CHAPTER 15: BUILDING DRAWINGS

15.1 Introduction of the Unit of Learning

In this unit, the aspects of building design that involve preparation and interpratation of engineering drawings, including architectural drawings, structural and civil drawings,plumbing layouts, as well as electrical and mechanical, will be addressed based on principles of engineering design.

15.2 Performance Standard

Interpret architectural drawings, prepare structural and civil drawings, interpret electrical drawings, design plumbing layout, and interpret mechanical drawings according to the size of the proposed site, construction regulations, planning requirements and client specifications, architectural code of design, ***building code***, and local authority by laws, regulatory requirements.

15.3 Learning Outcomes

15.3.1 List of Learning Outcomes

a) Interpret architectural drawings
b) Prepare structural and civil drawings
c) Interpret electrical drawings
d) Design plumbing layout
e) Interpret mechanical drawings

15.3.2 Learning Outcome No 1: Interpret Architectural Drawings

15.3.2.1 Learning Activities

Learning Outcome No 1: Interpret Architectural Drawings	
 **Learning Activities**	**Special Instructions**
1.1 Identify **Construction dimensions** 1.2 Interpret architectural drawings	• CAD Software integration • GPS mapping • Reference codes

15.3.2.2 Information Sheet No15/LO1 Interpret Architectural Drawings

Introduction to learning outcome

Before implementing a project, the architect has to prepare architectural impression of what is to be built. This impression must have dimensions in SI units of length. The design must also conform to the set international standards of practice like the BS code, Euro codes and other local standards.

Definition of key terms

Project plan – A project plan is a document that displays the objectives and relays the scope, in a time frame, of all the activities that will be undertaken in a given project.

Building code – A building code is a set of regulations that govern and designate the standards for the construction of buildings/structures.

Site investigation – A site investigation is a process of collecting relevant information from a given site, analyzing and processing the information for the purposes of highlighting the unknown potential problem that lies underneath the site.

Content/Procedures/Methods/Illustrations

1.1 Identify Construction dimensions according to the size of the proposed site, construction regulations, planning requirements and client specifications, (vertical dimensions, horizontal dimensions)

Construction dimensions are numerical values expressed in an appropriate unit of measure and are indicated on drawings along with lines, arrows, symbols, and notes to define the size and specification of an object. Vertical dimensions are all dimensions that have their alignment at a right angle to a horizontal plane such that their top is directly above their bottom. Horizontal dimensions are all dimensions that have their alignment at a right angle to a vertical plane such that they are parallel to the horizon.

There are two standardized forms of dimensioning named:

- Linear dimensioning which involves displaying of dimensions along the X-Y axis. This form of dimensioning is made up of a dimension line, which is in between, and perpendicular to extension lines.
- Ordinate dimensioning is a form of dimensioning that displays the length along the X-Y axis with the use of a leader line.
  Radial dimensions use leader lines to measure ellipses, circles and arcs.

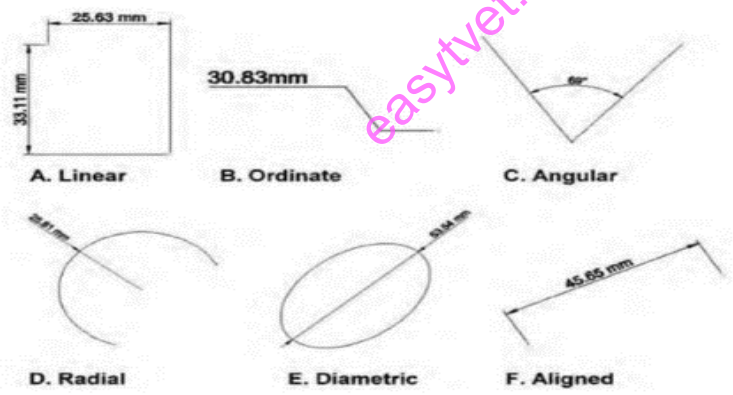


Figure 151: Different types of dimensions and diagram
Source: https://www.construction53.com/2011/08/understanding-dimensions/

1.2 Interpret architectural drawings in accordance with the architectural code of design, *building code*, local authority by laws, regulatory requirements and client specification, (BS 8110, Eurocodes, Kenya Building Codes, 1968 Civil engineering codes).

An architectural drawing is a specialized drawing that shows the views, sections and elevations of a structure/building. These drawings should conform to the mechanisms, design guidelines and standards put in place as a guideline in the production of architectural drawings.

Such mechanism exists as documents including the architectural code of design and the building code: BS 8110, Eurocodes, Kenya Building Codes, 1968 Civil engineering codes that provide regulations that govern and designate the standards for the drawing and construction of buildings/structures. Interpreting of Architectural plans requires one to be systematic and organized in order not to miss any piece of information provided. Here are some of the few guidelines one can adopt:

a) Start with the interpretation of the drawings from the upper left corner and hovering meticulously towards the right lower corner.
b) Read through the plan cover sheet since it contains a lot of information regarding the plans such as the projects information, architect, date, etc.
c) Forms of reference points such as structural references and a grid system may be used between sets of drawings and different professionals.
d) Review the plan index, which provides a list of all plan sheets.[1]
e) Begin with the site plan, which provides information on the plot boundary details and orientation.
f) You should be quite familiar with the symbol legend so that you may have a deeper interpretation on the plans through the symbols provided.
g) Before reading the actual architectural sheets always read the notes that communicate the design details via text to acquire a deeper interpretation.

Conclusion

This learning outcome has covered the basic aspects on how to interpret architectural drawings

Further Reading

Refer to Admin, (2011). *Understanding Dimensions,* http://www.construction53.com/2011/08/understanding-dimensions/, last accessed 23th June 2020. For further reading on construction dimensions and architectural drawings.

15.3.2.3 Self-Assessment

Written Assessment

1. Which of these is the SI Unit of length _____
    a) Centimetre
    b) Foot
    c) Inches
    d) Meter
2. Choose the term that best describes architectural drawings.
    a) Artistic
    b) Technical
3. State the different components found in an architectural drawing.
4. Differentiate between vertical and horizontal dimensions.
5. State the different codes one should observe when producing an architectural drawing.
6. Discuss the different types of building codes and their importance in the interpretation of architectural drawings.

Oral Assessment

Why are site investigations important?

Practical Assessment

Using the CAD software prepare the plan of a single room store with dimensions of your choice and clearly show the horizontal and vertical dimensions of the drawing.

Oral Assessment

What was observed as the difference in horizontal and vertical dimensions in the architectural drawing?

15.3.2.4 Tools, Equipment, Supplies and Materials

- Measuring and drawing tools
- Computers/internet
- Cad software
- Printers/plotting device

15.3.2.5 References

Admin, (2011).Understanding dimensions,http://www.construction53.com/2011/08/understanding-dimensions/last accessed 23th June 2020.

Akboy-Ilk, S. (2016). THE NATURE OF DRAWING IN THE CHANGING CULTURE OF ARCHITECTURAL DOCUMENTATION. Journal of Architectural and Planning Research, 33(1), 29-44. Retrieved June 23, 2020, from www.jstor.org/stable/44113126

BAUER, C., & Penner, B. (2020). ARCHITECTURE. In Modern Housing (pp. 212-223). Minneapolis; London: University of Minnesota Press. doi:10.5749/j.ctv11vcff7.23

15.3.3 Learning Outcome No 2: Prepare Structural and Civil Drawings

15.3.3.1 Learning Activities

Learning Outcome No 2: Prepare Structural and Civil Drawings	
Learning Activities	**Special Instructions**
2.1 Design Structural elements 2.2 Draw detailed plans and sections of designed elements 2.3 Bar bending schedule is prepared 2.4 Structural drawings are produced	• Reiterative allocation of rebar • Designing to standard codes of practice

15.3.3.2 Information Sheet No15/LO2 Prepare Structural and Civil Drawings

Introduction to learning outcome

Loading analysis - Loading analysis is performed in accordance with standard of practice, to come up with the reinforcement bar criteria and later on a bar bending schedule is prepared.

Structural detailing - Structural detailing is done to allocate the design rebar on to the structural drawing in accordance with the code of practice

Definition of key terms

Bar bending schedule – A list of reinforcement bars presented in form of a table that contains the details of the bars such as the diameter of the bar, the length of each bar, straight portions, angles of bending, shape of bending and the number of each type of bar.

Detailed plan – A technical drawing representing the layout of a structure, usually to scale, using set symbols where necessary to represents certain parts and showing specifications of precise dimensions.

Structural – Having structure or involving the mechanics of construction.

