Solar PV System Installation and Maintenance

Level-II

Learning Guide -35

Unit of Competence	Carry out Civil Work for PV Installation
Module Title	Carrying out Civil Work for PV Installation
LG Code	EIS PIM2 09 LO1 LG-35
TTLM Code	EIS PIM2 TTLM 0120V1

LO1.Plan and prepare

Instruction Sheet	Learning Guide: - 35

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:-

- Obtaining working instructions
- Occupational Health & Safety (OH&S)
- Identifying Signage/barricade requirements
- Selecting Plant, tools and equipment
  - ✓ Carrying out tasks in consistent with the requirements of the job
  - ✓ 1.4.2. Checking for service ability and any faults
  - ✓ 1.4.3. Rectifying or reporting prior to commencement

- Calculating material quantity requirements based on plans/specifications
- Identifying materials appropriate to the work
- Environmental protection requirements

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:-

- Obtain working instructions
- Occupational Health & Safety (OH&S)
- Identify Signage/barricade requirements
- Select Plant, tools and equipment
- Calculate material quantity requirements based on plans/specifications
- Identify materials appropriate to the work
- Environment protection requirements

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, Sheet 5, Sheet 6 and Sheet 7 in pages 3, 5, 10,13, 24, 28 and 31 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 Self-check 5 Self-check 6, Self-check 7 in pages 4, 9, 12, 23, 27, 30 & 32 respectively

Information Sheet-1	Obtaining working instructions

1.1 Definition of obtaining working instructions

A Work Instruction is a document that provides specific instructions to carry out an Activity. A Work Instruction is a step by step guide to perform a single instruction. A Work Instruction contains more detail than a Procedure and is only created if detailed step-by-step instructions are needed Inspect, then store purchased components in a secure, dry place.

- Read the installation guides
- Devise a safety plan
- Set up your staging area and logistics
- Assemble the tools you'll need
- Measure out and install the mounts
- Install the racking and equipment grounding wire
- Install the micro inverters (if applicable), then the modules
- Mount your central inverter (if using one), junction box and other electrical devices
- Install conduit
- Run the wire and make all the electrical connections
- Affix all required safety/danger labels
- Connect your systems monitoring gear (if any)

Whenever you're given instructions for a task or project, you'll need to make sure that you clearly understand what you have to do. Instructions may be provided in written or verbal form, or sometimes a mix of the two. Being able to give and receive instructions effectively is an important part of communication on the worksite. Here are a few tips to help you out if you're given instructions that are unclear or incomplete or if you have trouble understanding them.

- Take notes. It's hard to remember everything by keeping it in your head. Writing a few notes helps remind you what needs to be done.
- Ask questions. Don't be afraid to ask for more information or for clarification on something. Something simple like, 'I don't quite get what you mean by or Could you tell me a bit more about how to is a good way to get the details you need.
- Be aware of language. You may be teamed up with people from other countries or cultures who don't speak English as well as you do. This can sometimes make communication difficult, but be patient. Listen carefully, speak clearly, take notes and ask questions until both you and the other person(s) are sure the instructions and/or information have been communicated correctly.
- Confirm the instructions before you start the task. Never walk away feeling unsure about what you've got to do. A good way of confirming is to say something like, 'OK, before I go, I'll just check I've got this right…', then refer to your notes, run through the key points or steps, and ask for confirmation that you've got all the information you need.
- Sequence the instructions. Putting instructions and/or steps into the order you'll be completing them makes them much easier to follow

Self-Check – 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. say true or false for the following question below

1. A Work Instruction is a document that provides specific instructions to carry out an Activity.
2. A Work Instruction contains more detail than a Procedure

Note: **Satisfactory rating - 2 points** **Unsatisfactory - below 1 point**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-2	Following Occupational Health and Safety (OH&S)

2.1 OHS

OHS is to be in accordance with state and territory legislation and regulations and project safety plan and may include the following Solar Power Safety Rules to Minimize Your Risk

- Wear all necessary protective safety clothing including work clothes that fit well and allow you to move easily and freely, non-slip shoes, insulating gloves and a helmet.
- The first safety rule to keep in mind when working with photovoltaic panels or other PV components is, always stop working in bad weather. PV panels can be blown around by the wind or a storm which can result in you falling or damage to the PV system.
- Do not apply pressure on PV photovoltaic panels by sitting or stepping on them or they might break and cause bodily injury, electrical shock or damage to the solar panels. Also never drop anything on the PV panels.
- Through the entire process of photovoltaic solar installation, make sure you don't get the home's sheathing wet or your roof may leak thereafter. This is usually an issue with roofs that are just being built, but it can happen to older roofs too, if you have missing shingles or if you remove them at any point.
- Make sure that the roof where you'll be mounting your solar panels is strong enough to support the weight.
- This next pv safety rule could save your life. Make sure your entire PV system is properly and safely earth grounded to prevent electrical shock and injury.
- Always follow all the specific applicable electric codes for your area.
- Never work when it's raining, immediately after rain or in wet or slippery conditions or with wet tools.
- Never install a PV system near flammable gases or you could cause a fire or explosion.
- Cover your photovoltaic solar panels with an opaque material during wiring to stop or prevent electricity production.
- Also never touch any electrical contacts or wiring without proper protection and safety gear.
- As a basic rule, do not work on solar PV systems alone, always have a least one other person with you in case of accident or emergency.
- Inspect all your ladders and scaffolding and insure that they are safe and in proper working order.
- Be very careful of falling objects and do not ever throw objects up or down when installing a PV system.
- Always protect your wires or cables with flexible metal conduit when wiring through walls, for wires exposed to sunlight, rain or anywhere outdoors. Failure to follow this photovoltaic solar safety rule can result in electrical shock or short circuit. You can learn more about how to install conduit by clicking here to go to the Installing Conduit section of our website.
- Use waterproof fittings or duct seal to prevent water from entering the conduit and damaging your photovoltaic system.
- Always connect a grounding wire from the mounting hardware to the earth to prevent shock.
- A safe PV system is installed according to applicable building codes and standards.

- PV installer safety includes considerations for a safe work area, safe use of tools and equipment, safe practices for personnel protection, and awareness of safety hazards and how to avoid them.
- The installation of PV systems involves a number of safety hazards, principally electrical and fall hazards.

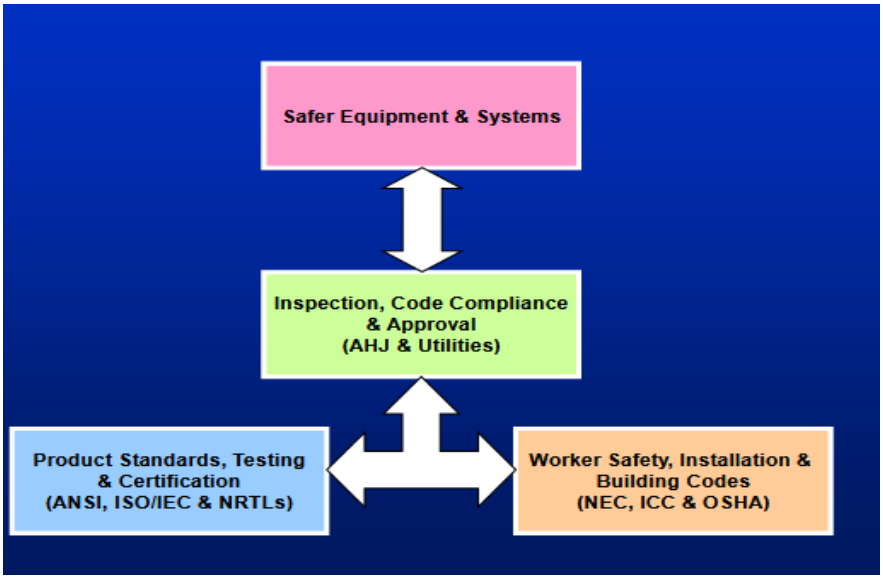

Figure 1: Worker Safety, Installation and Building Codes

2.2 OSHA: Occupational Safety and Health Administration

- Hazard Assessment and Training
- Personal Protection Equipment
- Employer and Employee Responsibilities
- Electrical Hazards

Fire Protection and Prevention

The employer is responsible for developing a fire protection program.

- Providing access to firefighting equipment at all times without delay.
- All firefighting equipment shall be conspicuously located.
- Periodically inspections and maintenance required.
- Defective equipment shall be immediately replaced

Figure 2: fire extinguisher

- **Fall Hazards**

Figure 3: Personal Fall Arrest Systems

- **Stairways and Ladders**

Ladders

- ❖ Ladders must be kept in a safe condition and free from slipping hazards.
- ❖ Area around the top and bottom of a ladder must be kept clear.
- ❖ Rungs, cleats, and steps must be level and uniformly spaced
- ❖ Use ladders only for designated purpose.

Figure 4: ladder

- ✓ Scaffolding
- ✓ Power Tools
- ✓ Materials Handling
- ✓ Excavations
- ✓ NEC: National Electrical Code (NFPA 70)
- ✓ ICC: International Code Council

Figure 5: Pre-Installation - Devise a safety plan

Always use some form of fall protection when working on the roof.
The ladder should be secured to the top of the roof.

Self-Check – 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. say true or false for the following question below

1. Using waterproof fittings or duct seal is to prevent water from entering the conduit and damaging your photovoltaic system
2. Installing a PV system near flammable gases could not cause a fire or explosion.
3. A safe PV system is installed according to applicable building codes and standards
4. Responsible employer will be Provide access to firefighting equipment at all times without delay.
5. No need of using some form of fall protection when working on the roof.

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 2 points**

Score = _____

Rating: _____

Answer Sheet

Information Sheet-3	Identifying Signage/barricade requirements

3.1 Barricading controls shall be implemented and authorized as part of the safe work system to protect persons from hazards such as:

- being struck by falling objects;
- being struck by moving plant;
- Fall from height, including falling into open excavations, penetrations, and falls from unprotected edges such as removed flooring, walkways, stairs and / or hand railings.
- Exposure to hazardous chemicals etc.
- Selecting Plant, tools and equipment

Figure 1: danger sign

3.2 Safety Signage Requirements

Safety signs are erected to warn workers or the public of specific hazards and to communicate necessary precautionary measures and emergency actions. Safety signage, in accordance with Queensland Work Health and Safety Regulation 2011, is required for:

- construction sites;
- confined spaces;
- asbestos;
- hazardous areas;
- hazardous chemicals;
- site specific Personal Protective Equipment (PPE) requirements;
- fire protection equipment;
- emergency and first aid information;
- emergency eyewash shower; and
- traffic management and pedestrian control

3.3 The location of signs:

- Must be in visible location where everybody can see it.
- Must be in safe location which doesn't make any risk for workers.
- If it will be possible out of direct sunshine to preventing any destroy.
- Be in location with suitable luminance and luminance without any severe shade.
- Mustn't be covered by any objects such as trees or so on.
- Doesn't obstruct the road or accesses or makes problem for transportation.
- Must has enough space for installing of signs

Table 1: colour sign/coding

Color	Meaning or Purpose	instruction &Information	Intrinsic Features
RED	Prohibition/ Danger alarm	Dangerous behavior; stop; shutdown; emergency cut-out devices; evacuate	Round shape; black pictogram on white background; red edging and diagonal line; red part to be at least 35% of the area of the sign
YELLOW Or AMBER	Warning	Be careful; take precautions; examine	Triangular shape; black pictogram on yellow background with black edging; yellow part to be at least 50% of the area of the sign
GREEN	Emergency escape; first aid. No danger	Doors; exits; escape routes equipment and facilities Return to normal	Rectangular or square shape; white pictogram on green background; green part to be at least 50% of the area of the sign
RED (firefighting signs)	Fire fighting equipment	Identification & location	Rectangular or square shape; white pictogram on red background; red part to be at least 50% of the area of the sign

Self-Check – 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. say true or false for the following question below

1. Safety signs are erected to warn workers or the public of specific hazards
2. The location of signs must be in visible location where everybody can see it.
3. the red color on sign location indicates danger

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 points**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-4	Selecting Plant, tools and equipment

4.1 plants

The term ‘plant’ refers to machinery, equipment and apparatus used for an industrial activity. Typically, in construction, ‘plant’ refers to heavy machinery and equipment used during construction works.

- **Construction plant** is generally re-useable, and so as well as being purchased new, it may be purchased second hand or hired. The Construction Plant Hire Association suggest that, ‘The UK plant hire industry is the best established and most professional in the world, and is worth over £4 billion to the UK economy.
- **Plant equipment** Personal property of a capital nature, consisting of equipment, furniture, vehicles, machine tools, test equipment, and accessory and auxiliary items, but excluding special tooling and special test equipment, used or capable of use in the manufacture of supplies or for any administrative or general plant purpose.

Considerations when using construction plant

Construction projects, in particular, large and complex projects, are increasingly dependent on **construction plant**, and there are a wide range of issues that need to be considered in its use:

- Public safety, employee safety and CDM. See below for more information.
- Type of applications.
- Program, lead times and continuity of use.
- Crane zones and lifting operations.
- Emissions.
- Storage and theft.
- Insurance.
- Power and fuel.
- Maintenance and breakdowns.
- Standards and regulations.
- Nuisance (noise, vibration, dust and so on). See below, and see Nuisance in Construction for more information).
- Logistics, access, segregation and diversions. See Site layout for more information.

Complex plant may have additional service requirements, some of which might be provided by the plant supplier:

- Design.
- Site accommodation.
- Operation.
- Communication links.
- Transportation.
- Fabrication and installation.
- Temporary services.

