = Population / Household size = 2,70, 000 / 4.5 = 60,000 Houses
Demand difference = 60,000 – 43,000 = 17,000 Houses

Initially we needed 43,000 houses but we had only 39,000. So, Initial Shortage = 43,000 – 39,000 = 4,000 Houses
Depleted Houses = 3,500 Houses
So, total demand = Demand difference + Initial shortage + Depleted houses = 17,000 + 4,000 + 3,500 = 24,500 Answer

Q3.