Content/Procedures/Methods/Illustrations

2.1 Design Structural elements according to the codes of practice (Slabs, Beams, Columns, Foundation, Stairs)

Slab design procedure:

i. Determine the condition of exposure of slab and assign nominal cover as per code of practice.
ii. Calculate the Design load, F.
iii. Calculate the ultimate bending moment, M_u.
iv. Calculate the lever arm, z, and Area of tension reinforcement A_s
v. Calculate the shear stress and check that it does not exceed design shear concrete stress.
vi. Check deflection and cracking requirements.
vii. Determine the diameter and spacing of links (reinforcement).

Beam design procedure:

i. Select concrete strength class, longitudinal & shear reinforcement grade, minimum member size and thickness of concrete cover.
ii. Estimate loads (dead & imposed) and calculate ultimate loads.
iii. Calculate design moment, M and design shear force.
iv. Estimate effective depth and width of beam.
v. Calculate ultimate moment of resistance, M_u
vi. Determine whether singly-reinforced or doubly- reinforced and design shear reinforcement accordingly.
vii. Check deflection
viii. Produce reinforcement details (diameter and spacing of links).

Column design procedure

i. Determine effective height of column.
ii. Determine whether short or slender.
iii. Calculate axial loading and check for buckling & compression failure.
iv. Produce reinforcement details.

Stairs design procedure

i. Determine thickness of concrete cover.
ii. Calculate design load & ultimate bending moment.
iii. Produce reinforcement details.
iv. Check for shear, deflection & cracking.

Foundation design procedure

i. Determine the design axial load, N.
ii. Determine plan area and dimensions of base.
iii. Determine self-weight of the foundation.
iv. Determine total ultimate load, W and Earth pressure ρ_s = W/Plan Area of base.
v. Calculate maximum design moment, $M = \frac{\rho s\ L2}{2}$
vi. Calculate ultimate moment M_u and determine whether compression reinforcement is required ($M_u > M$).
vii. Determine lever arm, z, and area of reinforcement, A_s.
viii. Calculate: punching shear, face shear and transverse shear.
ix. Produce reinforcement details.

2.2 Draw detailed plans and sections of designed elements as per dimensions and relevant standards

Once the design of the structural element is complete, a detailed drawing of the layout of the element must be produced on paper either manually or with the aid of Computer Aided Design software. Examples of these detailed plans are as follows:

- ✓ **Slab.**

The example below shows reinforcement details of an interior solid slab spanning 5000 mm, having a width of 175 mm and 20 mm nominal cover.

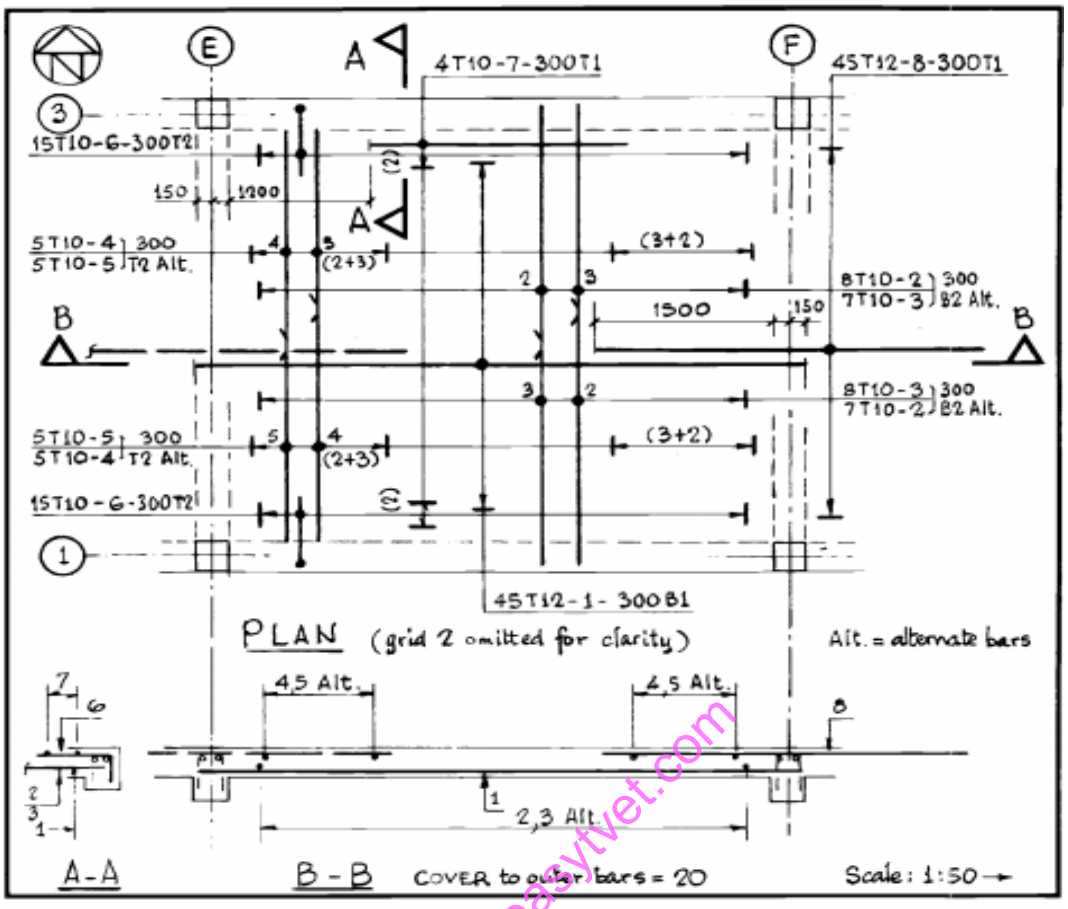


Figure 152: Designed elements as per dimensions and relevant standards

Source: Higgins, J.B. and Rogers, B.R., Designed and detailed (BS 8110: 1997), Crowthorne, British Cement Association, 1998.

- ✓ **Beam.**

The diagram below represents shows detailed plan of a two-way spanning flanged beam

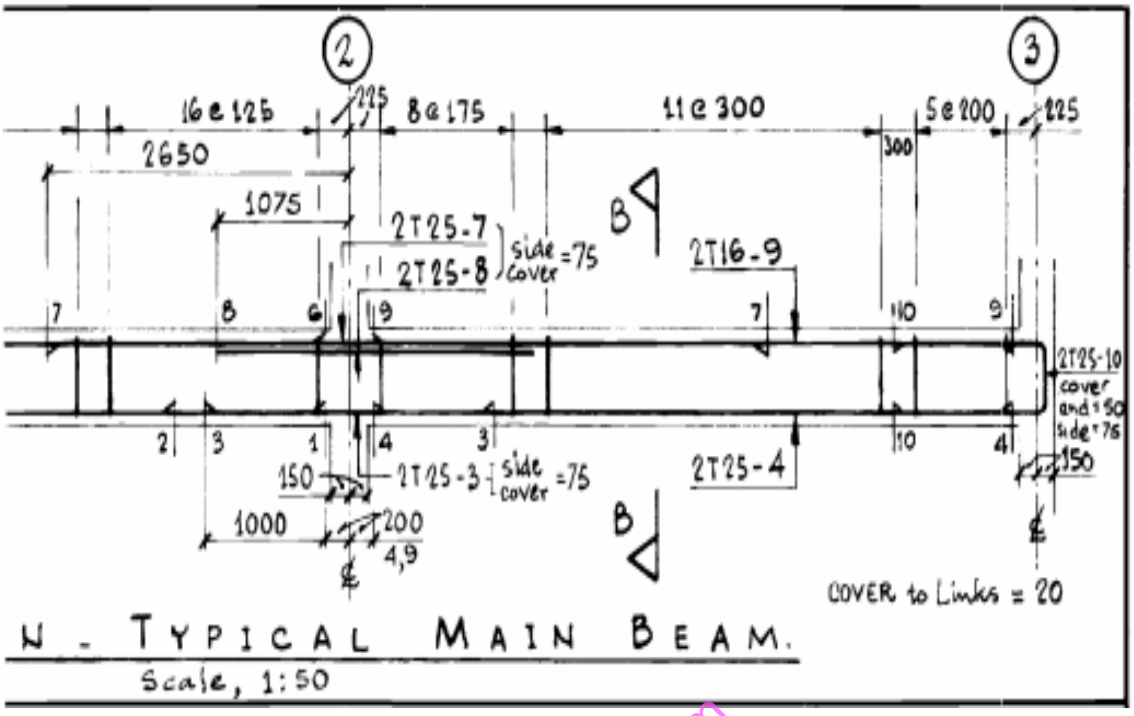


Figure 153: Detailed plan of a two-way spanning flanged beam

Source: Higgins, J.B. and Rogers, B.R., Designed and detailed (BS 8110: 1997), Crowthorne, British Cement Association, 1998.