Importance of Tools and Equipment

Proper tools and equipment are essential for the effective operation of any civil works site. Equipping the construction site with the correct tools and equipment plays an essential role in achieving timely and good quality results. For every construction activity there is an optimal

combination of tools, equipment and labour. Depending on the nature and content of the works, the technical staffs once on site, equipment requires trained operators and supervisory staff who are proficient in its operation and maintenance. Needs to know which tools to use and how to effectively combine them with manual labour

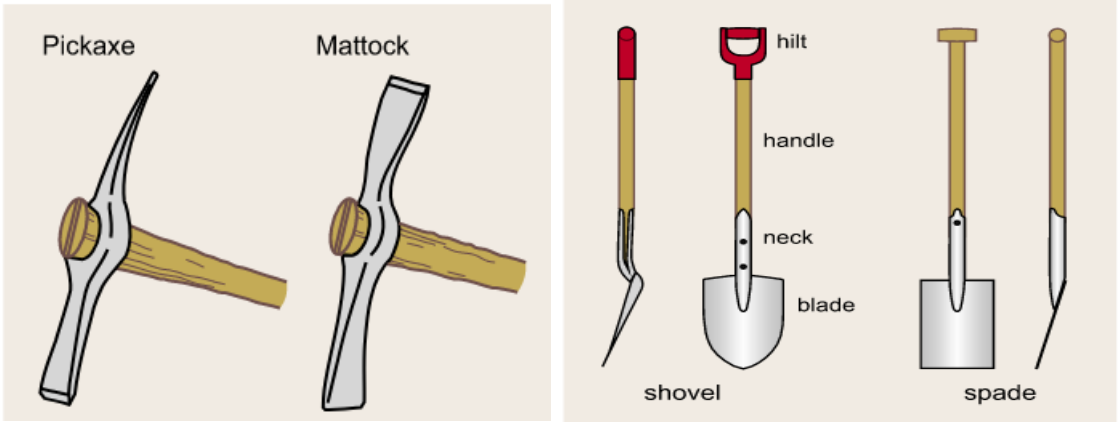

Figure 1a : tools & equipment

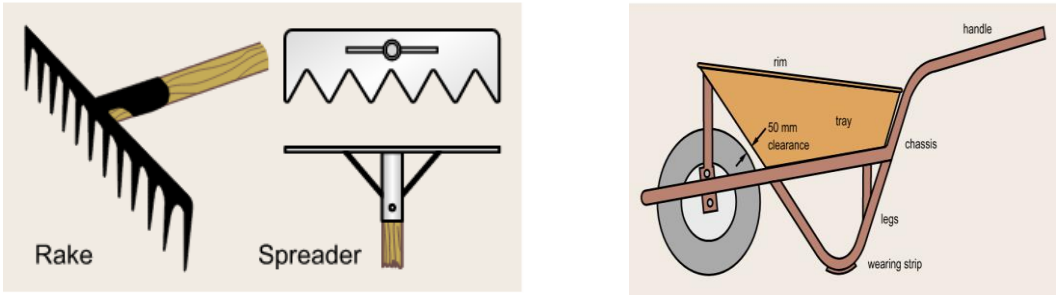

Figure 1b : tools & equipment

- **Other examples tools on site solar installation**:

  - ✓ Clamp meter
  - ✓ Screw drivers
  - ✓ Notepad
  - ✓ Pencil
  - ✓ Spare GFDI fuses

Figure 2 : Equipment, Machinery and Materials

Construction work has undergone major changes. Once dependent upon craftsmanship with simple mechanical aids, the industry now relies largely on machines and equipment.

New equipment, machinery, materials and methods have contributed to the industry's development. As time went on, the industry began using prefabricated construction units along with new techniques in the construction of buildings.

Instead of small, basic materials, such as bricks, tiles, board and light concrete, prefabricated construction units are commonly used today. Equipment has expanded from simple hand tools and transport facilities to complex machinery. Similarly, methods have changed, for instance, from wheel barrowing to the pumping of concrete and from manual lifting of materials to the lifting of integrated elements with the assistance of cranes.

4.2 Carrying out tasks in consistent with the requirements of the job System installation:

Step by step Attaching the Roof Hooks

To assist orientation, the position of the modules can be drawn on the roof using chalk. Where the roof hooks are going to be fitted, the roof tiles must be removed so that the rafters of the roof structure are visible at the designated points. The roof hooks are positioned so that the leg lies over the wave trough of the roof tile below and the mounting plate is located across the full width of the rafter. If the roof hook does not clear the tile surface by at least 5mm, it must be shimmed. Most manufacturers provide suitable shim plates.

The roof hooks are then fixed to the rafters using two timber screws (minimum screw diameter of 8mm, with a length of 80mm). Pre-drilling the holes in the rafters and lubricating the screws makes it easier to screw them in and helps to prevent them from shearing off. The screws should be screwed into the rafters to a depth of at least 60mm to 80mm. If insulation is located over the rafters, correspondingly longer screws must be used. Note that instead of roof hooks, it is also possible to use fixing tiles

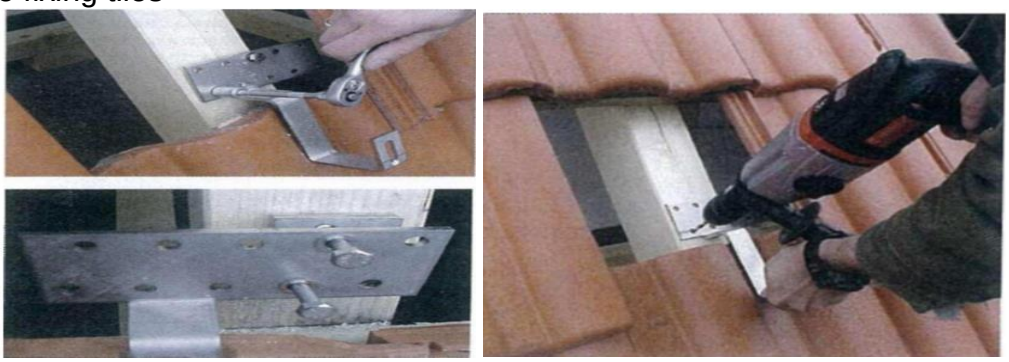

Figure 3 : fixing tiles/drills

- **Tile cutting**

The tiles that were lifted must lie flush on the roof tiles below and at the side when they are put back in their original places. The leg of the roof hook will prevent this with tiles that are grooved at the top and bottom. The roofer or installation engineer needs to cut or abrade these tiles so that they fit together cleanly again. Depending upon the roof tile, only the top tile or possibly both tiles will need to be adapted. Then the tiles that were removed can be replaced again. Next, the roof cover is sealed again and the roof is protected against weathering. Note that the roof hooks should not alter the position of the tiles since this could otherwise lead to roof leakages.

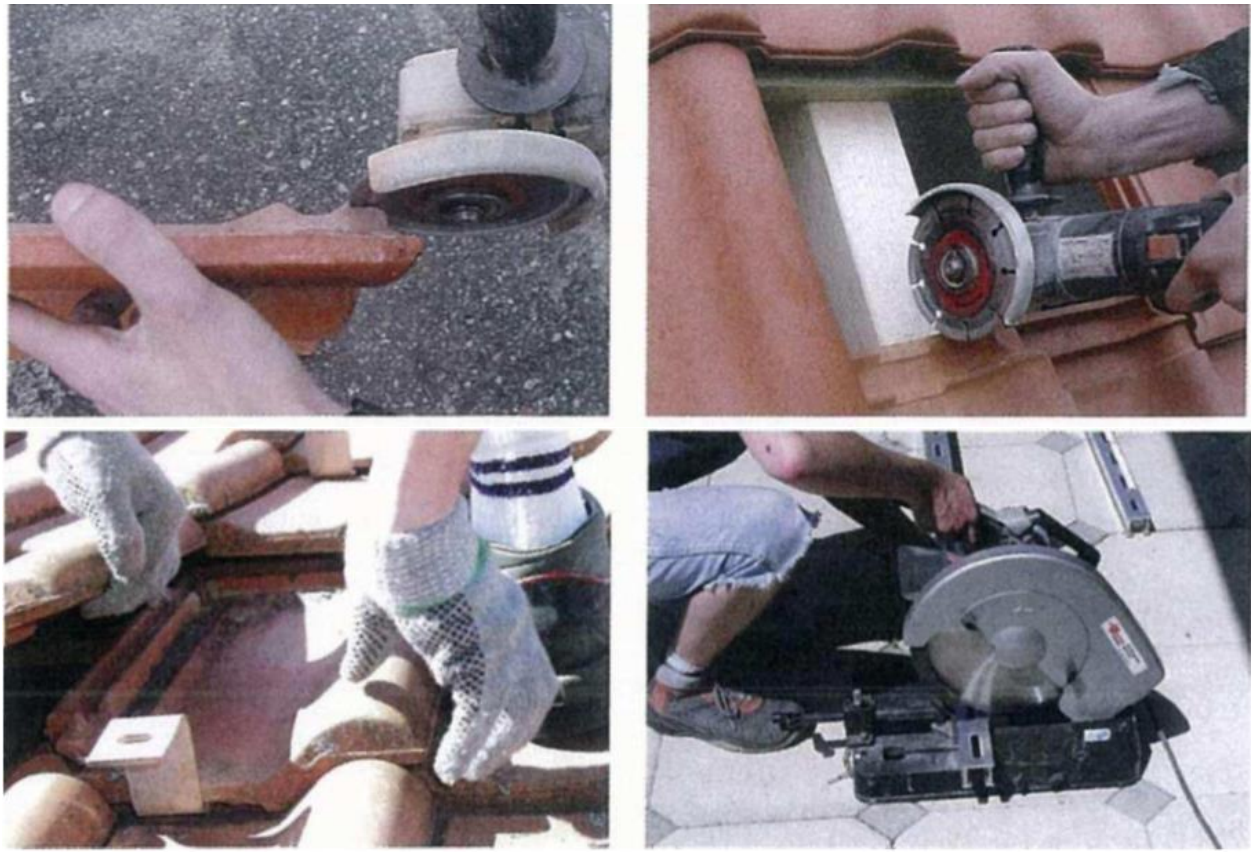

Figure 4 : tile cutting

- **FITTING THE FIXING RAILS**

The cross-member rails are previously cut to size or supplied in the required sizes, and then fastened to each roof hook. In our example, the rails are secured from below through the elongated holes using a hexagon socket screw, a washer, a spring washer and a nut. If using T-head bolts and slot nuts or threaded plates, ensure that they are inserted correctly into the rail groove. Unevenness in the roof can be compensated for via the elongated holes in the roof hooks and rails and, if necessary, by using spacers (such as flat washers) this is important in order to achieve a level array surface later on. Across the width of the roof, multiple rails need to be joined together.

Figure 4 : tile cutting

They are connected together using screwed flat connectors with a gap remaining to allow for linear expansion. Once the rails are in vertical alignment (a plumb line is helpful here), the screw fasteners are tightened using a torque wrench to the torque specified by the manufacturer.

Figure 5 : FIXING RAILS

Equipotential bonding and earthling/grounding of array support structure
Since transformer less inverter is used, the metal array support frame generally needs to be equipotent ally bonded to the building. The capacitive discharge currents resulting from the system must be safely conducted to earth/ground (personal protection). Earthing/grounding and equipotential bonding codes and regulations differ from country to country. These must be consulted and observed.

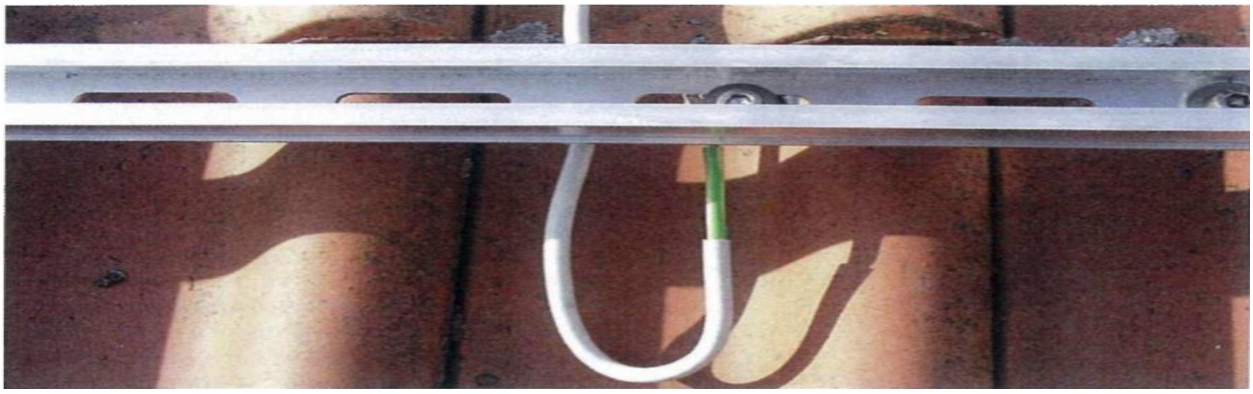

Figure 6 : Earthing/grounding

- **Mounting the Modules**

To prevent slippage, bolts are placed in the mounting holes on the module frame with the shaft outwards and secured in place with nuts. The threaded part of the bolt projects from the back and can be used to hang the modules in the upper horizontal rail during installation. Before the individual modules are finally secured in place, they are electrically connected to each other. The module leads that are already fitted with plug connectors are simply plugged together.

For modules without plugs, the module junction box has to be opened and the connections wired up inside it. The cables are best placed and secured in the transverse rails (e.g. using UV-resistant cable ties). This ensures that rainwater is not prevented from running off the roof and that no snowmelt can build up in the area of the array as a result of cables lying on the roof surface. It ensures that no drip water can run into the plug connectors or module junction boxes. The cables must be laid so that no mechanical damage can occur to the insulation through sharp edges, pointed objects, etc. (short-circuits and earth/ground fault proof wiring!).

Note: if metal cable conduits are used, insulating edge protection must be employed, where necessary. In the system in this example, the easiest way of installing the modules is in rows from top to bottom. At the start of the row, the first module is clamped to the rails by its outside long edge using two preassembled end clamps. Preassembled middle fastenings are inserted into the rails with a laterally positioned rail nut and pushed up to the module. When rotated, the nut engages in the rail. The next module is positioned flush next to it and the bolt of the middle fastening is tightened using a cordless screwdriver. The row end is, in turn, concluded with end clamps. The uniform torque can be established either on the first tightening of the individual fasteners or afterwards at all clamps.

Figure 7 : module mounting

The modules are attached to the ends of the module fixing channels using angle brackets screwed to them. Thin weather-proof spacers (e.g. neoprene) are inserted between the angle brackets and the module frames. The brackets enable sufficient mechanical tension to be generated in the module rows so that no rattling or vibration sounds can be created by the module frames.

- **Running the string cables through the roof**

The string cables are run in protective conduits through the roof's inner cladding, thermal insulation and vapor-proof barrier at a centrally defined point to the outside. The cable laying must not adversely affect the roof's vapor barrier or thermal insulation. It must also be ensured here that the cabling is short-circuit and earth/ground-fault proof. The protective conduits are first inserted through the previously made openings and fixed to prevent them from sliding out.

The cables are then drawn through them; with long distances, for example, this can be done with the help of a feed coil. It is also possible to draw the cables through the conduits in advance to enable the protective conduits and cables to be installed simultaneously. Running the cables through the protective conduits ensures a high level of operating safety and a long service life for the cables. The protective conduits should be inserted through the vapor barrier at the overlapping points of the sheeting. This ensures that it can be easily sealed again after installation.

Note that protective conduits must be UV resistant and rated for use in external areas. Finally, the string cables are run through the opening of a ventilation tile onto the roof. This is inserted at an appropriate point in the roof tiling and ensures that the roof remains impermeable to leakages at the lead-through point. For aesthetic reasons, this tile should be situated beneath the modules and

be invisible from outside. The string cables are attached to the mounting frame and connected to the corresponding modules (first and last modules in a string).