- ✓ **Column.**

The schematic below shows sections in their relative positions adjacent to their vertical reinforcements. The tabular presentation adapts to element repetition.

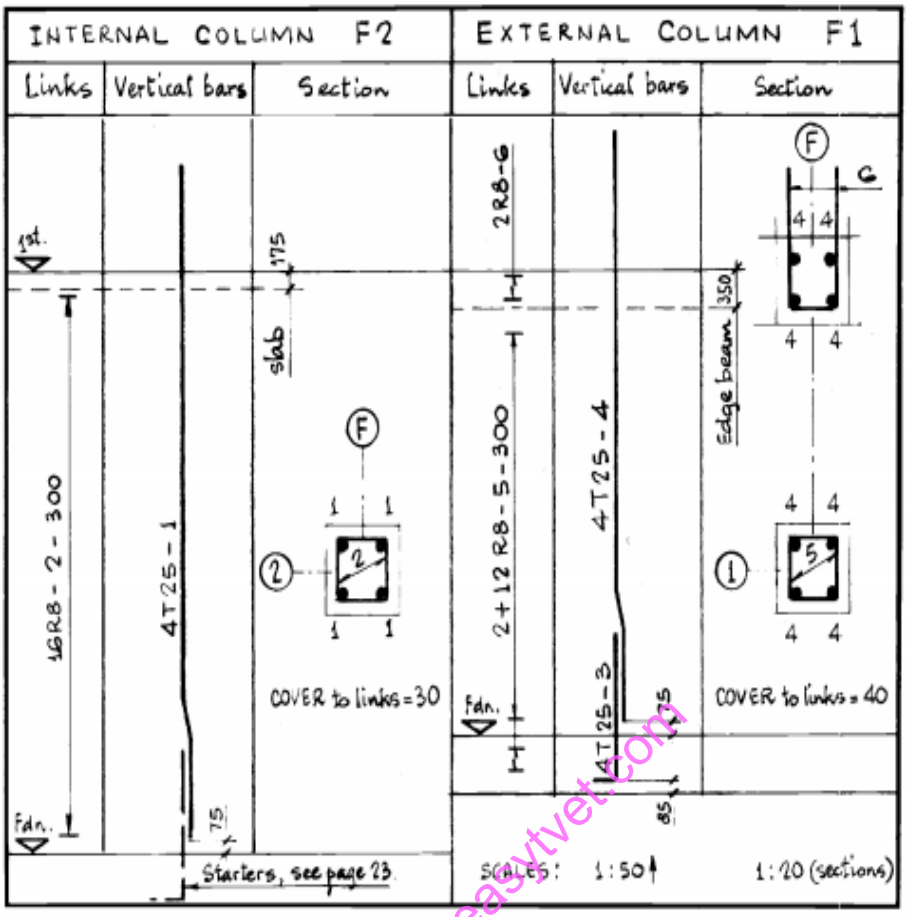


Figure 154: Relative positions adjacent to their vertical reinforcements

Source: Higgins, J.B. and Rogers, B.R., Designed and detailed (BS 8110: 1997), Crowthorne, British Cement Association, 1998.

- ✓ **Staircase.**

The following sketch shows the reinforcement details of an end-span continuous slab (staircase) with 20mm nominal cover.

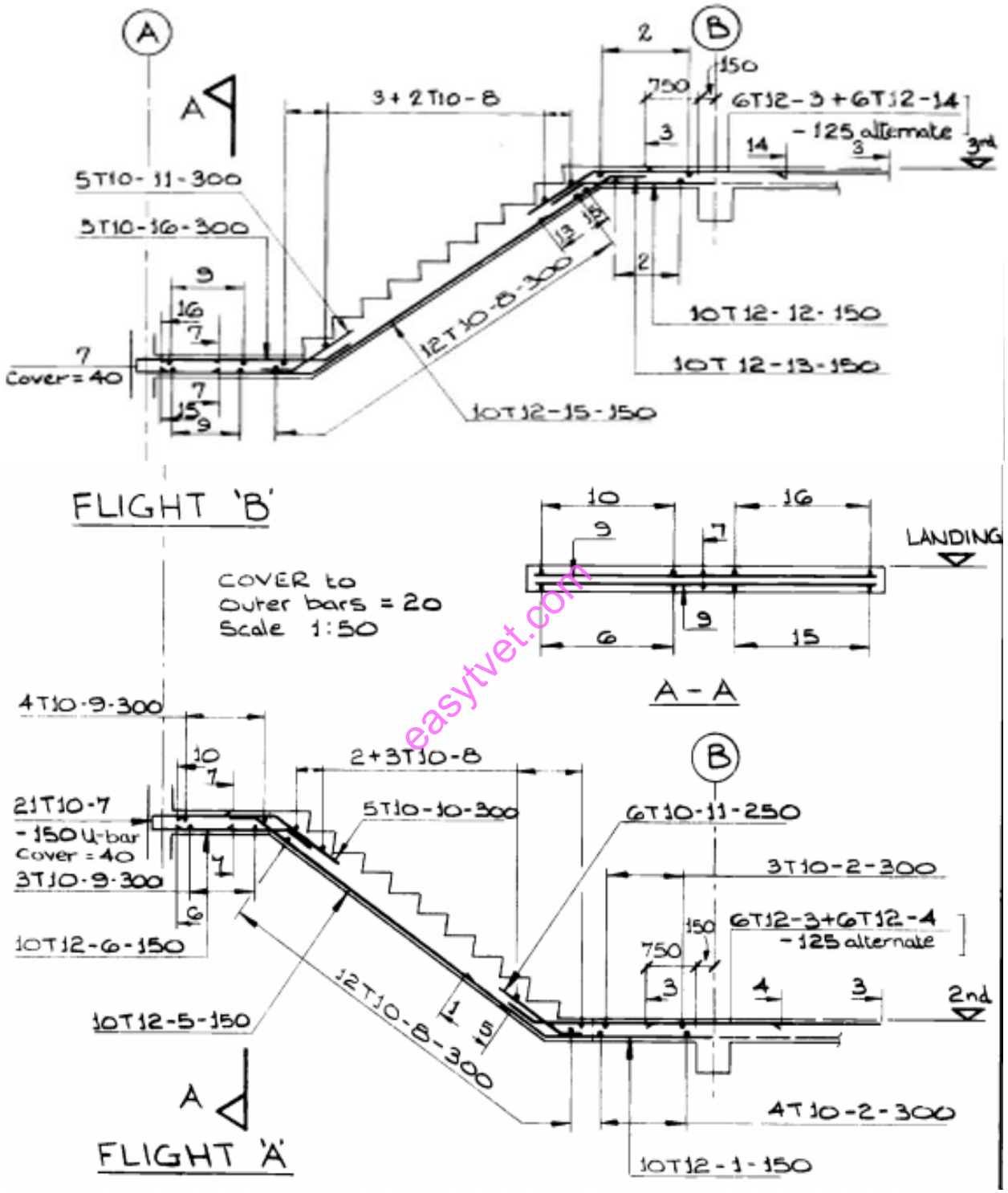


Figure 155: Reinforcement details of an end-span continuous slab (staircase) with 20mm nominal cover

Source: Higgins, J.B. and Rogers, B.R., Designed and detailed (BS 8110: 1997), Crowthorne, British Cement Association, 1998.

✓ **Foundation.**

The following is a 2750 × 600 reinforced pad footing.

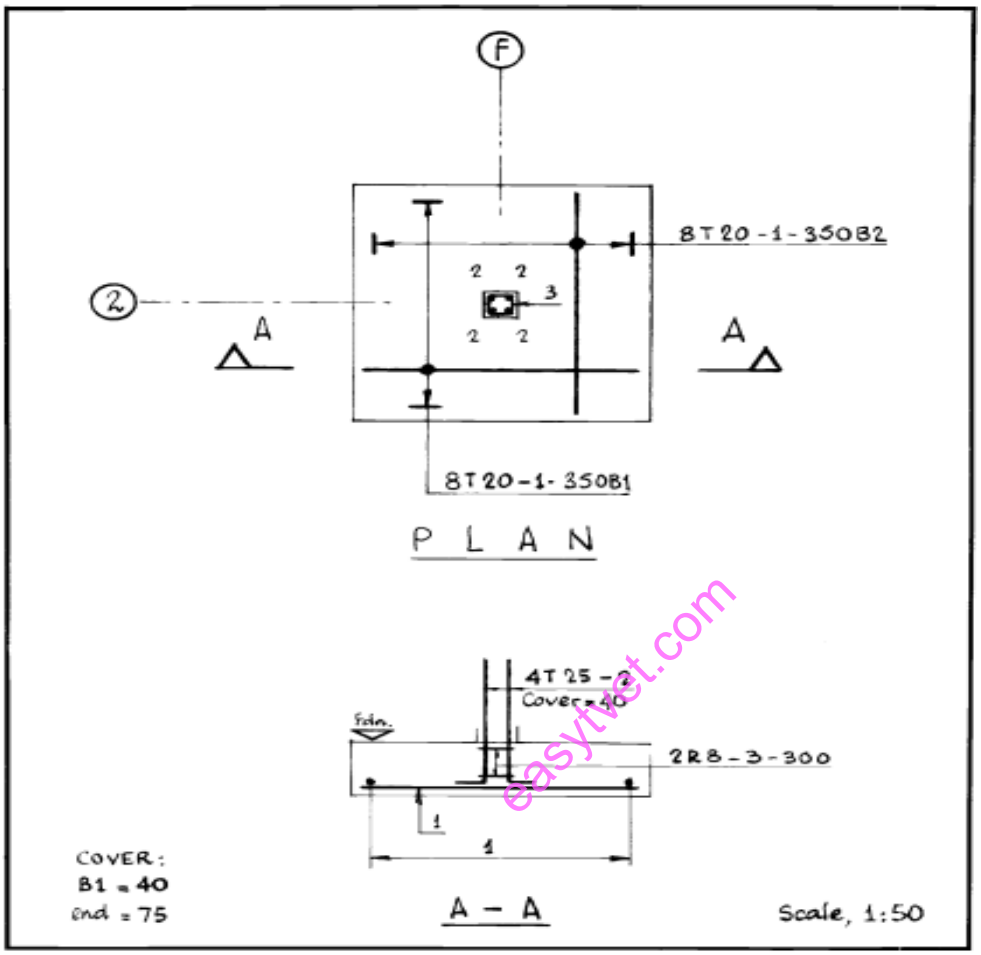


Figure 156: 2750 × 600 reinforced pad footing

Source: Higgins, J.B. and Rogers, B.R., Designed and detailed (BS 8110: 1997), Crowthorne, British Cement Association, 1998.

2.3 Prepare Bar bending schedule as per the code of practice

Bars should be grouped together for each structural element.

Bar Bending Schedule contains the following basic items: the member, description, bar No., spacing, bar shape, No. of bars, cut length, total length, No. of items and total weight as indicated in the example shown below:

Table 35: The member, description, bar No., spacing, bar shape, No. of bars, cut length, total length

Civil4M Solutions LLP

Forum Project

Address of the Project

Bar Bending Schedule

Name of the Project :	Sample Project				Location :	https://civil4m.com									Drawing No :	You can write the ref. drawing numbers at here							
Prepaired by :	Dnyan				Level :	Learning at 100.00 meter										and here too							
Checked by :	You				Structure :	Sample Structure Tower No 01									Date:	The date on which you prepared it							
Sr No	Member	Shape of Bar	Bar Mark	Dia. of Bar	Diamensions of bar in meter										No of Members	Bars Per Member	Total No of Bars	Total Cutting length of bars in meter							
					a	b	c	d	e	f	45° 0.25	90° 0.5	180° 1	Cut Length				6	8	10	12	16	20	25	32
1	Column 1 (0.2 x 1 x 3m)																								
	Verticals		V1	25	3									3.000	4	10	40							120	
	Stirrups		St	8	0.1	0.16	0.92	0.16	0.92	0.1		5		2.340	4	30	120		280.8						
	Hooks		Hk	8	0.1	0.16	0.1					1	1	0.348	4	60	240		83.52						
2	Slab S1 (3 x 3 x 0.15)																								
	Bottom Long		BtL	12	0.1	2.95	0.1					2		3.138	2	20	40				125.52				
	Bottom Short		BTS	12	0.1	2.95	0.1					2		3.138	2	20	40				125.52				
	Top long		TL	10	0.1	2.95	0.1					2		3.140	2	20	40			125.6					
	Top Short		TS	10	0.1	2.95	0.1					2		3.140	2	20	40			125.6					
	Chairs		Ch	12	0.2	0.4	0.2					4		0.776	2	10	20				15.52				

Source: www.civil4m.com

2.4 Produce Structural drawings in accordance with building code, local authority by laws, regulatory requirements and client specification

The structural drawings can be produced manually or with the aid of computer softwares such as AutoCAD, Inventor, ArchiCAD, etc. Once produced, they must be approved by the county planning department before a building is erected. This ensures that the building is constructed in line with certain requirements such as public health, the environment, land rates etc. all the relevant departments must approve the drawings before onset of construction.

Conclusion

This learning outcome encompassed the details on how to prepare structural and civil drawings including: how designs should be done in line with codes of practice, how detailed plans should be drawn, preparation of bar bending schedules and approval of structural drawings by relevant departments.

Further Reading

Bond, A.J. et al., How to design concrete structures using Eurocode 2, The Concrete Centre, 2006

Read on bar bending schedule step by step preparation at www.civildigital.com or on www.quora.com.

15.3.3.3 Self-Assessment

Written Assessment

1 The following are structural elements except?

a) Slab.
b) Plan.
c) Column.

2. Structural elements can either be vertical or horizontal. Among the following, which is the vertical element?

a) Beam.
b) Slab.
c) Column.

3. Explain Cutting length, bending angle and bar shape in a bar bending schedule. Justify

4. Elabourate how structural drawings should be produced

5. Some of the codes of practice used in Kenya are listed below. Which one is false?

a) BS 8110 for reinforced concrete.
b) BS 5950 for steel work.
c) BS 5950 for unreinforced masonry.

6. For a building to be approved, the drawings must satisfy the requirements of the following departments EXCEPT?

a) Planning.
b) Agriculture.
c) Public health.

7. Differentiate beam and a slab in their structural element whereas a column and retaining walls are vertical elements

Essay questions

Summarize the procedure of designing a beam.

Summarize the differences between British Standards and Eurocodes as codes of practice used in the design of structural elements.

Oral Assessment

Explain the procedure of designing a slab.

Summarize some of the basic items that are provided in a bending schedule.

Practical Assessment

Prepare a one-page bar bending schedule for a two-storey building to be done in your local area.

15.3.3.4 Tools, Equipment, Supplies and Materials

- Measuring and drawing tools
- Computers/internet
- Printers/plotting device
- Cad tools

15.3.3.5 References

Allen, E. & Iano, J., (2013). Fundamentals of Building Construction: Materials and Methods, 6th edition. Hoboken, New Jersey: Wiley.

Arya, C., (2009). Design of structural elements: Concrete, Steelwork, Masonry and Timber Designs to British Standards and Eurocodes, third edition. New York: Taylor & Francis.

Geren, R., (2016). Applying the Building Code: Step-by- Step Guidance for Design and Building Professionals (Building Codes Illustrated), 1st edition. Hoboken, New Jersey: Wiley.

15.3.4 Learning Outcome No 3: Interpret Electrical Drawings

15.3.4.1 Learning Activities

Learning Outcome No 3: Interpret Electrical Drawings	
Learning Activities	**Special Instructions**
3.1 Sketch Electrical circuits drawings 3.2 Draw Electrical connection layout	• Network modeling software • Demonstration by trainer • Filed trip

15.3.4.2 Information Sheet No15/LO3 Interpret Electrical Drawings

Introduction to learning outcome

In this section, the architectural drawing is still used in conjunction with the electrical code to come up with the electrical circuit diagrams.

Definition of key terms

Circuit diagram- This is simply a graphical representation of an electrical circuit.

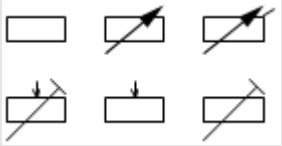
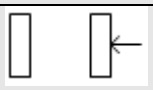
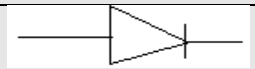
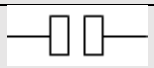
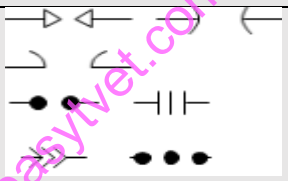
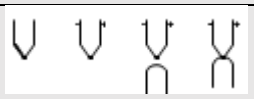
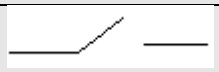
Layout- This is a diagram that makes use of electrical symbols and shapes to represent electrical devices and shows the entire wiring system of a structure such as housing unit.