Figure 7 : Running the string cables through the roof

The assembly and installation of the PV array on the house roof is now complete. During the assembly of the array, the individual module strings are measured electrically (open-circuit voltage, short-circuit current and insulation resistance) and the results recorded. This ensures that all array strings work without problems and that the work on the roof is, in fact, finished.

4.3 Checking for service ability and any faults

- **Checking the PV System for Ground Faults**

Danger to life due to electric shock when touching live system components in case of a ground fault if a ground fault occurs; parts of the system may still be live. Touching live parts and cables results in death or lethal injuries due to electric shock.

Disconnect the product from voltage sources and make sure it cannot be reconnected before working on the device.

- ✓ Touch the cables of the PV array on the insulation only.
- ✓ Do not touch any parts of the substructure or frame of the PV array.
- ✓ Do not connect PV strings with ground faults to the inverter.
- ✓ Ensure that no voltage is present and wait five minutes before touching any parts of the PV system or the product.

- **Testing /Measure the voltages:**
  - ✓ Measure the voltage between the positive terminal and the ground potential (PE).
  - ✓ Measure the voltage between the negative terminal and the ground potential (PE).
  - ✓ Measure the voltage between the positive and negative terminals. If the following results are present at the same time, there is a ground fault in the PV system:
  - ✓
- **Measure the insulation resistance.**

Reconnect the strings without ground faults to the inverter and recommission the inverter (see inverter installation inverter).
The example shows a ground fault between the second and third PV module.

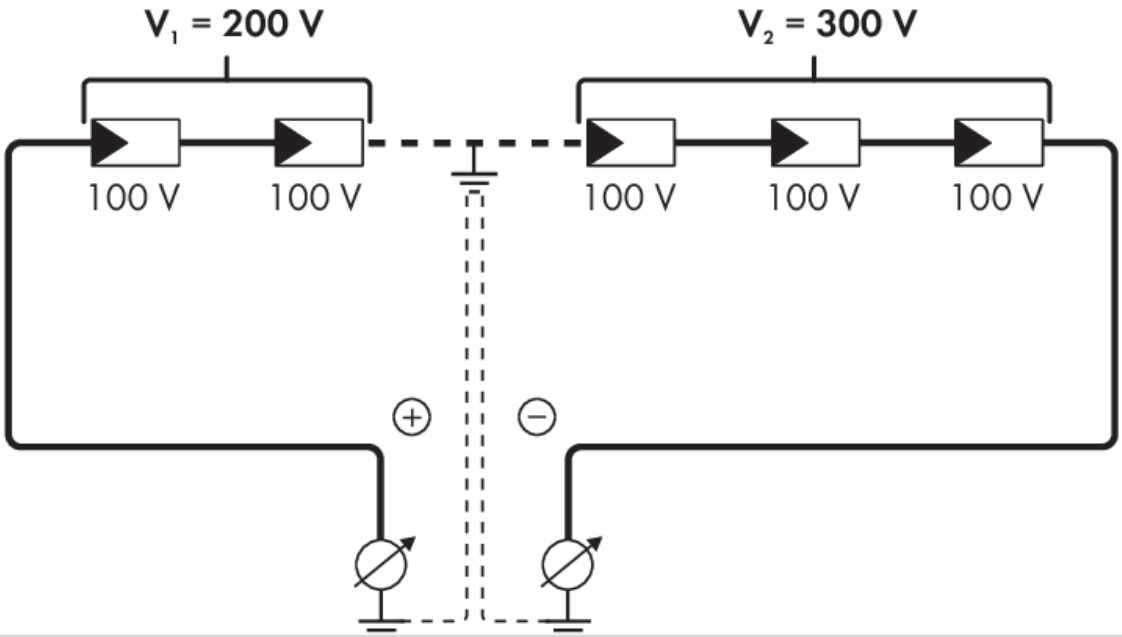

Figure 8: Measuring voltages

If the voltage measurement does not provide sufficient evidence of a ground fault, the insulation resistance measurement can provide more exact results.

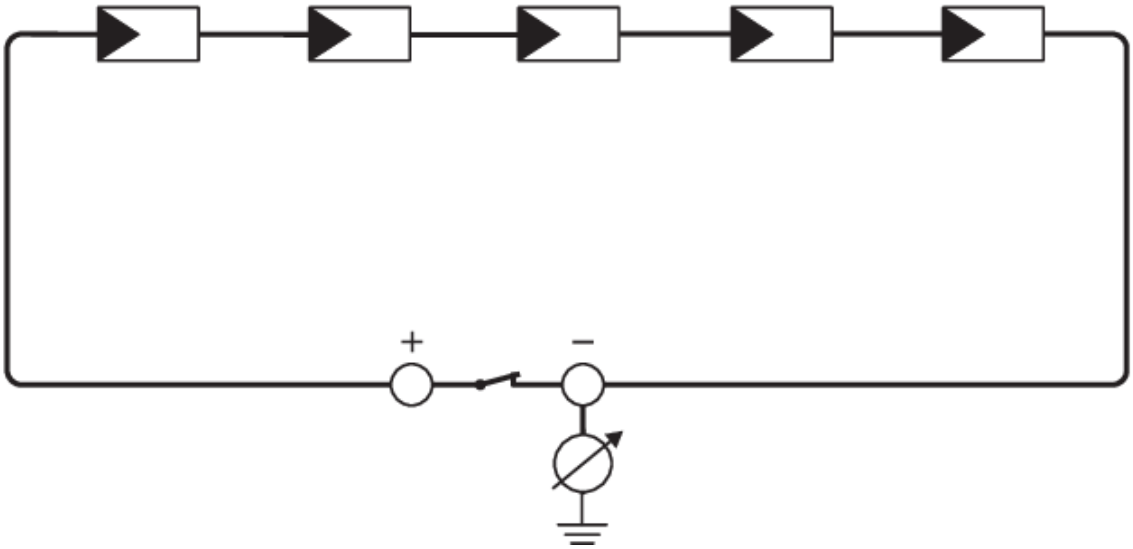

Figure 9: Measuring insulation resistance

Start off by inspecting the system at the inverter and ending at the array. Carefully inspect equipment and wiring for any evidence of Burt or melted wire. Don't forget your nose. You can often sniff out the problem where your eyes will not allow you to see.

Check the GFDI fuse to see if it has blown. If it is not a visual fuse, use your multimeter to test continuity. If you have a audio multimeter it will beep. If, not check the display. If the fuse is blown you should see the infinity symbol that will indicate that there is no resistance and the fuse is in-fact blown.

Next use your multi-meter (DC capable) with the current clamp to measure current at the inverter if there is enough slack in the wiring to get the clamp in and around the wiring. If there isn't enough

slack you can also measure at the disconnect or combiner if there is one. If the GFDI fuse has blown there should be no current measured at this point. If there is, this could be an indication of a double fault.

The next step is to take voltage measurements; positive to ground, negative to ground, and open circuit voltage (positive to negative). Record your measurements in your notepad.
If the fault exists and the system has multiple strings, you will want to measure at the string level to determine where the fault has occurred. The process from above is the same, just repeat for each string in the system. Record your measurements for each.
To understand what your recorded measurements are telling you is the key here. If you inspected the fuse and it had turned out to have continuity (was not blown) this does not rule out a ground fault. It could be that the fault is lower than the trip rating of the fuse.
To test that, remove the fuse and measure positive to ground and then negative to ground. If a fault is not present, both readings should be approximately half of the system's Voc rating. Let's assume it is not and move to the next step.
If the voltages on the positive and negative conductors are quite different this can help you to locate the string the fault has occurred and where within the string the fault has occurred.
When you isolate the strings and have taken measurement you might see something like:

- ✓ Positive to Negative = 432V
- ✓ Positive to Ground = 324V
- ✓ Negative to Ground = 108V

Assume that the Voc of the module is 36V under normal operating conditions. A reading on the negative conductor has shown us 108V. If we divide our negative reading by 36V when get a result of 3. The fault reading indicates that the third module, counting up from the negative conductor side of the string, is where the fault has occurred.
Inspect the module for any damage. Look for cracks on the glass or cells below. Also don't forget to check the module's back sheet for any gouges or scratches. Check the PV wire for chaffing, severing or if the cable has been chewed on by wildlife. Likely you will spot the damage that lead to the fault. Replace the faulty module if necessary then replace the GFDI fuse. The system should now be in working order and can be brought back online.

4.4 Rectifying or reporting prior to commencement

Definition of rectification to make, put, or set right; remedy; correct: He sent them a check to **rectify** his account. To put right by adjustment or calculation, as an instrument or a course at sea.

After the issue of an occupation permit (OP) for a new building, it has been the industry's practice for the registered general building contractor (RGBC) and/or registered specialist contractor (RSC) responsible for the construction of the building / building works to continue with the rectification of the approved works under the supervision of the authorized person (AP) / registered structural engineer (RSE) / registered geotechnical engineer (RGE) of the building project (relevant parties including contractors collectively referred to as "Project Team") under obligations in the construction contract. These works1 are mostly related to the enhancement of aesthetic quality of the completed building or building works and involve building works shown on the latest approved plans based on which the OP was issued. In general, they are of minor nature and seldom involve structural elements. For the purpose of this letter, the aforesaid post-OP works subject to the Buildings Ordinance (BO) are collectively referred to as "rectification works".

- **Rectification period?**

The rectification period is the period stated in the contract that provides for: the making good of minor faults; and omissions or items that fail to perform suitably that may be outstanding, or occur after practical completion has...

- **Rectification period in construction?**

A period following practical completion (usually six or 12 months) during which a building contractor retains liability under a building contract for dealing with any defects which manifest themselves. Also known as a rectification period.

- **Site Safety Supervision Plan**

Site Safety Supervision Plan a site safety supervision plan (SSSP) for the relevant rectification works should be submitted, if required, in accordance with paragraphs 6.4 and 11 of the Technical Memorandum for Supervision Plans 2009. If no corresponding SSSP has been submitted before, a commencement notice (Appendix I) with the required SSSP should be submitted to the BA within 7 days prior to the commencement of work.

- **Commencement Notice**

Building authority (BA) within 7 days prior to the commencement of the rectification works but in no case later than one month after the issue of OP otherwise the approval & Consent Regime or the MWCS should be followed as appropriate.

- **Completion Certificate**

A completion Certificate should to the BA by the Project Team within 24 months from the date of the OP or 14 days upon completion of the rectification works, whichever is the earlier.
For discernment of responsibilities, the Project Team should keep proper records including the time, locations, nature and extent of rectification works carried out. However, these records are not required to be submitted to the BA unless there is a change of the Project Team member during the course of works.

Self-Check – 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. say true or false for the following question below

1. The term ‘plant’ refers to machinery, equipment and apparatus used for an industrial activity
2. Proper tools and equipment are essential for the effective operation of any civil works site
3. To prevent slippage, bolts are placed in the mounting holes on the module frame with the shaft outwards and secured in place with nuts
4. When we test a voltage, measure the voltage probe between the positive terminal and the negative terminal.
5. Rectification period is period following practical completion during which a building contractor retains liability

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 2 points**

Score = _____

Rating: _____

Answer Sheet

Information Sheet-5	Calculating material quantity requirements based on plans/specifications

5.1 Calculating material quantity

How to calculate how many solar power panels are needed for a whole house

Calculating the number of solar panels needed to power your entire home involves determining your daily energy requirements, finding the daily peak sunlight hours for your location and then dividing your overall needed watts by the watt rating for the solar panels you choose.

- **Daily Energy Requirements**

To sustain your entire house, you need to average your daily use of electricity. Your electric bill probably details your average daily use or presents a one-year total. Dividing the one-year total by 365 calculates your daily average. As an example, if you used 6,000 kilowatt-hours (kWh) in a year, divide by 365 to arrive at a 16.4 kWh daily average.

- **Target Daily Average**

Solar panels do not always operate with maximum efficiency. The system may lose stored power or inefficiently collect solar energy. There may also be sustained periods of insufficient sunlight.

Therefore, adding a 25-percent cushion protects your system from running out of juice. Multiplying your 16.4 daily average by 1.25 calculates a target daily average of 20.5 kWh.

- **Daily Peak Sunlight Hours**

Solar panels rely on the sun to capture electricity, so your panel needs are directly related to the amount of sunlight you get. The Renewable Resource Data Center provides this information for your state and further breaks it down by major city. Dividing the daily requirement by the number of daily peak sunlight hours calculates the amount of energy your panels need to pick up every peak sunlight hour.

Continuing with the example, if you lived in Daytona Beach, Florida, with 5.2 daily peak sunlight hours, divide 20.5 by 5.2 to calculate 3.94 kW required per hour. Multiply the kW by 1,000 to convert the measurement to watts. In the example, multiplying 3.94 times 1,000 converts the figure to 3,940.

- **Number of Panels**

Solar panels are available in a wide range of wattages, such as 100-W or 200-W models. The wattage of your panels determines the number of panels you need. Dividing your hourly requirement by the solar panels' wattage calculates the total number of panels you need. In the example, dividing 3,940 W by a panel's 200-W rating calculates 20 panels needed to sustain your entire house.

- Calculating the amount of electricity used:

You can determine the average usage of electricity for each day in watts with the help of the electricity bill for the month of December. Generally, all utility bills state the total electricity usage of

the house for the whole month. You can add the total hours in kilowatts for the entire year and then you can divide the figure by 365. This will give you your average usage of electricity. Next, you can convert the result into watts by multiplying the figure by thousand. You might not need to do this because most electrical companies across the globe state this figure on all electricity bills that are issued.

- Calculating the total amount of sunlight:

You can also find out the total sunlight that is received by your area on an average per day. For this purpose, you will require a solar calculator which you can easily find online for instance, it is available on Resources. Also, it is very important that you know your exact location on the globe in order to find out the figure with accuracy and precision. To calculate the amount of sunlight received, you will need to divide the total power in the form of watts that is used every day with the average number of hours during which sunlight is received in your area. The result will be the number of watt which you will be required to generate each hour. Ultimately, you can divide the watts that you will be required to generate each hour with the panel ratings that you have decided to buy. This result will be the number of solar panels that you need to purchase to fulfill your electricity requirements.

- **Solar Panels - PV System Sizing and Power Yield Calculator**

A simple PV array size (meters, sq. m, KWP) and power output (KWP, KWHRs) calculator.
The given measurements are for unobstructed areas of roof space to be made available for solar photovoltaic (PV) panels.
Use this calculator to quickly estimate how many large solar panels you could fit onto a roof and roughly calculate how much power they could generate (KWHRs). The number of panels, the roof layout, the overall system size including mounting equipment and example power output figures (**KWHRs**) are provided for each system.