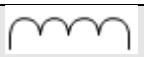
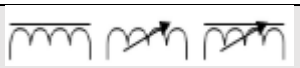
Content/Procedures/Methods/Illustrations

3.1. Sketch Electrical circuits drawings in accordance with the electrical code of practice and the architectural layout

- To be able to sketch electrical drawings, one must first get familiar with standard electrical symbols used in electrical engineering. This makes understanding of the circuitry easier.
- There are numerous electrical symbols in use today. These symbols may vary from one region to another.
- One electrical device may have several different representations.
- Some of the most commonly used electrical devices, their functionality and symbols are shown below.

Table 36: Electrical devices

Device	symbol	Alternative symbol	Functionality
Lamp			Produces light when electrical current flows through it.
Battery			Provide source of current.
Resistor			Reduces current flow.
Fuse			Stops flow of current when the intensity of current exceeds set value thus protecting electrical circuits.
Diode			Allows current flow in one direction
Ground/ Earth			Electrical shock protection and zero potential reference point.
Surge protector			Protects a circuit from a spike / surge in voltage.
Antenna			Marks a device, rod, or wire designed to capture radio and electromagnet waves into electrical signals and vice versa.
Circuit breaker			Protects an electrical circuit against damage caused by overload or short circuit.
Oscillator			Produces a repetitive electronic signal i.e. sine wave or square wave.
Thermocouple			Converts temperature difference at junction terminals to a voltage
Switch			Disconnects the current when open.
Capacitor			Stores electrical charge. Used with a resistor in timing circuits.

Inductor / coil			Stores energy in a magnetic field or flux.

- The example shown below illustrates a simple Surface installation of one lamp controlled by two, two- way switches.

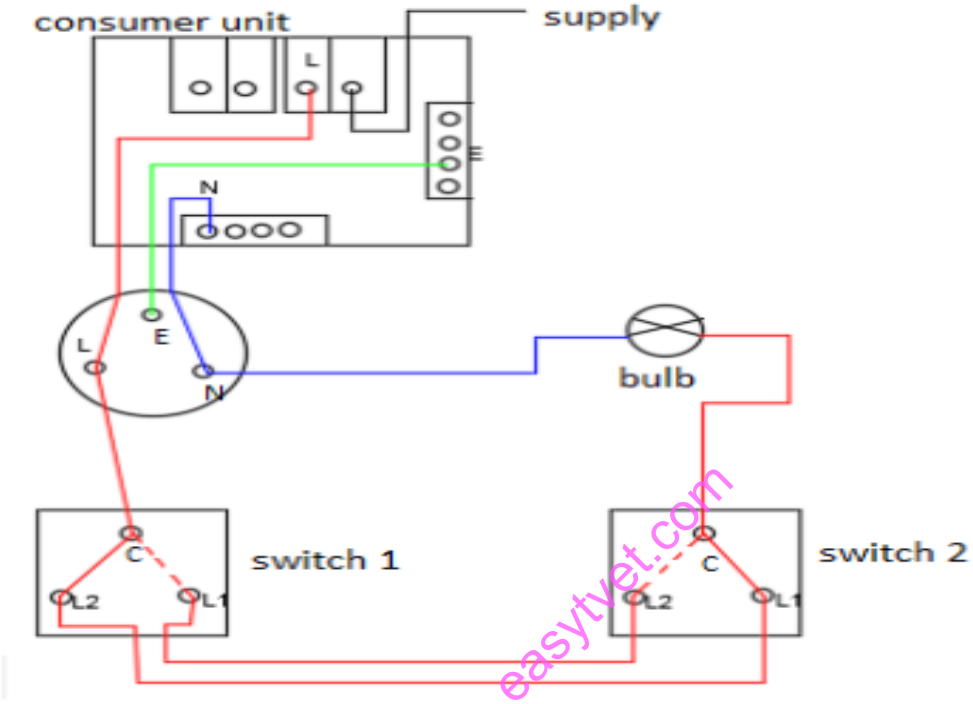


Figure 157: a simple Surface installation of one lamp controlled by two, two- way switches

3.2. Draw Electrical connection layout in accordance with the electrical code of practice

- After understanding all the symbols used in electrical circuitry, one may then draw a layout diagram easily.
- The diagram is provided with a legend/ key listing all the symbols used in drawing the layout to be able to assist one in interpreting the circuit.
- See the following example of a circuit diagram:

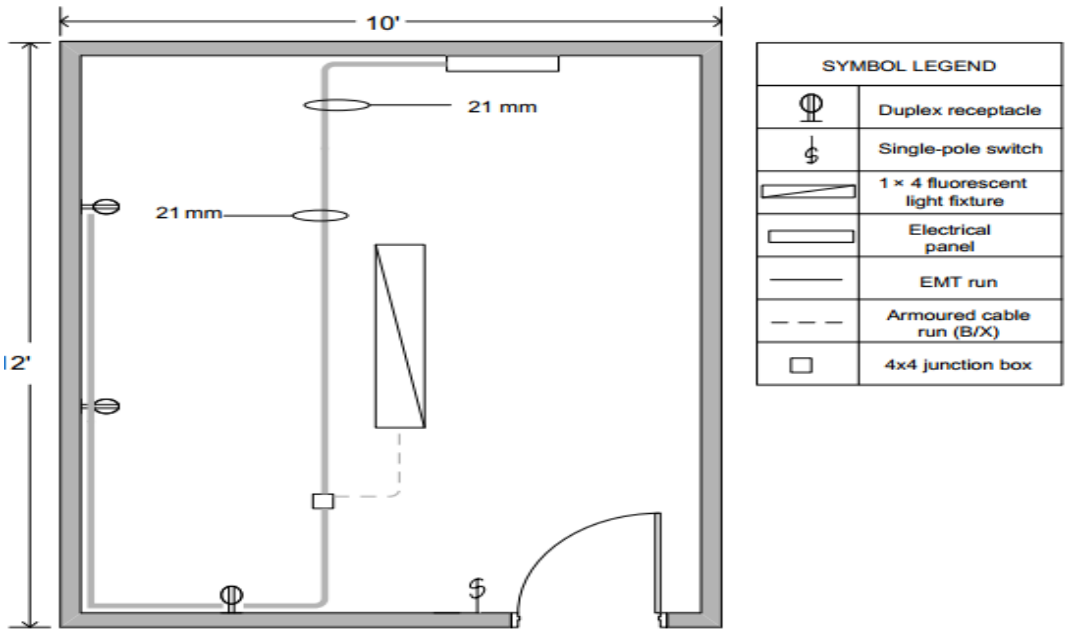


Figure 158: Circuit diagram

Source: https://mytrainingbc.ca.

- ✓ The following example illustrates a simple Surface installation of a ring socket. A ring socket outlet is an arrangement of sockets such that a ring of wires from a consumer unit go through all the sockets, each at a time, then back to the consumer unit. The ring is usually fed from a protective device located in the consumer unit, usually a fuse or a circuit breaker of rating about 32A. Wiring is done using a 2.5mm2 cable.

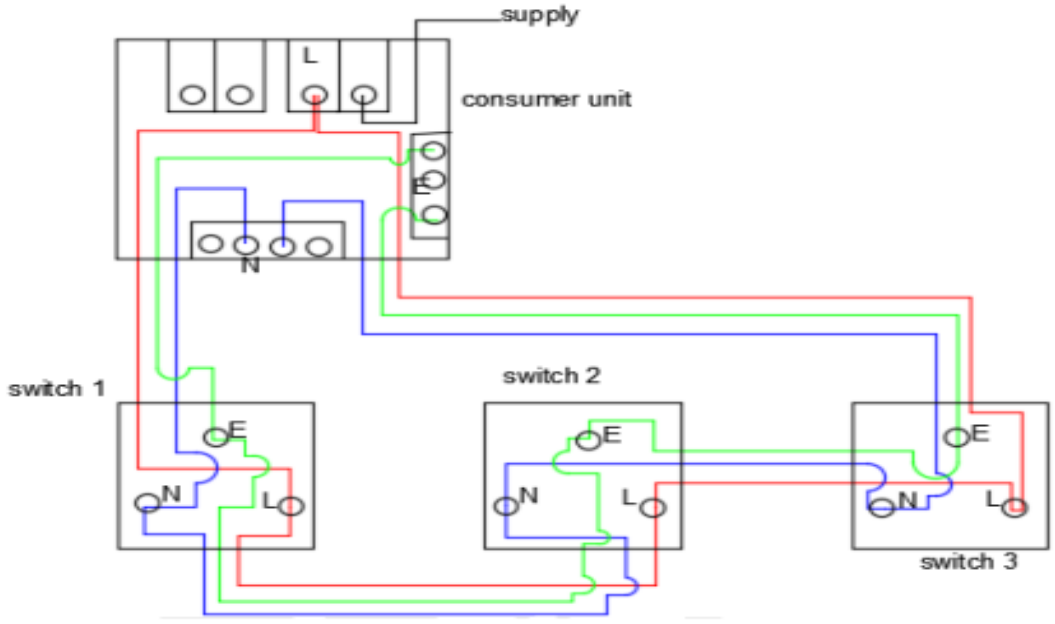


Figure 159: Simple Surface installation of a ring socket

Conclusion

This learning outcome reviews the basics on how to interpret electrical drawings which revolve around being able to identify every distinct electrical device and its interconnection with other devices in the circuit.