Table 2: Solar Panels - PV System Sizing and Power Yield Calculator

Panel Orientation	No. Panel Rows	No. Panel Columns	Total No. Panels	PV Array Width	PV Array Height	Mounting Area (m2)	Max Power (Wp/kWp)	Output (kWhrs, Year)
Portrait	1	4	4	4.06m	1.68m	6.82m sq.	0.98kWp	841 kWhrs
Portrait	2	4	8	4.06m	3.37m	13.68m sq.	1.96kWp	1682 kWhrs
Portrait	3	4	12	4.06m	5.06m	20.54m sq.	2.94kWp	2524 kWhrs
Panel Orientation	No. Panel Rows	No. Panel Columns	Total No. Panels	PV Array Width	PV Array Height	Mounting Area (m2)	Max Power (Wp/kWp)	Output (kWhrs, Year)
Landscape	1	3	3	5.06m	1m	5.06m sq	0.735kWp	631 kWhrs
Landscape	2	3	6	5.06m	2.02m	10.22m sq	1.47kWp	1262 kWhrs
Landscape	3	3	9	5.06m	3.04m	15.38m sq	2.2kWp	1888 kWhrs
Landscape	4	3	12	5.06m	4.06m	20.54m sq	2.94kWp	2524 kWhrs
Landscape	5	3	15	5.06m	5.08m	25.7m sq	3.67kWp	3150 kWhrs

Self-Check – 5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. say true or false for the following question below

1. Solar panels do not always operate with maximum efficiency.
2. Dividing your hourly requirement by the solar panels' wattage calculates the total number of panels you need
3. To sustain your entire house, you need to average your daily use of electricity

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 point**

Score = _____

Rating: _____

Answer Sheet

Information Sheet-6	Identifying materials appropriate to the work

6.1 Install battery equipment

- **Knowledge of:**
  - ✓ NFPA 70 (NEC) articles for use, installation, and construction specifications for batteries
  - ✓ OSHA safety standards
  - ✓ NFPA 70E (National Fire Protection Association— Standard for Electrical Safety in the Workplace)
  - ✓ Proper installation of batteries and battery equipment (e.g., labeling, spill kits, enclosure, ventilation)
  - ✓ Neat and workmanlike manner of installation of battery equipment
  - ✓ Proper conductor installation, routing, identification, size, color, type, and rating
  - ✓ Proper battery handling, storage, future maintenance, and installation techniques
- **Skill in:**

  Implementing the site-specific safety plan confirming battery equipment placement per plans and client input Installing batteries and battery-related equipment per NFPA 70 Conducting field verification of proper conductor identification, size, color, type, and rating

Install ground-mounted structure

- **Knowledge of:**
  - ✓ Authorities having jurisdiction criteria (e.g., codes, standards, zoning, covenants, regulations)
  - ✓ OSHA safety standards
  - ✓ Foundation and structural elements (e.g., geotechnical requirements)
  - ✓ Construction and assembly of PV structure and racking
  - ✓ Neat and workmanlike manner of installation
  - ✓ Location of underground utilities (e.g., call ahead, underground locator services)
  - ✓ Environmental impact (e.g., protected species, water management)
  - ✓ Site protection and restoration (e.g., straw and seed)
  - ✓ Equipment requirement and availabilities
- **Skill in:**

  Managing excavation to design specifications (e.g., trenching, piers, foundations) Interpreting design and construction documents (e.g. site plan, system design plan)

- **Install building-mounted system**
  Knowledge of:
  - ✓ Authorities having jurisdiction criteria (e.g., codes, standards, zoning, covenants, regulations
  - ✓ OSHA safety standards (e.g., fall protection, hoisting, scaffolding)
  - ✓ Mounting surface compositions (e.g., tile, composite, membrane, metal)
  - ✓ Mounting surface and structure protection and restoration
  - ✓ Array layouts per location (e.g., inter-row shading, electrical efficiency)
  - ✓ Neat and workmanlike manner of installation
  - ✓ Types of roofing system construction
  - ✓ Lightning protection systems
  - ✓ Staging materials and equipment (e.g., roof or other structure loading, security)
  - ✓ Waterproofing building penetrations
  - ✓ Equipment requirements and availabilities

- **Skill in:**
  Effectively implementing the site-specific safety plan Interpreting and applying approved design (e g., engineered drawings, manufacturer specifications) Installing points of attachment to roof manufacturer requirements
- **Install PV modules**
  Knowledge of:
  - ✓ NFPA 70E (National Fire Protection Association— Standard for Electrical Safety in the Workplace)
  - ✓ OSHA safety standards (e.g., fall protection, ladder use, lifting)
  - ✓ Neat and workmanlike manner of installation (e.g., coplanar, square)
  - ✓ Proper module handling and preparation
  - ✓ Proper wire management methods and materials
  - ✓ Termination and connection per NFPA 70
  - ✓ Grounding and bonding (e.g., integrated grounding, bonding washers, lugs)
  - ✓ Regional considerations (e.g., animal guarding, ice and snow, wind)

- **Skill in:**

Effectively implementing the site-specific safety plan conducting field verification of equipment selection (e.g., nameplate, racking compatibility) Interpreting design and construction documents

Self-Check – 6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. say true or false for the following question below

1. Installing solar battery needs the Knowledge of Proper battery handling, storage, future maintenance, and installation techniques
2. Install ground-mounted structure needs Skill in Managing excavation to design specifications and Interpreting design
3. Install PV modules needs Knowledge of Proper module handling and preparation
4. Install PV modules needs skill in effectively implementing the site-specific safety plan

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 2 point**

Answer sheet

Score = _____

Rating: _____

Information Sheet-7	Environmental protection requirements

7.1 **Environmental Requirement: -** means any legal **requirement** relating to the environment and applicable to the Borrower or the Properties, including but not limited to any such **requirement** under CERCLA or other **Environmental** Law

- **Environmental protection laws**

  Environmental protection is the practice of protecting the natural environment by individuals, organizations and governments. Its objectives are to conserve natural resources and the existing natural environment and, where possible, to repair damage and reverse trends.

  The purpose of environmental law is to protect the environment and create rules for how people can use natural resources. ... Laws may regulate pollution, the use of natural resources, forest protection, mineral harvesting and animal and fish populations.

  We first broadly describe five major laws,
  - ✓ the Clean Air Act (CAA),
  - ✓ the Clean Water Act (CWA),
  - ✓ the Safe Drinking Water Act (SDWA),
  - ✓ Resource Conservation and Recovery Act (RCRA), and
  - ✓ The Comprehensive Environmental Response, Compensation, and Liability Act/Superfund Amendments and Reauthorization Act (CERCLA/SARA).

- **Environmental Principles of Nature (Explanation)**
  - ✓ Nature knows best
  - ✓ All forms of life are important
  - ✓ Everything is connected to everything else
  - ✓ Everything changes
  - ✓ Everything must go somewhere
  - ✓ Ours is a finite earth
  - ✓ Nature is beautiful and we are stewards of God's creation

Self-Check – 7	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. say true or false for the following question below

1. legal **requirement** relating to the environment and applicable to the Borrower or the Properties is called Environmental Requirement
2. The purpose of environmental law is to protect the environment and create rules for how people can use natural resources
3. Environmental protection is the practice of protecting the natural environment by individuals only.

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 point**

Score = _____

Rating: _____

Answer Sheet

REFERENCE

1. 29 CFR 1910, "Occupational Safety and Health Administration, Department of Labor." a. Subpart J, "General Environmental Controls." (S/RID) b. 29 CFR 1910.144, "Safety Color Code for Marking Physical Hazards." c. 29 CFR 1910.145, "Specifications for Accident Prevention Signs and Tags."
2. 29 CFR 1926, "Safety and Health Regulations." a. Subpart G, "Signs, Signals, and Barricades." (S/RID) b. 29 CFR 1926.200, "Accident Prevention Signs and Tags." http://www.iosh.co.uk/
3. CPCCCO3026A Carry out repair and rectification of concert, Approved © Commonwealth of Australia, 2012

Solar PV System Installation and Maintenance

Level-II

Learning Guide -36

Unit of Competence	Carry out Civil Work for PV Installation
Module Title	Carrying out Civil Work for PV Installation
LG Code	EIS PIM2 M09 LO2 LG-36
TTLM Code	EIS PIM2 TTLM 0120V1

LO2.Prepare surface

Instruction Sheet	Learning Guide: - 36

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:-

- Preparing requirements from site inspection based on plans/specifications
- removal of hazards, obstructions and attachments
- Selecting and setting up surface preparation tools
- following manufacturers' specifications

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:-

- Prepare requirements from site inspection based on plans/specifications
- removal of hazards, obstructions and attachments
- Select and setting up surface preparation tools
- follow manufacturers' specifications

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, in pages 36, 41, 44 &47 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 in pages 40, 43, 46 & 48respectively

Information Sheet-1	Preparing requirements from site inspection based on plans/specifications

2.1 Preparing requirements from site inspection

- **Knowledge of:**
  - ✓ Characteristics of appropriate array locations
  - ✓ Characteristics of viable roof surfaces
  - ✓ Live and dead load characteristics of PV arrays
  - ✓ Common roof structural design
  - ✓ Drilling and trenching equipment capabilities
  - ✓ Characteristics of appropriate equipment locations
  - ✓ Types of electrical services
  - ✓ Point of interconnection
  - ✓ Raceway installation parameters
  - ✓ Effect of obstructions
  - ✓ Construction site hazards
  - ✓ Characteristics of appropriate staging/lifting/ access locations
  - ✓ Shading analysis tools and techniques
  - ✓ Azimuth measurement tools
  - ✓ Magnetic declination
  - ✓ Slope tools and techniques
  - ✓ Building use and dimensions
  - ✓ Effects of wind exposure
  - ✓ Required site information documentation

CONSTRUCTION INSPECTION REQUIREMENTS

The Village of Point Venture requires that an inspection company make all the inspections listed below during construction. Payment for these inspections will be billed to and paid by the Village. Should an inspection fail, the builder must schedule a re-inspection and will pay the inspection company for this re-inspection. The builder is responsible for contacting the inspection company and scheduling these inspections, (contact information below). Copies of the inspection reports will be given to the builder by the inspection company, except for the Final inspection.

- **Required inspections are:**

Plan Review:

3 sets of plans shall be submitted for permit. EACH SET OF PLANS shall include the following:

- ✓ Floor plans
- ✓ Elevations
- ✓ Electrical Plan
- ✓ Typical Cross Section
- ✓ Foundation Plan certified by a Registered Professional Engineer or a Registered Professional Architect, including their seal & signature.
- ✓ Roof and Ceiling Framing Plans
- ✓ Res Check Energy Calculations In Accordance with IECC

- ✓Registered Survey
- ✓Culvert Plan
- ✓Construction Specifications
- ✓Copies of Licenses for Electricians, Plumbers, and HVAC Mechanical Contractors.

- **First Site Inspection:**

Temporary Meter Loop Inspection: If your site has temporary power already hooked up through PEC it must be inspected. Temporary power must be GFCI protected.

- **Second Inspection:**

Layout Inspection: Foundation form boards are installed, and the Building Permit is posted. Verify finish floor elevations. Portable toilet, temporary trash receptacle, silt fence and Burke Safety fences are to be in place. A form survey will be required on site upon completion of form set-up and must be provided to the inspector. The approved building plans must be on site for this inspection. Form survey approval will be required at this inspection.

- **Third Inspection:**

Plumbing Rough: After Layout is approved. To be requested when drain waste, vents, and supports are in place and tested prior to concrete placement. Ten (10) foot head of water pressure or 5-PSI air pressure is required on DWV piping. All pipes and fittings must be exposed for visual inspection.

- **Fourth Inspection:**

Copper or Supply Piping Inspection

To be requested when all water supply lines in place and protected with no joints in the slab. All lines must be sleeved to protect pipes. 50 PSI required on copper lines. Hot water lines must be insulated. This inspection is required prior to foundation inspection.

- **Foundation Inspection**

To be performed by the professional Engineer or Architect that designed the foundation Must submit engineer's letter of certification prior to

- **Final Inspection**

Additionally, the Building Official requires a pre-pour foundation inspection for our records.

- **Fifth Inspection:**
  - ✓ Electrical Rough Inspection: To be requested when all wiring, boxes, piping load centers, (service and sub panels), service drop, and all work to be covered are installed, but prior to Frame Inspection. This inspection must be cleared before moving to next inspection.
  - ✓ Mechanical Rough Inspection: To be requested when all duct systems and vents are in place, but prior to frame inspection. Furnace closets and/or attic catwalks and work platforms have been completed. A.C. primary drains and overflow drains properly installed and sloped to drain. Must be clear before next inspection.
  - ✓ Plumbing Top out Inspection: To be requested when all pipes are in place, supports connected, vent takeoffs, roof flashings and boots, (or jacks), water heater location, and trap arms are completed. Water, sewer, and gas lines tests are to be in place and ready to verify. Must be cleared before Frame inspection.
  - ✓ Frame Inspection: Electrical rough, mechanical rough and plumbing Top out are to be completed and inspected prior to framing inspection. Frame inspection to be requested when all framing, fire-blocking, fastening, and bracing are in place, roof is dried in, materials are loaded, and pipes and vents and wiring installed. Fireplace is to be installed. Windows and exterior doors are in place and flashed. This is not to be used by the builder as a punch out inspection. We require the builder to do his/her own punch out and corrections prior to Frame inspection.
  - ✓ Exterior Sheathing Inspection: If required by builder, to start masonry or for house wrap. Sheathing inspection must be done before house wrap or felt is installed over sheathing. (Exterior Sheathing Inspection may be performed prior to fourth inspection at the builder's request).
- **Sixth Inspection:**

Insulation Inspection: To be requested after framing, electrical, plumbing, and mechanical are approved and when all insulation is installed and all joints and penetrations are sealed. Under some circumstances, partial insulation inspections may be needed.

- **Seventh Inspection**:

Wallboard Inspection: To be requested after insulation and frame group are approved and when all wallboard is in place and fastened properly according to code schedule, but prior to taping and floating any walls and ceilings.

- **Eighth Inspection**:
  - ✓ Electrical Final Inspection: To be requested when all fixtures, switches, receptacles, grounds, appliances, smoke detectors and equipment are installed as per code and ready for use with meter loop, but prior to Final Building Inspections. Re-inspections may be inspected at Final Building Inspections.
  - ✓ Mechanical Final Inspection: To be requested when all equipment has been installed and ready for use; including dryer vents, exhaust hoods, furnace and water heater vents, and all distribution and return air grilles installed. Combustion air supplies and gas line sediment traps installed. Must be cleared before Final Inspection.
  - ✓ Plumbing Final Inspection: To be requested when all valves and fixtures are installed and all vents are completed. Water systems to be tested. Gas pipes to be connected and final tested. Septic or sewer connected and approved by City Sanitarian. Approved backflow devices at water meter, hose bibs, sprinkler

systems, pools, and dishwashers properly installed. Must be cleared before Final Inspection.