Further Reading

How to Read Electrical drawing – Edraw (https://www.edrawsoft.com).
Typical Electrical Drawing Symbols and Conventions – NRC (https://www.nrc.gov).
Alexander, C.K. & Sadiku, N.M., (2013). *Fundamentals of Electric Circuits, 5th edition*. New York, USA: MacGraw-Hill Companies Inc.

15.3.4.3 Self-Assessment

Written Assessment

1 Arrowheads placed on circuit line generally represent?
   a) Indicates the room in which the circuit is installed
   b) Indicates the circuit to be controlled by a wall switch
   c) Indicates the direction of current flow

2. Explain the electrical circuits diagrams bellow?
   a) Schematics and Pictorials
   b) Architectural diagrams

3. Electrical symbols are represented using?
   a) Pictorials
   b) Schematics
   c) Graphics

4. Identify the electrical device that is incorrectly matched with its functionality?
   a) Push button – momentarily allows current flow when button is pushed in, breaks current when released
   b) Antenna – Used for protection

5. The work of a Surge protector is to?
   a) Change AC voltage from high to low and vice versa
   b) Store electric charge and generate constant voltage
   c) Protect a circuit from a spike in voltage

6. Explain the work of a Diode is to?
7. The following symbol represents which electrical device?

a) Fluorescent fixture.
b) Flood Light.

8. Evaluate the various symbols used to indicate a fuse.
9. Color plays an important role in electrical code of practice, explain briefly?
10. Differentiate between an electrical circuit and a circuit diagram.
11. Differentiate between a lamp and a flood light by their symbols?

Essay questions

Draw and label at least fifty electrical symbols used in code of practice.
Draw a circuit diagram with two outlets that require separate circuits for a fridge and a dishwasher that go directly back to panel?

Oral Assessment

Differentiate between an electrical circuit and a circuit diagram.
Differentiate between a thermostat and rheostat?

Practical Assessment

Design a wiring diagram from a switch box running two lights. Include a Legend.

Project Assessment

Visit a nearby factory, study the electrical wiring diagram of the factory plant and see whether you understand it completely. Consult the Factory Engineer where necessary and try reproducing the same diagram in CAD, having understood it.

15.3.4.4 Tools, Equipment, Supplies and Materials

- Codes of practice
- Mechanical conventions,
- Workstation
- CAD & GIS Software

15.3.4.5 References

Alexander, C.K. & Sadiku, N.M., (2013). Fundamentals of Electric Circuits, 5th edition. New York, USA: MacGraw-Hill Companies Inc.

Robertson, C.R., (2008). Fundamentals of Electrical and Electronic Principles, 3rd edition. Oxford: Elsevier.

How to Read Electrical drawings; Retrieved from https://www.edrawsoft.com

Typical Electrical Drawing Symbols and Conventions Retrieved from (https://www.nrc.gov).

Standard electrical symbols for electrical schematic diagrams; Retrieved from https://www.edrawsoft.com/electrical-symbols.html

15.3.5 Learning Outcome No 4: Design Plumbing Layout

15.3.5.1 Learning Activities

Learning Outcome No 4: Design Plumbing Layout	
 **Learning Activities**	**Special Instructions**
4.1 Identify building dimensions 4.2 Determine pipe sizes are 4.3 Determine pipe types and	• Sketch up software • Mathematical models • Practical exercise • Demonstration by trainer

15.3.5.2 Information Sheet No15/LO4 Design Plumbing Layout

Introduction to learning outcome

The plumbing layout will portray the orientation of the various pipe sections as they may appear superimposed on to the architectural drawing and structural drawings. The components are sized depending on the water demand of the building with respect to the consumptive use and future projections of population.

Definition of key terms

Building dimensions- is a numerical value defined in appropriate units and used to express the size, location, orientation, form or geometric properties of any part of a building.

Pipe– is a hollow tube with circular cross section for transportation of fluids (gases and liquids).

Content/Procedures/Methods/Illustrations

4.1 Identify Building dimensions as per the architectural drawings, structural and electrical drawings.

There are several standard forms of dimensions:

i. Linear dimensions;
   Measures the distance between points especially those in a line.
   These are used for measuring and displaying length along the horizontal or vertical axis.
   Are axial measurements either Y or X direction.

ii. Radial Dimensions
   Measures the radius of circular dimensions and displaying them with a leader line.
   This dimension is designated using an R followed by the value.

iii. Ordinate dimension- axial measurements are displayed as text using a leader..

Dimensions is composed of two parts; nominal value and a componential value which varies either higher or lower than the nominal value.

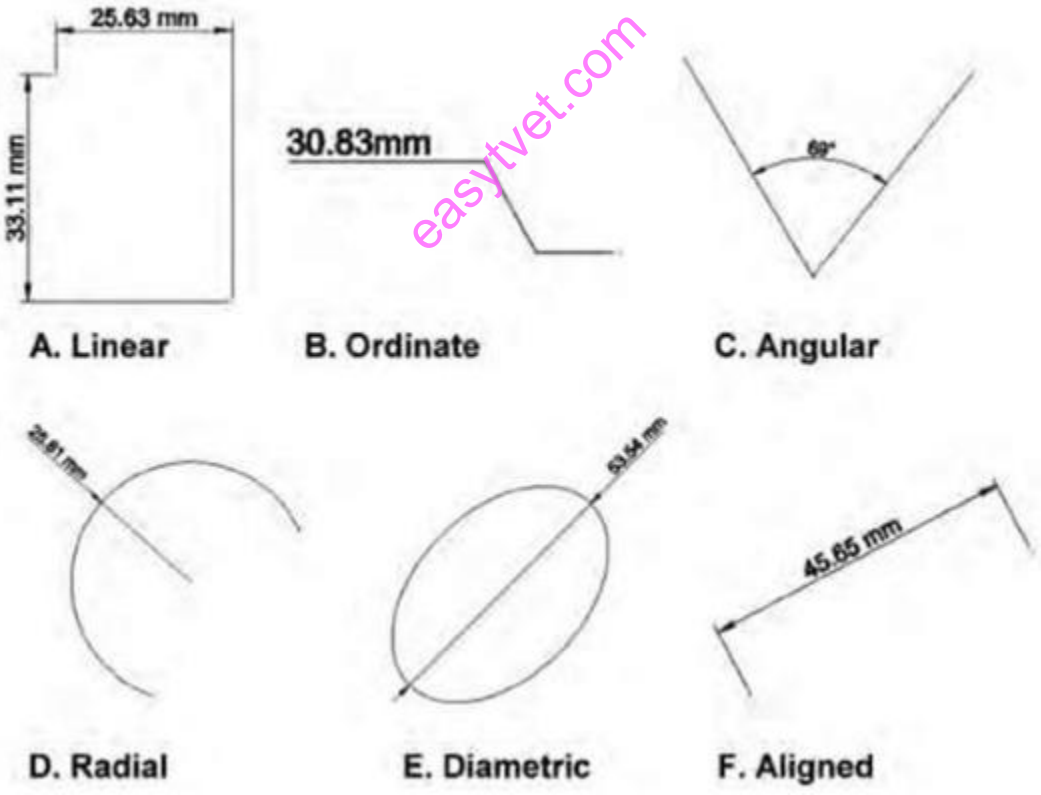


Figure 160: Ordinate dimension- axial measurements are displayed as text using a leader
Source: https://www.construction53.com/2011/08/understanding-dimensions/

4.2 Determine *Pipe* sizes are as per consumption (PVC, GI pipes, Mild steel, PPR)

Pipe sizing is used to determine the amount of fluid that can be supplied at a given rate. There are several ways of calculating pipe sizes for example determining friction head loss, sizing from velocity, determining pipe sizes arithmetically and many more.