- ✓ Final Building Inspection: Call for inspection when the building is complete, all other inspections cleared, and ready for occupancy. The inspector will take the final inspection report to the BC for the issuance of a Certificate of Occupancy, which will be issued after the project has passed the Village's site inspection, conducted by the Field Maintenance Supervisor, to ensure the building was constructed as submitted and approved, the exterior is completed, there was no damage done to the right-of-way or adjacent property, all construction items have been removed, (i.e. debris, dumpster, port-a-can, silt fences, etc.), and that it was built in compliance with all applicable codes and ordinances. No building shall be occupied until this
- ✓ Customer Service Inspection Certificate: After the final plumbing has passed, the inspector will certify that the water service connection does not have potential to contaminate the city water supply. Additional Required Inspections:
- ✓ Water Yard line Inspection: Required after properly sized water line, (based on fixture count), is installed in open trench at least 12 inches deep and bedded in sand. An A.W.W.A. approved owners shut off valve same size as water line and a pressure reducer valve, (PRV) required on the yard-line in a service box. Full city water pressure or 60-PSI test required. If water line is run under flatwork or drive, it must be sleeved, (2 pipe sizes larger). The sewer yard-line installed in open trench per code 4 inch diameter Schedule 40 P.V.C. Clean outs required at house and sewer tap. Line to be bedded in sand with a minimum fall not less than ¼ inch per foot. Sewer yard-line must have flood test in place.
- ✓ Electric Service: Underground conduit lain in open trench as per code 26 inch deep for primary, 20 inch deep for secondary.
- ✓ Driveway/Flatwork Inspection: To be requested when forms and reinforcements are in place. Minimum 6 inch X 6 inch X 10 inch wire mesh and expansion joints 15 foot on center required. Treated expansion joints or cold joint required where flatwork or drive meets foundation.

Self-Check – 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Matching from column B to column A

A	B
1. Third Inspection	A. Foundation Inspection
2. Second Inspection	B. Layout Inspection
3. First Site Inspection	C. Insulation Inspection
4. Fourth Inspection	D. Electrical Final Inspection
5. Fifth Inspection	E. Temporary Meter Loop Inspection
6. Sixth Inspection	F. Plumbing Rough
7. Seventh Inspection	G. Electrical Rough Inspection
8. Eighth Inspection	H. Wallboard Inspection

Note: **Satisfactory rating – 6 points** **Unsatisfactory - below 4 point**

Score = _____

Rating: _____

Answer Sheet

Information Sheet-2	Removal of hazards, obstructions and attachments

2.1 Develop safety plan

- **Knowledge of:**
  - ✓ OSHA requirements (e.g., fall protection, competent/qualified person, reporting of incidents)
  - ✓ NFPA 70E (National Fire Protection Association— Standard for Electrical Safety in the Workplace)
  - ✓ Personal protective equipment (PPE) (e.g., specific equipment required for project, maintenance of PPE)
  - ✓ Material safety data sheet (MSDS)
  - ✓ Emergency response resources and protocols g. Weather event response actions
  - ✓ Emergency response resources and protocols
  - ✓ Specific equipment and training required for site
  - ✓ Elements of an effective safety meeting
- **Safeguard against hazards**
  Knowledge of:
  - ✓ NFPA 70E (National Fire Protection Association—Standard for Electrical Safety in the Workplace)
  - ✓ OSHA CFR 29 1926 safety standards
  - ✓ Proper care and use of safety equipment (e.g., life cycle, defects, storage)
  - ✓ Proper care and use of test equipment (e.g., life cycle, defects, storage)
  - ✓ Proper care and use of power tools (e.g., life cycle, defects, storage)
  - ✓ Safe work practices
  - ✓ Training requirements (e.g. education materials, security clearances, certifications, manufacturer recommendations)

Photovoltaic (PV) Solar Power Hazards & Safety

While solar energy is among the cleanest and least hazardous of energy sources, there are four significant hazards during installation and maintenance:

- **Lifting**: Solar panels are awkward and heavy. Improperly lifting panels can cause strains, muscle pulls, and serious back injuries, including:
  - ✓ Herniated discs
  - ✓ Rotator cuff tears
  - ✓ Hip-low back strains
- **Electrical:** Solar systems include many components that conduct electricity. Electricity comes from two sources: the utility company and the solar array (i.e. the sun). Even when a building's main breaker is shut off, the PV system will continue to produce power. Risks include:
  - ✓ Thermal burns
  - ✓ Muscle, nerve, and tissue damage
  - ✓ Falls from a surprise shock
  - ✓ Death

Even low-light conditions can create sufficient voltage, shocking a worker and causing a fall.

- **Trips and fall:** In construction, falls accounted for nearly 40% of fatalities in 2014. The most common height of fatal construction falls over the 2011-14 periods was from more than 30 feet (211 deaths); however, fatalities from 11 to 15 feet are almost as deadly (194 deaths). Other risks include
- **Ladders:** Among construction workers, approximately 81% of fall injuries treated in emergency rooms involve a ladder. Between 2011 and 2014, ladders accounted for 24% of fatal falls (281). Other risks include:
  - ✓Fractures or sprains
  - ✓Puncture injuries
  - ✓Back, neck, and head trauma
  - ✓Cuts and bruises

Self-Check – 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say True Or False For The Following Question Below

1. Solar systems include many components that conduct electricity
2. Among construction workers, approximately 81% of fall injuries treated in emergency rooms involve a ladder
3. Improperly lifting panels can cause strains, muscle pulls, and serious back injuries

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 point**

Score = _____

Rating: _____

Answer Sheet

Information Sheet-3	Selecting and setting up surface preparation tools

3.1 Tools for a Successful Solar Electric Install

We've all heard that bit of wisdom thousands of times. And it's no different for a Solar Electric (PV) system installation than for anything else. Fortunately, most of the tools needed for a PV install are commonly used and easily found. There are very few highly specialized tools. Below are several lists that describe many of the tools needed for an installation. They are broken out into functional groups for site assessment, installation and maintenance. Most of the specialized tools fall into the site assessment and maintenance categories; the installation tools are probably already in your tool box!

- **Site Assessment Tools**
  - ✓ 50-100 ft. tape measure
  - ✓ Solar Pathfinder (evaluates the solar energy potential at a site)
  - ✓ Compass (not needed if you're using a Solar Pathfinder)
  - ✓ Maps (reference for location latitude and magnetic declination)
  - ✓ Digital camera

- **Basic Tools Needed for Installation**

  - ✓ Angle finder
  - ✓ Torpedo level
  - ✓ Fish tape
  - ✓ Chalk line
  - ✓ Cordless drill (14.4V or greater), multiple batteries
  - ✓ multiple drill bits (wood, metal, masonry)
  - ✓ Hole saw
  - ✓ Hole punch
  - ✓ Torque wrench with deep sockets
  - ✓ Nut drivers (most common PV sizes are 7/16", ½", 9/16")
  - ✓ Wire strippers
  - ✓ Crimpers
  - ✓ Needle-nose pliers
  - ✓ Lineman's pliers
  - ✓ Slip-joint pliers
  - ✓ Small cable cutters
  - ✓ Large cable cutters
  - ✓ AC/DC multimeter
  - ✓ Hacksaw
  - ✓ Tape measure
  - ✓ Blanket, cardboard or black plastic to keep modules from going "live" during
  - ✓ installation
  - ✓ Heavy duty extension cords
  - ✓ Caulking gun
  - ✓ Fuse Pullers
  - ✓ **Additional Tools to Consider (especially for multiple installations)**
  - ✓ DC clamp-on ammeter
  - ✓ Reciprocating saw / Jig saw
  - ✓ Right angle drill
  - ✓ Conduit bender
  - ✓ Large crimpers

- ✓ Magnetic wristband for holding bits and parts
- ✓ C-clamps
- ✓ Stud finder
- ✓ Pry bar

- **Tools for Battery Systems**

  - ✓ Hydrometer or Refracto meter
  - ✓ Small flashlight (to view electrolyte level)
  - ✓ Rubber apron
  - ✓ Rubber gloves
  - ✓ Safety goggles
  - ✓ Baking Soda (to neutralizer any acid spills)
  - ✓ Turkey Baster
  - ✓ Funnel
  - ✓ Distilled Water
  - ✓ Voltmeter

Self-Check – 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say True Or False For The Following Question Below

1. solar pathfinder is an example of site assessment tools
2. Small flashlight is a tool which used to view electrolyte level
3. Angle finder and Torpedo level is an examples of basic tools needed for Installation

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 point**

Score = _____

Rating: _____

Answer Sheet

Information Sheet-4	Following manufacturers' specifications

4.1 manufacturer's specification

Table 3: technical specifications for crystalline modules

Module Technical Specifications

Technical Specifications for Crystalline Modules	
Output power – Pmax (Watts)	250 Wp +3%
Nominal Voltage (Vmp)	36.00 V
Nominal Current (Imp)	6.95 A
Open-circuit voltage (Voc)	43.78 V
Short circuit current (Isc)	7.20 A
Maximum system voltage (Volts)	IEC: DC 1000V / UL: DC600V
Efficiency	15.26 %
Type of solar PV cell	Poly / Multi - Crystalline silicon
Suitability	For on / off grid connected system
Module output	Bizlink electronics plug (male and female)
Certification	IEC 61215, IEC 61730, MNRE Approved

What are the applicable codes and standards for PV systems?

- Electrical codes - NEC Article 690 - Solar Photovoltaic Systems – NFPA 70
- Uniform Solar Energy Code – ICC
- Building Codes – ICC, ASCE 7-05
- UL Standard 1703, Flat-plate Photovoltaic Modules and Panels
- IEEE 1547, Standard for Interconnecting Distributed Resources with Electric Power Systems

The following are some of the key applications of photovoltaic:

- Building-integrated photovoltaic (BIPV) – They can be located near the building, on its roof, or integrated into the building itself.
- Cost-effective solar solutions for remote places
- Solar-powered LED lighting
- Auxiliary power for boats and cars
- As electric power for use in space
- To power calculators and novelty devices
- Solar-powered remote fixed devices - for products such as parking meters, emergency telephones, water pumps, temporary traffic signs, trash compactors, and remote guard posts and signals.
- Solar-powered lighting for roadways/highway

Self-Check – 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say True or False For the Following Question Below

1. Building-integrated photovoltaic can be located near the building, on its roof, or integrated into the building itself
2. IEEE 1547, Standard for Interconnecting Distributed Resources with Electric Power Systems
3. Solar-powered lighting for roadways/highway is an example of key applications photovoltaic

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 point**

Answer Sheet

Score = _____

Rating: _____

References

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Solar PV System Installation and Maintenance

Level-II

Learning Guide -37

Unit of Competence	Carry out Civil Work for PV Installation
Module Title	Carrying out Civil Work for PV Installation
LG Code	EIS PIM2 M09 LO3LG-37
TTLM Code	EIS PIM2 TTLM 0120V1

Lo3: set up and use leveling device

Instruction Sheet	Learning Guide #37

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics:

- Levelling Procedures
- Identifying heights or levels to be transferred /established for levelling procedures
- Setting up and testing Levelling devices
- Levelling device tolerance checks
- Appling levelling staffs accurately
- Transferring levels shot and heights to job requirements
- Documenting results of levelling procedurally

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, **upon completion of this Learning Guide, you will be able to**:

- Identify heights or levels to be transferred /established from project plans or instructions for levelling procedures.
- Set up and test Levelling devices in accordance with manufacturer instructions, including levelling device tolerance checks.
- Apply levelling staffs accurately.
- Shot levels and transfer heights to required location and mark and/or record to job requirements.
- Document results of levelling procedure to organisational requirements.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 , Sheet 4”. Sheet 5, Sheet 6 & Sheet 7 in page 52, 56, 65, 67, 70, 75 & 80 respectively.
4. Accomplish the “Self-check 1, Self-check t 2, Self-check 3, Self-check 4, Self-check 5, Self-check 6 & Self-check 7 **in page 55, 64, 66, 69, 74, 79 & 82** respectively.

1.1. Leveling procedures

- ***Setting up***
  - ✓ Back sight and foresight distances should be approximately equal to avoid any errors due to collimation, refraction or earth curvature.
  - ✓ Distances must not be so great as to not be able to read the graduations accurately.
  - ✓ The points to be observed must be below the level of the instrument, but not lower than the height of the staff.
- ***Elimination of parallax***

Parallax is the apparent movement of the image produced by movement of the observer's eye at the eyepiece.
It is eliminated by focusing the telescope on infinity and then adjusting the eyepiece until the cross-hairs appear in sharp focus. The setting will remain constant for a particular observer's eye.

- ***Setting up the instrument***

Use the following procedure to set up a tripod mounted instrument.

- ✓ Place the tripod so it will be a fi rm and stable base for the instrument. The base of the legs should be about 3′-6″ apart. Make sure the points are well into the ground and the head is fairly level.
- ✓ Check the wing nuts on the adjustable legs.
- ✓ They should be tight enough to carry the weight of the instrument without collapsing or sinking. Tighten the hex nuts holding the legs to the head to the desired tension.
- ✓ Carefully lift the instrument from its case by the base plate. Before mounting the instrument, loosen the clamp screws. On some instruments, the leveling screws must be turned up so the tripod cup assembly can be hand-tightened to the instrument mounting stud. Set the telescope lock lever of the transit in the closed position.
- ✓ Attach the instrument to the tripod. If it is to be located over an exact point, such as a benchmark, attach the plumb bob and move the instrument over the spot. Do this before the final leveling.

1.2. Procedure leveling the instrument

Leveling the instrument is the most important operation in preparing it for use. None of the readings taken or levels sighted will be accurate unless the instrument is level throughout the work. To level the instrument:

- Release the horizontal clamp screw and line up the telescope so it is directly over a pair of the leveling screws.
- Grasp the two screws between the thumb and Fore finger, as shown in Figure below uniformly turn both screws with your thumbs moving toward each other or away from each other.
- Keep turning until the bubble of the level vial is centered between the graduations. You will find on most instruments that the bubble travels in the direction your left thumb moves.
- When the bubble is centered, rotate the telescope 90° (so it is over the other pair of leveling screws) and repeat the leveling operation.
- Recheck the instrument over each pair of screws.

When the instrument is level at both positions, the telescope can be turned in a complete circle without any change in the bubble.

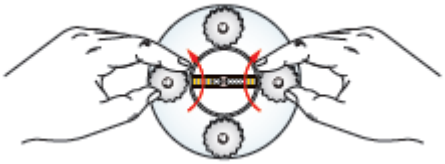

Figure 1: adjust levelling screws to center the bubble in the level vial

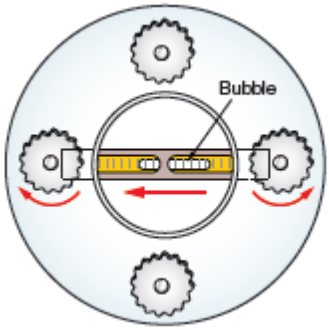

Figure 2 : the bubble of the level

The bubble of the level vial will generally move in the same direction as the left thumb. This bubble needs to move left Sighting procedure

Most builders' levels have a telescope with a power of about 20×. This means that the object being sighted appears to be 20 times closer than it actually is. The procedure for sighting is easy to learn:

- Line up the telescope by sighting along the barrel and then look into the eyepiece.
- Adjust the focusing knob until the image is clear and sharp.
- When the crosshairs are in approximate position on the object,
- Make the final alignment by turning the tangent screw.

Figure 3 : View through the telescope

Both eyes are kept open during sighting. This reduces eye strain and provides the best view. Hand signals tell the rod holder whether to raise or lower the target on the leveling rod.

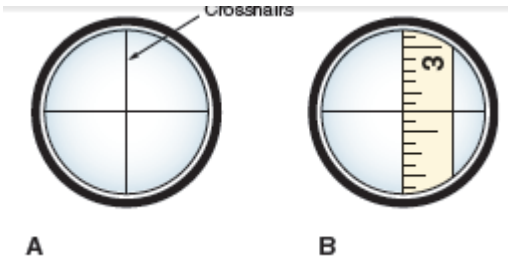

Figure 4: Sighting a level line with a builder's level

- A—Crosshairs vertically and horizontally split the image area in half.
- B—the object in the view should be centered on the crosshairs.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say true or false for the following questions below

1. Leveling the instrument is the most important operation in preparing it for use.
2. Place the tripod so it will be a fi rm and stable base for the instrument
3. Parallax is the apparent movement of the image produced by movement of the observer's eye at the eyepiece
4. Back sight and foresight distances should be approximately equal

Note: **Satisfactory rating above- 3 points** **Unsatisfactory - below 2 points**

Score = _____

Rating: _____

Answer Sheet

Information Sheet-2	Identifying heights or levels to be transferred /established

2.1 Introduction to identifying heights or levels to be transferred/established

The primary reference at water-level recording stations is a set of stable bench-marks, installed in locations where their level should not change. Upon initial set-up of a station, the levels of the relevant parts of the installation are established and recorded by means of accurate leveling.

At least every two years, the levels of the staff gauges, sensor level, internal gauge, tower structure and benchmarks should be measured relative to each other as a check that records are not in error due to bank subsidence or other movement.

Accurate leveling is thus a particularly important part of site establishment, installation and quality assurance. All staff shall be thoroughly familiar with its theory and practice.

Leveling and surveying methods are also used for measurements of river channel and lake configurations. Often, less accurate methods can be used for this work than for water-level recording stations, although the techniques are common.

2.2 Definitions

- **Height of Instrument (HI)** the elevation of the line of sight established by the instrument
- Height of Instrument (HI) The elevation of the line of sight established by the instrument
- Back sight (BS) The reading on the rod when held on a known or assumed elevation Back sights are used to establish the height of instrument. A sighting with a level back to a point of known elevation
- Foresight (FS) The reading on the rod when held at a location where the elevation is to be determined. Foresights are used to establish the elevation at another location, often a turning point
- Differential leveling is the term applied to any method of measuring directly with a graduated staff the difference in elevation between two or more points.
- Precise leveling is a particularly accurate method of differential leveling which uses highly accurate levels and with a more rigorous observing procedure than general engineering leveling. It aims to achieve high orders of accuracy such as 1 mm per 1 km traverse.
- A level surface is a surface which is everywhere perpendicular to the direction of the force of gravity. An example is the surface of a completely still lake. For ordinary leveling, level surfaces at different elevations can be considered to be parallel.
- A level datum is an arbitrary level surface to which elevations are referred. The most common surveying datum is mean sea-level (MSL), but as hydrological work is usually just concerned with levels in a local area, we often use:
- An assumed datum, which is established by giving a benchmark an assumed value (e.g. 100.000 m)to which all levels in the local area will be reduced. It is not good practice to assume a level which is close to the actual MSL value, as it creates potential for confusion.
- A reduced level is the vertical distance between a survey point and the adopted level datum.

- Change/Transfer Point (CP/TP) It is a point on which fore-sights and back-sight are taken
- Peg Test Surveying operation carried out to determine if the levelling bubble and telescope line-of-sight are parallel
- Elevation of Instrument Elevation of the telescope cross hairs
- Closure Error Difference in elevation determined from the leveling survey and the known elevation of a benchmark
- A bench mark (BM) is the term given to a definite, permanent accessible point of known height above a datum to which the height of other points can be referred.
- It is usually a stainless steel pin embedded in a substantial concrete block cast into the ground. At hydrological stations rock bolts driven into bedrock or concrete structures can be used, but structures should be used warily as they themselves are subject to settlement. The locations of benchmarks shall be marked with BM marker posts and/or paint, and recorded on the Station History Form.
- A set-up refers the position of a level or other instrument at the time in which a number of observations are made without mooring the instrument. The first observation is made to the known point and is termed a back sight; the last observation is to the final point or the next to be measured on the run, and all other points are intermediates.
- A run is the leveling between two or more points measured in one direction only. The outward run is from known to unknown points and the return run is the check leveling in the opposite direction.
- A close is the difference between the starting level of the initial point for the outward run and that determined at the end of the return run. If the levels have been reduced correctly this value should be the same as the difference between the sum of the rises and falls and also the difference between the sum of the back sights and foresights.
- Height of Collimation is the elevation of the optical axis of the telescope at the time of the setup.
- The line of collimation is the imaginary line at the elevation.
- Orders of leveling refer to the quality of the leveling, usually being defined by the expected maximum closing error.

Table1 :order of levelling

Order	Purpose	Maximum close
Precision order	Deformation surveys	0.001 x km
First order	Major levelling control	0.003 x km
Second order	Minor levelling control	0.007 x km
Third order	Levelling for construction	0.012 x km

The accuracy requirements for water-level stations relate to the standards. Change points are points of measurement which are used to carry the measurements forward in a run. Each one will be read first as a foresight, the instrument position is changed, and then it will be read as a back sight.

2.3 Types of levels

A level is basically a telescope attached to an accurate leveling device, set upon a tripod so that it can rotate horizontally through 360°. Normally the leveling device is a bubble, but modern ones incorporate a pendulum. There are three basic types of level

- **Dumpy levels**

These are more basic levels often used in construction work. The telescope is rigidly attached to a single bubble and the assembly is adjusted either by means of a screwed ball-joint or by foot screws which are adjusted first in one direction, then at 90°.

- **Tilting levels**

This type of level is fitted with a circular bubble for preliminary approximate leveling and a main bubble which is attached to the telescope. For each observation (not setup) the main bubble is viewed through an eyepiece and the telescope tilted by a fine screw to bring the two ends of the bubble into coincidence.

- **Automatic levels**

This more modern type of level is now in general use. It has a compensator which consists of an arrangement of three prisms. The two outer ones are attached to the barrel of the telescope. The middle prism is suspended by fine wiring and reacts to gravity. The instrument is first leveled approximately with a circular bubble; the compensator will then deviate the line of sight by the amount that the telescope is out of level.

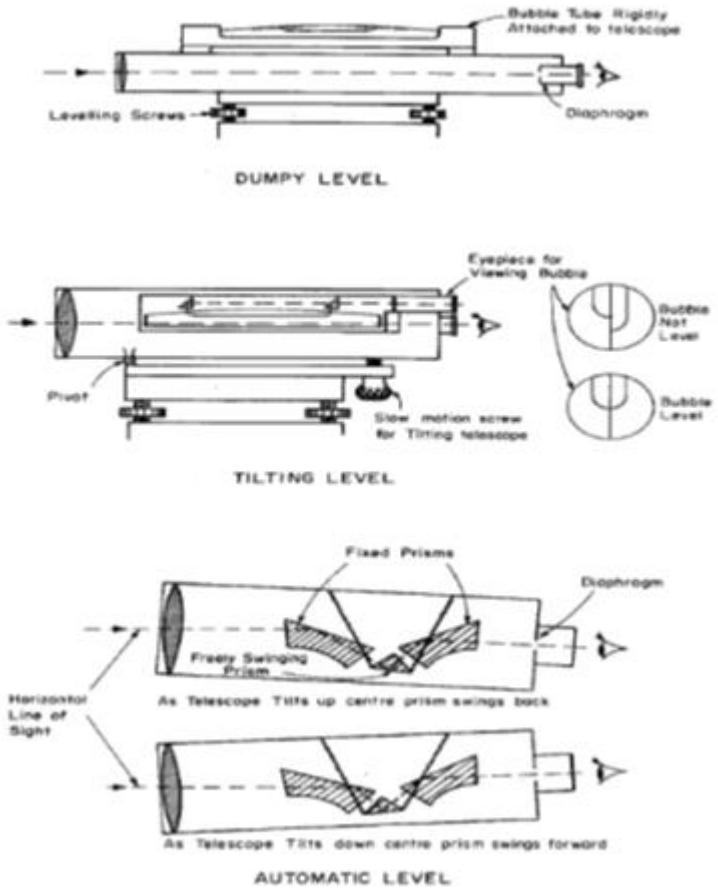

Figure 4 : automatic levelling

2.4 Checking the level's accuracy

Levels can move out of adjustment so that their line of sight (line of collimation) is not truly horizontal. This will cause errors in readings which become greater as the viewing distance increases. However if a back sight and a foresight are exactly equi-distant from the instrument, the error in each sighting will cancel each other out.

- install three pegs or marks firmly in the ground at distances of 30 m apart in a straight line; the center peg is only to mark the distance, but the outside two shall be firm enough for reliable change points
- Set up the level over the center peg and read the staff on each of the outside pegs in turn. Book these values and calculate the height difference. This will be a true height difference, as the distances are equal and any errors will be self-compensating
- Set up the level about 4 m to the far side of one of the outside pegs. Read the staff on the peg 4 m away and then on the one 64 m away. Book these values and calculate the apparent height difference
- Compare the two height differences; if the instrument is in adjustment (i.e. its collimation is true) they will be within 5 mm.

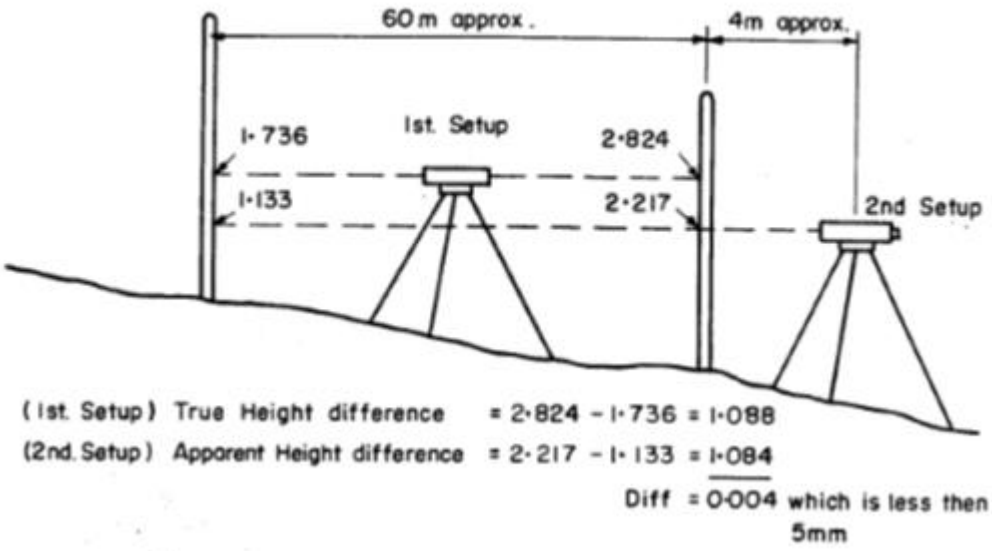

Figure 4 method of checking the level of accuracy

2.5 Drawing/Sketch

Drawing is a system of representing visual ideas and thoughts on a surface. Most commonly it is used as a means of depicting three dimensional realities on a two dimensional surface using pencil, charcoal, crayon, pen, brush etc. on a paper, cloth, wall etc. Drawing is also used as a tool for 'visualization'. In other words, visualization means representation of one's imagination for others. Where design ideas can be two dimensional or three dimensional, Drawing, in spite of being a two dimensional representation, can provide a convincing illusion of three dimensional environments.

There are different ways to draw, such as drawing from seeing, drawing from memory, drawing by analysis and drawing from imagination etc. In professional practice all kinds of drawings are used by a graphic design. Let's first understand and acknowledge some of the virtues and benefits of practicing drawing.

- **Types of Drawing**

To 'draw' means to 'fetch' or 'pull' as we pull water from the well. In the fields of design, fine arts and architecture, to draw' means to fetch ideas from 'within' .These ideas are our thoughts, emotions, feeling etc. Similarly, we fetch ideas from external reality i.e. man-made environment, social environment and natural environment. Drawing also means to describe to extract and to capture the essence of internal and external reality and represent it in a best possible way using appropriate medium.

Sketch means first rough draft or plan of any design, an outline or a drawing using pen, pencil or any other similar medium. It also means a descriptive representation of a concept, thought or principal ideas. In the fields of art, design and architecture the word sketching and drawing are used as synonyms although there is a subtle difference in the meanings of their words.