Calculation of pipe size arithmetically

Information required include;

u = Flow velocity (m/s)
v_g = Specific volume (m³/kg)
$\dot{m}_s$ = Mass flowrate (kg/s
$\dot{V}$ = Volumetric flowrate (m³/s) = $\dot{m}_s \times v_g$

From this information, the cross sectional area (A) of the pipe can be calculated:

$$\text{Cross sectional area (A)} = \frac{\text{Volume flowrate } (\dot{V})}{\text{Flow velocity (u)}}$$

$$\text{i.e.} \quad \frac{\pi \times D^2}{4} = \frac{\dot{V}}{u}$$

Rearranging the formula to give the diameter of the pipe (D) in metres:

$$D^2 = \frac{4 \times \dot{V}}{\pi \times u}$$

Figure 161: Calculation of pipe size arithmetically
Source;spiraxsarco.com/learn-about-steam/steam-distribution/pipes-and-pipe-sizing.

Example

A process requires 5 000 kg/h of dry saturated steam at 7 bar g. For the flow velocity not to exceed 25 m/s, determine the pipe size.

Where:

Flow velocity (u) = 25 m/s
Specific volume at 7 bar g (v_g) = 0.24 m³/kg
Mass flowrate ($\dot{m}$) = 5 000 kg/h or 1.389 kg/s
Volumetric flowrate = $\dot{m} \times v_g$
Volumetric flowrate = 1.389 kg/s x 0.24 m³/kg
Volumetric flowrate = 0.333 m³/s

Therefore, using:

$$\text{Cross sectional area (A)} = \frac{\text{Volumetric flowrate } (\dot{V})}{\text{Flow velocity (u)}}$$

$$\frac{\pi \times D^2}{4} = \frac{\dot{V}}{u}$$

$$D^2 = \frac{4 \times \dot{V}}{\pi \times u}$$

$$D = \sqrt{\frac{4 \times \dot{V}}{\pi \times u}}$$

$$\text{Pipe diameter (D)} = \sqrt{\frac{4 \times 0.333}{\pi \times 25}}$$

Figure 162: Example of Calculation of pipe size arithmetically
Source; spiraxsarco.com/learn-about-steam/steam-distribution/pipes-and-pipe-sizing

Alternative pipe sizing methods

Procedure for sizing pipes.

i. A favorable diameter is assumed.
ii. An assumed size is always determined and proven to contain the expected flow.
iii. A flow rate is determined with considerations.
iv. Instead of maximum flow, it is designed for peak flows based on probability theory.
v. Use of charging units;
    - A charging unit is a number given to an appliance relating flow rate to the length of time while being used and probable usage.
vi. In case of continuity in flow
    - Automatic reservoirs must be considered as continuous flow instead of applying probability theory. For such appliances the full design flow rate for the outlet fitting must be used.
vii. Obtain the intended flow rate by adding (a) and (b).
    - The intended flow rate is the summation of the flow rate determined from charging units and the continuous flows.
viii. Effective pipe length determination
ix. Measured pipe length is determined;
x. Work out the pipe length for fittings that is equivalent;
    - Resistances to flow in fittings are conveyed in terms of length of pipe having similar resistance to flow as that of the fitting.
xi. Equivalent pipe length for draw for draw-offs is determined;
xii. By adding (d), (e) and (f), you obtain the effective pipe length.
    - Summation of the pipe length measured (d) and the equivalent pipe lengths for fittings (e) and draw-offs (f) gives effective pipe length.
xiii. Acceptable or permissible head loss is worked out:

xiv. (h) Available head is determined from the previous data and workings:
xv. Head loss per meter runs through pipes is determined;
xvi. (j) Determine the head loss through fittings;
xvii. (k) Followed by calculation of head loss through fittings on the pipe.
    - Permissible head loss= (m/m run)

xviii. Pipe diameter is then determined:
xix. Check whether the pipe size will give the intended flow rate in (C) without excess head loss.

- PVC

  They are different types depending on wall thickness: Low, Medium and high grade.

- PVC schedule

Is the thickness of the PVC pipe wall, mostly are 40 and 80. As the schedule gets larger the wall gets thicker from outside.

- Galvanised Iron pipes
  For corrosion protection, it is dipped into zinc and is used for water pipe lines.
  Used for distribution treated or raw water in rural or urban areas. These are cheaper, lightweight and easy to handle.
- Mild steel pipes
  These type of pipes are made of low carbon steel and due to this they do not harden and are usually easy to use. These type of pipes are strong in tension hence can withstand high pressure but not heavy loading as pumping main.
  Their major applications include supply of drinking water, fire fighting and HVAC systems.

- PPR
  This type of pipes refer to those made of Polypropylene Random Copolymer. They are usually made for hot and cold water supply and other heating applications. They have their uses varying from civil buildings such as hospitals, apartments, schools etc., commercial buildings such as hotels, restaurants, offices etc., to industrial buildings such as factories, air conditioning etc.
  The common outer diameter specifications of PPR water pipes are 20mm, 25mm,

Conclusion

Under this study the methods explored were centered on how to Design plumbing layout.

Further Reading

Explore additional ways of determining pipe sizes
Practice reading metric pipe schedule.

15.3.5.3 Self-Assessment

Written Assessment

1. Which is not a characteristic of plumbing application pipes.
    a) Pressure rating (Psi)
    b) NPS
    c) Length of pipe
    d) Manufacturers brand name
2. What is the most likely risk of injury when cutting large diameter pipes?
    a) You may damage your muscle due to continued use
    b) You may cut yourself
    c) Trapping of fingers
    d) A sharp metal may fly off and cause damage
3. State the safest mode of transportation of PPR pipes and Mild steel pipes based on their sizes and specifications.
4. Explain type of pipe is used below and above the ground?

Essay question

Students have been asked to determine pipe sizes of certain pipes provided. Use one method and describe the procedure.

Oral Assessment

1. Explain what scheduling entails
2. Explain how does poor pipe sizing affect building
3. Students have been asked to join plastic soil pipes in the space of a building using a strong hazardous solvent yet they've not been provided with Respiratory Protective equipment, what should you do

Project Assessment

Design a two-bedroom house so as to appreciate various building dimensions.

15.3.5.4 Tools, Equipment, Supplies and Materials

- Codes of practice
- mechanical conventions,
- workstation
- CAD & GIS Software

15.3.5.5 References

Jim J. Williams, Labouratory plumbing 101. Basharkhah Engineering, Inc
William p. Spence, (2000) Architectural working drawings. North Carolina: Wiley

15.3.6 Learning Outcome No 5: Interpret Mechanical Drawings

15.3.6.1 Learning Activities

Learning Outcome No 5: Interpret Mechanical Drawings	
Learning Activities	**Special Instructions**
5.1 Obtain Mechanical component dimensions 5.2 Identify ***Mechanical components*** 5.3 Interpret Mechanical drawings	• Open source modeling software • Numerical analysis

15.3.6.2 Information Sheet No15/LO7 Interpret Mechanical Drawings

Introduction to learning outcome

In this review the design of mechanical components starts with the identification and sizing of the components in accordance with the provided architectural and structural drawings, while making relevant referencing from the design codes of practice.

Definition of key terms

Mechanical drawing: Is a drawing of mechanical or architectural structures drawn to scale and with the use of precision instruments.

Specifications: Are information which describe the products, materials and work required by a construction contract.

Content/Procedures/Methods/Illustrations

5.1 Obtain Mechanical component dimensions as per structural and architectural drawings

Mechanical component refers to any single part of a machine (not programmable/ not digital) that is visible and when subjected to forces runs a machine.

Examples of mechanical components are;

- Bearing
- Shafts
- Bolts
- Nails
- Blades
- Cover
- Rods
- Gears

- Pulleys
- Chains

There exist conventions that that both a drafter and the interpreter of architectural and structural drawings.
The following therefore should be taken into consideration;

- Feet and inches both need to be shown for example 5 ft, 5 inch; even if the dimensions have no value, the 0 remains part of designation.
- The lines of dimensions are continuous with the number being placed at the center or placed slightly above the line or broken at the center and the number placed.
- Inches are used when the dimensions are too small.
- Dots, arrowheads or slashes are put at end of the dimension lines to show the extent of dimension.
- Irrespective of the scale used, dimension lines indicate actual building sizes.
- Dimension of doors is also shown in the floor plan symbol or represented by the door symbol.
- On plan views, dimension giving location are provided at the centerlines of both openings.
- To eliminate confusion with other dimension lines curves are used.