- **Leveling Devices**

Most common leveling instrument today is the Automatic or Self-leveling level –Has an internal compensator that automatically provides a horizontal line of sight and maintains this through gravity

Differential Leveling: Most common type today determine the difference in elevation using a horizontal line of sight and readings on graduated rod Circuit must be closed on BM of origin or on BM of equal accuracy Process: Reading on point of known elevation (BS)
BS reading + BM elevation = HI Reading on point of unknown elevation (FS) HI –FS = elevation of new point

- **Modern Tilting Level**

Small up/down motion of telescope is possible. Adjustment of level bubble needed before measurement. This type of level is fitted with a circular bubble for preliminary approximate leveling and a main bubble which is attached to the telescope. For each observation (not setup) the main bubble is viewed through an eyepiece and the telescope tilted by a fine screw to bring the two ends of the bubble into coincidence


Figure 5: modeming tilting level

- **Dumpy Level** levels by the help of bubble tube. Adjustment of level bubble needed only once after level set up. These are more basic levels often used in construction work. The telescope is rigidly attached to a single bubble and the assembly is adjusted either by means of a screwed ball-joint or by foot screws which are adjusted first in one direction, then at 90°

Figure 6 : dumpy level

- **Automatic Level** automatic levels-Levels automatically by compensators. Self leveled instruments an automatic level, self-leveling level or builder's auto level, includes an internal compensator mechanism (a swinging prism) that, when set close to level, automatically removes any remaining variation from level

This reduces the need to set the instrument truly level, as with a dumpy or tilting level. Self-leveling instruments are the preferred instrument on building sites, construction and surveying due to ease of use and rapid setup time this more modern type of level is now in general use. It has a compensator which consists of an arrangement of three prisms. The two outer ones are attached to the barrel of the telescope. The middle prism is suspended by fine wiring and reacts to gravity. The instrument is first leveled approximately with a circular bubble; the compensator will then deviate the line of sight by the amount that the telescope is out of level

- **Automatic Level**

Automatic levels- Levels automatically by compensators. Self leveled instruments
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Figure 7: Automatic Level

- **Tripod**

A tripod for supporting the leveling instrument Tripods provide a fixed base for all types of surveying instruments and sighting equipment. Instrument manufactures nave standardized surveying tripods

Figure 8: Tripod

- **Staff Bubble** These are generally a small circular bubble on an angle plate which is held against one corner of the staff to ensure that the staff is held in a vertical position. If the staff is not held vertical, the reading will be too large and may be significantly in error A staff bubble shall be used at all times. If one is not available, the "chainman" (staff operator) shall rock the staff slowly back and forth about the

vertical in a line towards the instrument. The observer notes the smallest reading which will occur when the staff is vertical

Figure 9: Staff Bubble

- **Leveling Rod (Staff)**

Leveling rods are graduated scale, held vertically over the points and viewed through the telescope of the level where the central horizontal hair of telescope cuts the rod is called the rod reading and this is equal to vertical distance between the line of sight of the level and the point on which the rod is held. Rods are usually made of wood although aluminum alloy and fiber glass rods are also available.

The length of rod is generally in the range of 3-5m and they may be hinged or telescopic for convenience in transporting the graduation is usually in alternate blocks and spaces of 10 mm with numbering in meters and decimeters. The subdivisions are painted in various colors on black on white, red on white or red or yellow. The rods should be protected from sun, rain in inclined storage and drops and hits. The base plate should not be subjected to strong bangs or hits while putting the rod over a point

Figure 10: Leveling Rod (Staff)

www.youtube.com/watch?v=j8poe2vvD2Q

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say true or false for the following questions below

1. Leveling rods are graduated scale, held vertically over the points and viewed through the telescope of the level
2. Staff Bubble These are generally a small circular bubble on an angle plate which is held against one corner of the staff
3. Most common leveling instrument today is the Automatic or Self-leveling level
4. Drawing is a system of representing visual ideas and thoughts on a surface
5. A level datum is an arbitrary level surface to which elevations are referred.

Note: **Satisfactory rating above - 4 points** **Unsatisfactory - below 3 points**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-3	Setting up and testing Levelling devices

3.1 Setting up the Level

The legs of the tripod must be tightened securely

The legs of the tripod should be firmly pressed into the ground with the tripod base plate roughly horizontal

When leveling a four-screw level, the telescope is rotated until it is over two opposite screws as shown below

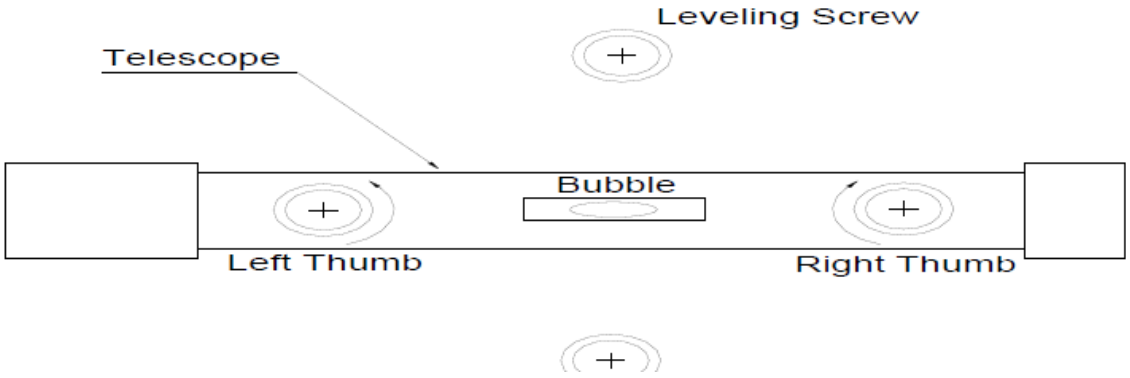

Figure 1: telescope

- Again level the telescope using the leveling screws
- when the scope is level, rotate the telescope another 90 degrees and make any minor adjustments to level the instrument
- rotate the scope another 90 degrees and again, make any minor corrections as required
- Continue rotating and leveling the scope until the instrument is fully level along both axes
- As final check, gently spin your telescope and allow it to come to rest, no matter what direction it faces
- **Examine your leveling bubble**
- It should be exactly centered If it is not, repeat the entire leveling procedure

3.2 Instrument Tests

- Instrument Test 1 (level tube check)
- instrument Test 2 (cross hair check)
- instrument Test 3 (2 peg test)

Self-Check -3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

i. Say true or false for the following questions below

1. when the scope is level, rotate the telescope another 90 degrees
2. The legs of the tripod must be tightened securely
3. level tube check is the first testing of leveling

Note: **Satisfactory rating above- 3 points** **Unsatisfactory - below 2 points**

Score = _____

Rating: _____

Answer Sheet

Information Sheet-4	Leveling device tolerance check

4.1 What is tolerance?

Tolerance refers to the total allowable error within an item. This is typically represented as a +/- value off of a nominal specification. Products can become deformed due to changes in temperature and humidity, which lead to material expansion and contraction, or due to improper feedback from a process control device. As such, it's necessary to take errors into consideration with regard to design values in the manufacturing and inspection processes. If these errors cannot be tolerated, most products will be deemed unacceptable. In this way, tolerance is meant to be used when setting the acceptable error range (the range within which quality can still be maintained) based on the design value with the assumption that variation will occur at any given step

- Application
  The tolerances hereinafter prescribed shall be applied equally to errors in excess and errors in deficiency.
- Minimum Tolerance Values
- On a particular tank, the maintenance and acceptance tolerance applied shall be not smaller than the volume corresponding to the graduated interval at the point of test draft on the indicating means or 2 L (½ gal), whichever is greater. (Amended 1980)
- Basic Tolerance Values.
- The basic maintenance and acceptance tolerance shall be 0.2 % of the volume of test liquid in the tank at each test draft. (Amended 1975)
- Basic Tolerance Values, Master Meter Method.
- The basic maintenance and acceptance tolerance for tanks tested by the master meter method shall be 0.4 % of the volume of test liquid in the tank at each test draft.

.

4.2 What is measurement accuracy?

Accuracy represents a measurement's degree of correctness. Accuracy can be used in such expressions as, “This measurement system offers a high degree of accuracy, so it can be assumed that the expected measurement results can be obtained,” or, “The accuracy of the measurement system has decreased; calibration may be required.” When applied to the measurement process, accuracy is referred to as measurement accuracy. The accuracy of the measurement equipment can be used as in indicator in determining how accurate the results will be. Measurement systems with higher measurement accuracy are able to perform measurements more accurately.

4.3 How tolerance and measurement accuracy affect each other

When manufacturing a cylinder with a length of 50 mm and a tolerance of ±0.1 mm (acceptable range: 49.9 mm to 50.1 mm), inspection with a measurement system is assumed to be as follows.

- Measurement system A: Accuracy ±0.001 mm
- Measurement system B: Accuracy ±0.01 mm
- Measurement system C: Accuracy ±0.03 mm
- According to the above, the acceptable range for each measurement system will be as follows.

- Measurement system A: 49.901 mm to 50.099 mm
- Measurement system B: 49.910 mm to 50.090 mm
- Measurement system C: 49.930 mm to 50.070 mm
- As shown above, measurement systems with higher accuracy are capable of obtaining more accurate results. In addition, increased measurement accuracy makes it possible to reduce the number of products with acceptable tolerances judged mistakenly as unacceptable.
- Reference product: 50 mm, tolerance: ±0.1 mm

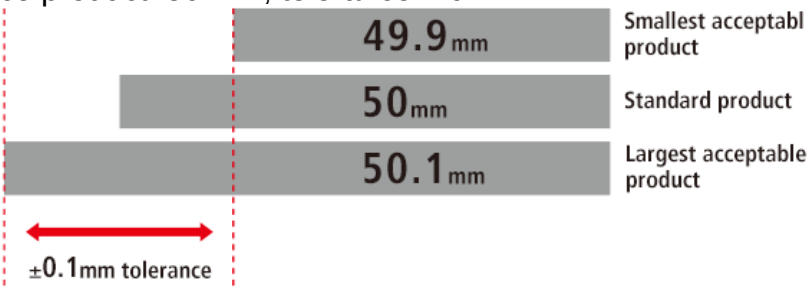

Figure 1:telerance

Tolerances are provided to ensure the finished concrete surface is acceptable for the application and the intended function. Setting tolerances also demonstrate that some degree of variation is inherent in all building work.

The position of the concrete element, its function, appearance and the influence of these on the total project would, in many cases, define the appropriate tolerances.

- Formed Surface: A Surface requiring formwork to provide shape and texture/finish to the concrete.
- Unformed Surface: A surface that does not require formwork to provide either shape or finish to the surface, e.g. the top surface of slabs or pavements.
- These surfaces generally have to meet two independent tolerance criteria: the ‘flatness’ of the surface and variation from the designed elevation (levelness).
- Flatness: The deviation of the surface from a straight line joining two points on the surface.
- Levelness (elevation tolerance):
- The permitted vertical variation of the surface from a fixed external reference point or datum
- Straightedge

Tolerances can be determined by placing a straightedge anywhere on a concrete surface in any direction and measuring the maximum deviation of the surface from the straightedge the use of a 3m straightedge has been found to be a simple and generally satisfactory method of measurement in Australia. A shorter length (0.3m to 15m) straightedge is one of the methods for measuring surface tolerances of formed concrete prescribed by AS 3610.11. The variation from the straightedge is typically expressed as a maximum deviation value over the straightedge length but can be assessed by the method provided

Self-Check -4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

ii. Say true or false for the following questions below

1. Formed Surface a Surface requiring formwork to provide shape and texture/finish to the concrete.
2. Unformed Surface a surface that does not require formwork to provide either shape or finish to the surface
3. Tolerance refers to the total allowable error within an item

Note: **Satisfactory rating above- 2 points** **Unsatisfactory - below 1 point**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-5	Appling levelling staffs accurately

5.1 Using a staff

To take a precise level reading, you use a staff to measure elevation in meters to three decimal places, eg 1.255; that is, the meters and tenths, and hundredths and thousandths of a meter.

While there is a variety of staffs available, the E-staff is the most commonly used on construction site

5.2 Reading an E-staff

An E-staff has a series of ‘E’ shapes printed at set intervals along its length, with two small squares between each. These shapes are used like the lines on a ruler or tape measure but are easier to see at a distance.

Figure 1: E-staff

Note: The design and color of the staff can vary; however, most staffs use a combination of black and red with an alternating pattern of E-shapes.

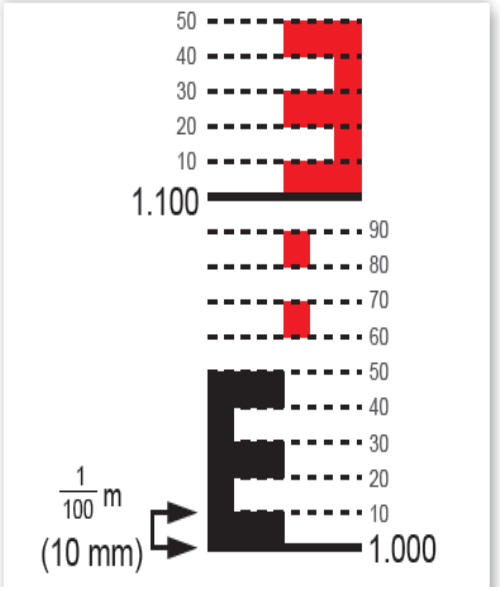

Figure 2: colour staff

As each block is 10 mm high, the **thousandths of meter's** (1 mm) can be estimated by dividing each color block (or space) into 10.

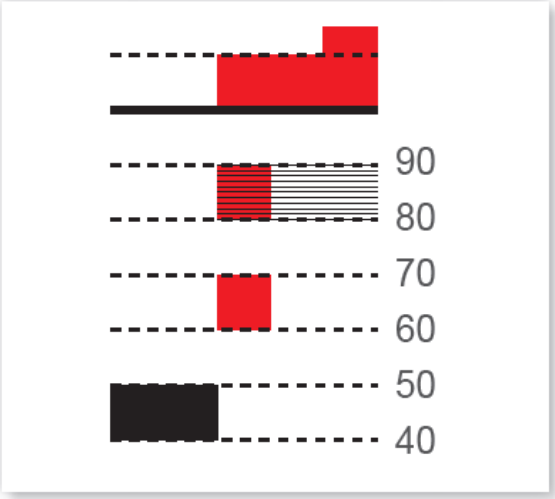

Figure 3: levelling reading

The process for taking a level reading on an E-staff is completed in three steps.

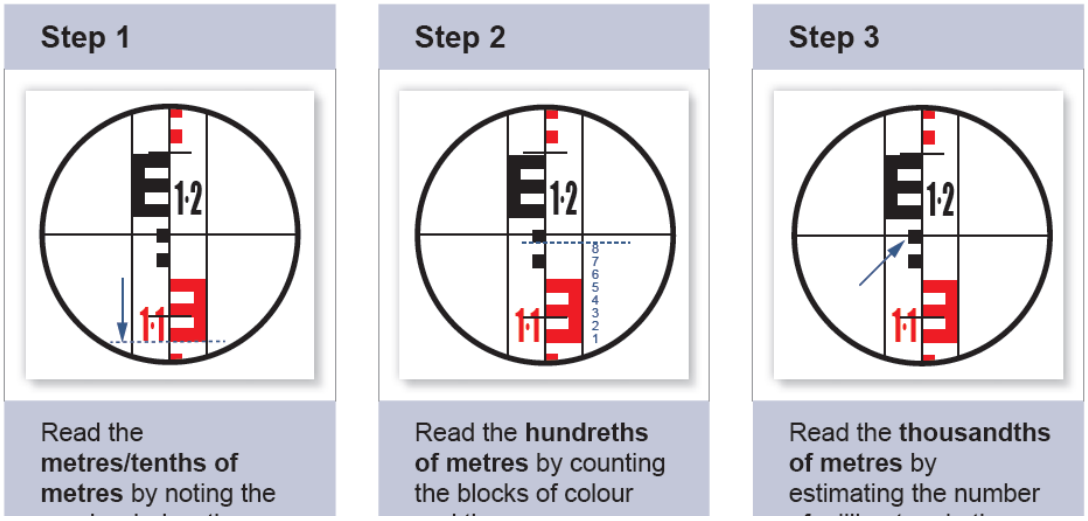

Figure 4: levelling estimating

5.3 Holding a staff

Taking a level with an optical leveling instrument usually requires an operator to look through the telescope and take the reading, and an assistant to hold the staff at the measurement point. A land surveyor's assistant is also known as a chain person because surveyor's measure distances with a special type of chain rather than a tape.