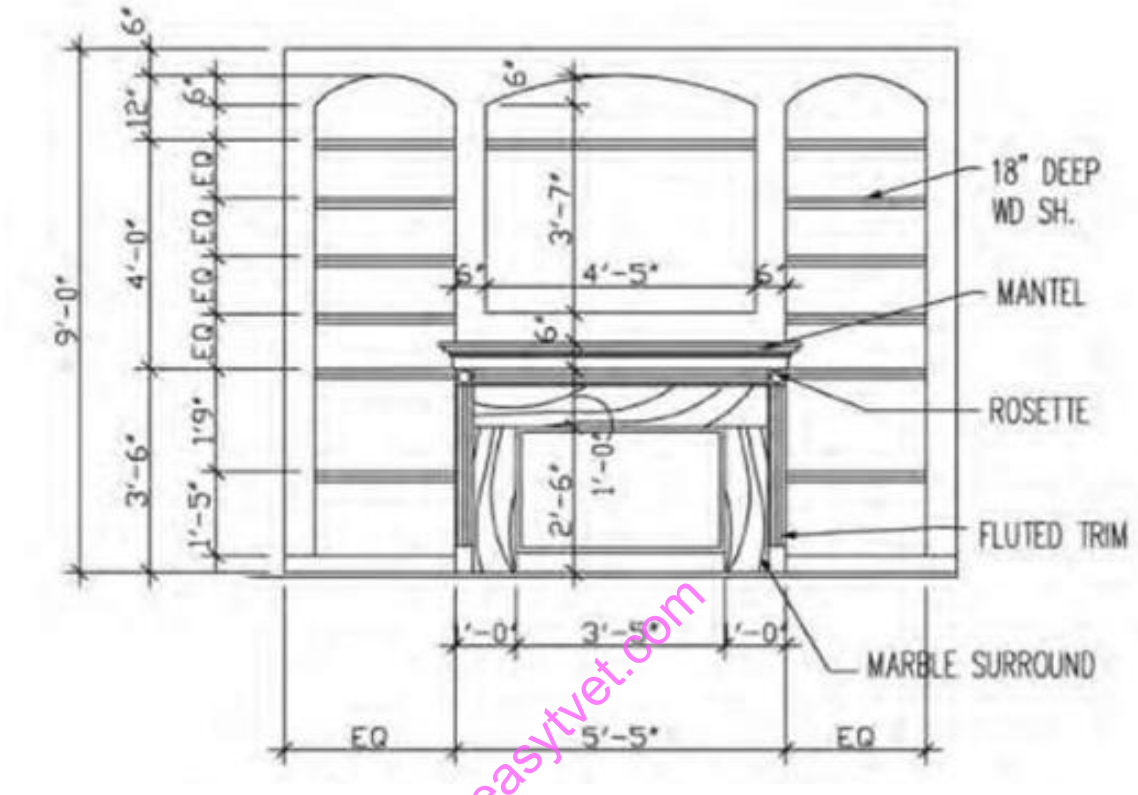


Figure 163: Dimensions
Source: https://www.construction53.com/2011/08/understanding-dimensions/

Mechanical components include various categories as follows:

i. Fasteners
   The diameter is typically measured on the outside of the threads.
   They include nuts and bolts, screws, pins and rivets.
   Size; for most consists of three parts i.e. diameter, length and thread count.
ii. Nuts and washers.
   Their sizes are the same the diameter of the fastener they are meant to work with.
   Hence a 0.5inch washer fits 0.5inch bolt/ screw.
iii. Bolt
   Is a form of a threaded fastener with external male thread. Strength and circumstance determine material selection for bolts.
   Example of bolts include blind bolts, hex bolts, anchor bolts, carriage bolts and double end bolts.
iv. Joints -a section of a machine which is used to connect one or more mechanical parts to another. Integral joints include seams, shrink-fits and crimps.

5.2 Identify *Mechanical components* as per architectural and structural drawings (Union, Bends)

1. Union- Connects two pipes and allows for future disconnection for maintenance.

Used in pipe systems to link straight sections of pipe or tube and are flexible to accommodate different sizes or shapes and fluid flow regulation.

Consists of three parts: a nut, female and a male end.

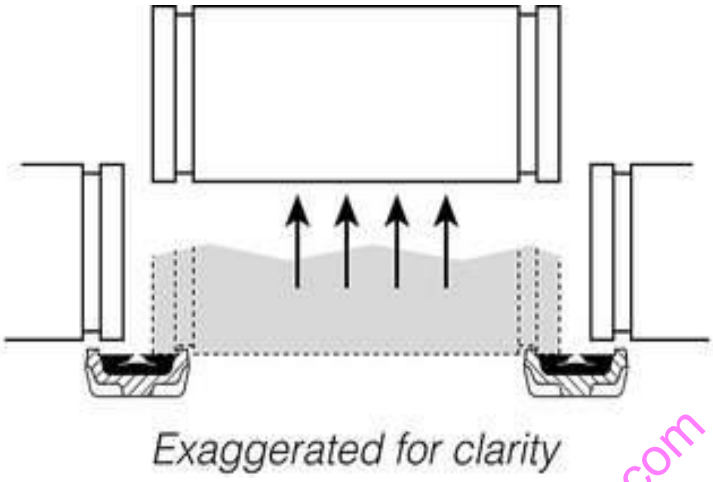


Figure 164: UNION

Source:https://media5.picsearch.com/is?Vd_nAZZ1cV1rnb7UevBg-VooU7uuVweHEizBErqw3E&height=194

2. Bends- is a device shaped with a bending to retain fluid. Traps are usually U, S, Q or J shaped. Bend is an offset or change in direction of in pipe networks.

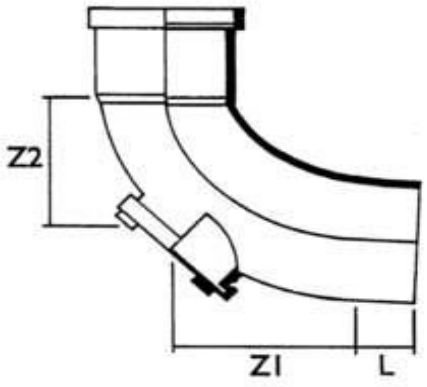


Figure 165: BENDS

Source:https://media1.picsearch.com/is?ByImvXIB5qUVwCWAmlgwmqWzPMz8hj72adZWCTmffcw&height=255

5.3 Interpret Mechanical drawings as per specifications

Interpretation of mechanical drawings depicts the major mechanical and electrical components in a building system or any kind of system, the links and the sensors placed for collection of data and monitoring of operation process. The components have an input and output which are sampled by the sensors and instruments so as to evaluate performance of the component to be evaluated and to determine adjustments needed. The components are represented symbolically and flow paths are usually depicted using distinctive line convention.

- For interpretation, conversion of mechanical drawings to CAD (Computer Aided Design) must be enabled and thus the following are required:
    i. Accuracy
    Converted information must be compatible to the input system.
    ii. Ability to recognize complex entities
    iii. Use of all properties.
- Reasoning on blocks
  The drawing is divided into various blocks whose relative position to one another has a technological meaning.
- Correction and conversion to CAD

Conclusion

The mechanical components to be constructed have been subjected to rigorous and ingenious process that starts with learning how to interpret mechanical drawings

Further Reading

How to obtain size of various mechanical components based on mechanical drawings.
Numerical analysis

15.3.6.3 Self-Assessment

Written Assessment

1. What is the first step in a mechanical drawing process
    a) Brainstorm solutions
    b) Prepare rough sketches
    c) Prepare a budget

2. Identify Critical issue drafters need to pay attention to
    a) Size of the sheet
    b) Designers intentions
    c) Scale of drawing
3. The size (diameter) of the hole in which the split pin is to be put is when D is the diameter of the hole.
    a) 0.1D
    b) 0.12D
    c) 0.4D
    d) 0.3D
4. Evaluate different types of mechanical components
5. Differentiate between mechanical drawing and fine art

Essay questions

Evaluate the process of interpretation of engineering drawing

Project Assessment

Perform a mechanical drawing of pip networks

15.3.6.4 Tools, Equipment, Supplies and Materials

- Codes of practice
- mechanical conventions,
- workstation
- CAD & GIS Software

15.3.6.5 References

Moubray, J. (2001). Reliability-centered maintenance. Industrial Press Inc.

Hillier, S., Grimmer-Somers, K., Merlin, T., Middleton, P., Salisbury, J., Tooher, R., & Weston, A. (2011). FORM: an Australian method for formulating and grading recommendations in evidence-based clinical guidelines. BMC medical research methodology, 11(1), 23.

Kilgarriff, A., Baisa, V., Bušta, J., Jakubíček, M., Kovář, V., Michelfeit, J., & Suchomel, V. (2014). The Sketch Engine: ten years on. Lexicography, 1(1), 7-36.