The most important aspect of holding a staff is making sure it's plumb (vertical). If it's earning in any direction, the crosshairs will appear to be further up the staff and the reading will be incorrect.

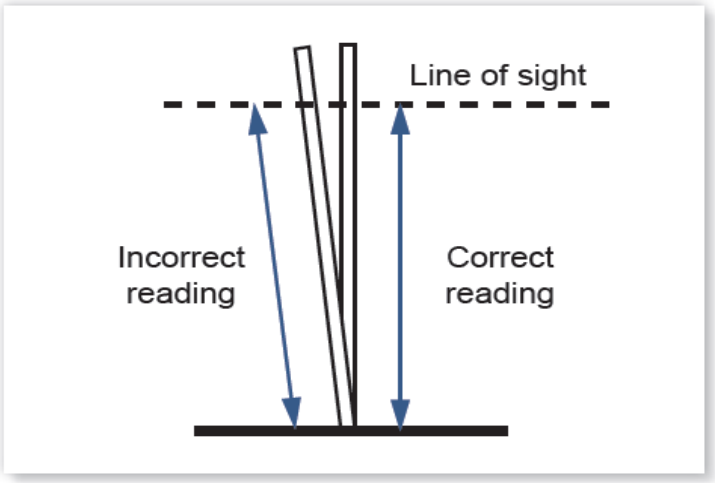

Figure 5:holding staff

If the assistant stands behind the staff, neither the assistant nor the instrument operator can tell whether the staff is vertical from the side.

Figure 6: staff direction

Note: The movements of the staff in this direction are generally referred to as ‘fore and aft’.

If the assistant stands to the side of the staff, they can tell if it’s vertical ‘fore and aft’, while the instrument operator can see if it’s vertical the other way Assistant’s view.

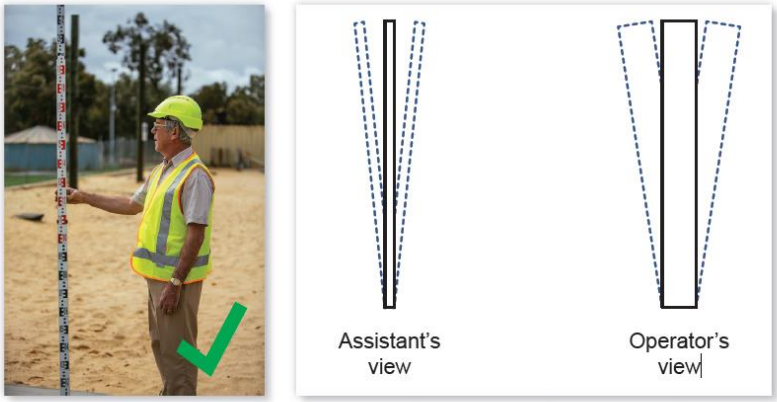

Figure 7:assistants view

5.4 Staff level

You can buy a small circular level that’s made especially for keeping the staff vertical.
It’s held against the staff and the assistant holds the staff so that the bubble is inside the etched circle.

Self-Check -5	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say true or false for the following questions below

1. Taking a level with an optical leveling instrument usually requires an operator to look through the telescope
2. The design and color of the staff can vary
3. An E-staff has a series of ‘E’ shapes printed at set intervals along its length
4. To take a precise level reading, you use a staff to measure elevation in meters

Note: **Satisfactory rating above- 3 points** **Unsatisfactory - below 2 points**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-6	Shotting levels and transferring heights to job requirements

6.1 transferring levels

Multi-story building construction on solar work or tall-column construction on a bridge project requires that ground elevations be transferred vertically as the structure progresses upward to maintain the design grades. Occasionally, this can be accomplished by normal differential leveling procedures of back sights and foresights when there is an adjacent structure or high ground. However, the most common method of transferring elevation up into a structure is to use a good calibrated chain and measure vertically along a column, the elevator/stair core or any other part of the structure that is solid and progressing vertically. A simple process, but one that requires following exact procedures to obtain accurate results.

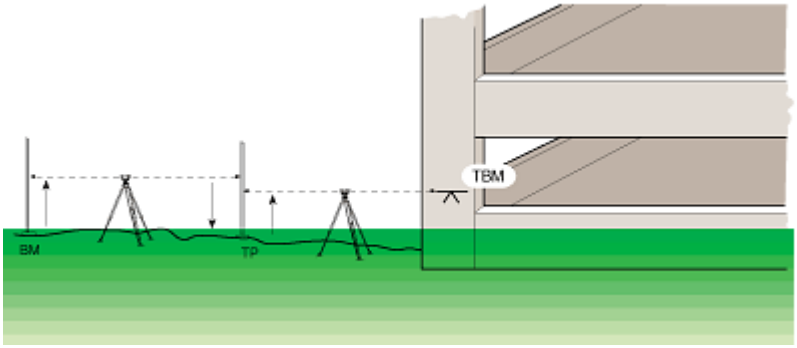

Figure 1: *Run a level loop to the structure and establishes a temporary bench mark (TBM) at the bottom of the structure.*

- **Procedure**

  Plan for the efficient and accurate establishment of the elevations. Check with the project superintendent and the foremen to determine what floor the elevations are needed on. Determine if the elevation is needed on just one side of the structure, on two sides, or all the way around it. Locate two nearby bench marks, one to start from and one to check into after a temporary bench mark has been established on the structure. Be sure to make the check prior to measuring up along the side of the building in case one of the bench marks has been disturbed.

6.2 Types of problems you will be facing

- There are three types of problems in the measurement of height differences.
- Calculating height differences

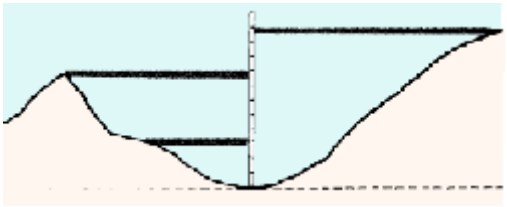

Figure 2: height differences

- You may have to measure any differences in height among a series of points on the ground, and compare them. From the results of this comparison, you can calculate the heights of given points so that you can make a map
- A counter line

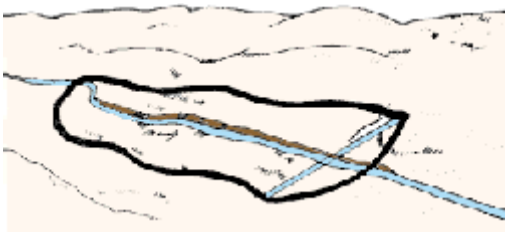

Figure 3: counter line

You may have to locate points which are at the same height. This is called laying out contour lines, or contouring

- **Setting out a slope**

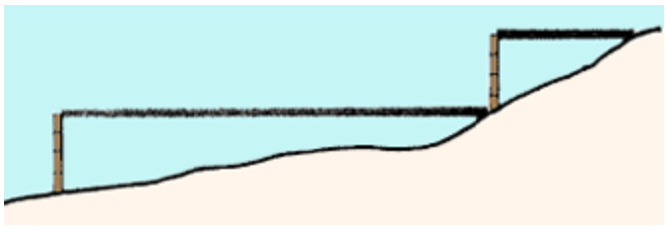

Figure 4: slope

- **Measuring the height of ground points**

  Differences in height between two points are usually measured with a device called a level. It is called a level because it gives a true horizontal line. The height of each point is then measured by its vertical distance above or below this horizontal line

- **A straight edge level**

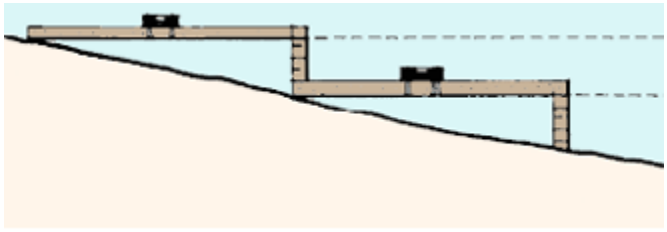

Figure 5: edge level

This horizontal line can be formed in two ways, depending on the type of measuring device you are using to find the heights of points. If you use a non-sighting level You will always use sighting levels together with a vertical graduated scale, which measures the height of the line of sight at each station

- **Sighting level**

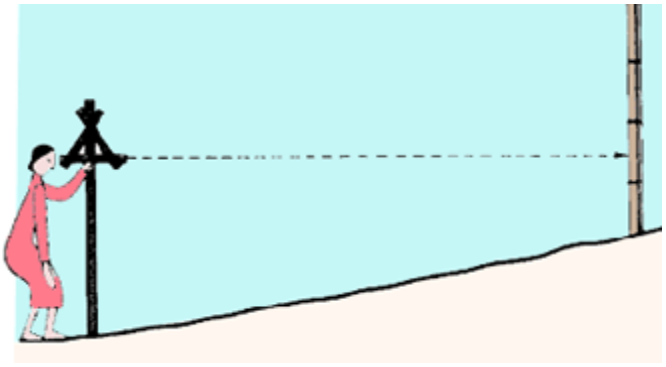

Figure 6: Sighting level

A ruler with a vertical graduated scale is called a leveling staff. There are several models which you can buy, or you can make your own (see the following steps). Leveling staffs are usually 2 to 5 m long, foldable or telescopic, and made of plastic-coated wood or aluminum. Self-reading leveling staffs are usually graduated in meters, decimeters, and centimeters. These graduations are upside-down so that you can read them with a telescope. On a target leveling staff, there is a moveable "target" with a reference line*, which can be positioned at a fixed height.

- **Leveling staffs**

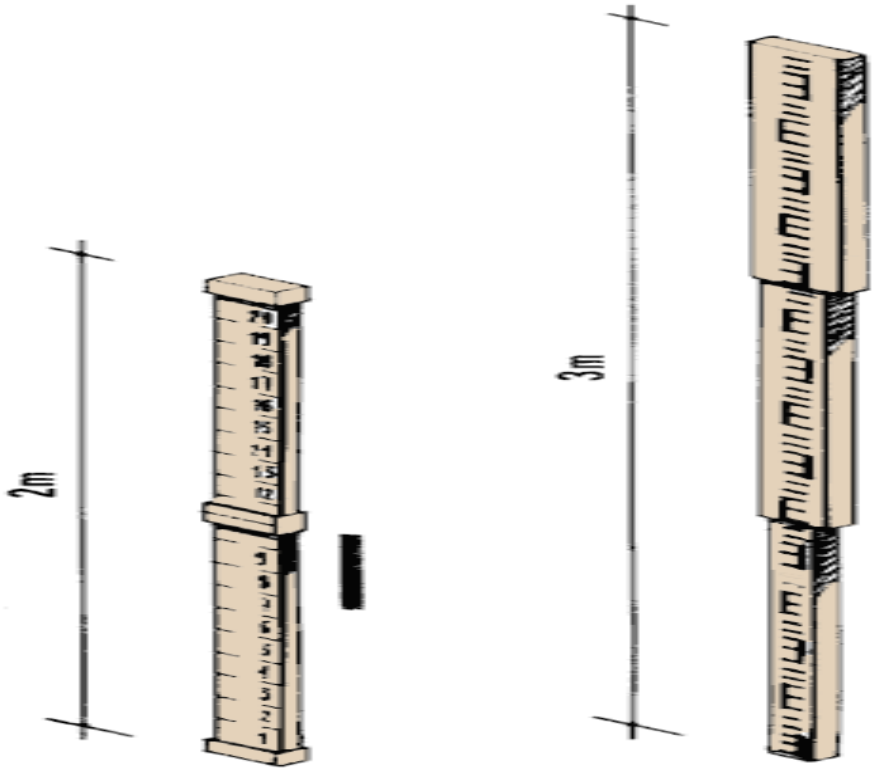

Figure 6: Leveling staffs

Self-Check -6	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

II. Say true or false for the following questions below

1. A counter line locates points which are at the same height.
2. A ruler with a vertical graduated scale is called a leveling staff

Note: **Satisfactory rating above-2 points** **Unsatisfactory - below 1 point**

Score = _____

Rating: _____

Answer Sheet

Information Sheet-7	Documenting results of leveling procedure

7.2 Introduction to documenting results of leveling

File documentation accompanying grantee welfare outcomes survey data files should help researchers use these data and prevent grantees from having to bear the burden of supporting and interpreting data files to researchers in the future. The Work Group recommends that grantees use a standardized approach to producing survey data file documentation. This will improve researcher understanding and reduce the amount of work required by grantees to produce these documents. To assist grantees with producing file documentation using a standardized approach, the Work Group developed a set of documentation templates. These templates are provided in the Grantee Toolkit

Level books

All leveling shall be booked in either level books or leveling sheets which shall be retained as permanent records.

Level books shall be numbered so that they can be referenced on station history and inspection forms. They should be stored in fire-proof storage as for original record. They should also include an index.

Leveling sheets shall be filed in time-sequential order in site files, and also need to be in fire-proof storage as for level books.

7.3 LEVELING PROCEDURES AND FIELD BOOKS

The levels are recorded in a field book; this field book must always show the following:

- The date and year on each page;
- Name of surveyor;
- The job description (name of canal, site, grid survey etc);
- Serial number and type of the survey instrument used;
- Page number.

You may also use your field book to note field decisions made, instructions received from visiting engineers, hours worked etc. In other words your field book is a complete daily record of your work in the field. It is recommended to use a ball-point- pen to enter your measurements. The entries should be clear and neat, any other person should be able to use the field book for future reference. First of all, the draughtsman should be able to use it for plotting and mapping work. If you make a mistake, don't make the figure invisible but put a line through the error.

Draw small diagrams where necessary, always show with an arrow the direction of flow in a waterway. If indicating the right and left bank, always name them when looking in downstream direction.

There are two methods of recording, the Collimation Method and the Rise and Fall method.

- **Collimation method**
  - ✓ Level at B = height of collimation - reading at B
  - ✓ Level at D = height of collimation - reading at D

The collimation method is also known as the "height of instrument" method. Throughout the field work the instrument height is always known by taking the first sight on a. paint of known (or assumed) level. At any time therefore, the level of a point can be quickly worked out by subtracting its staff reading from the level of the instrument (instrument height). The method is convenient for obtaining the levels of many points from one set-up.

Thus the first point of reading should always be of known level, preferably a Bench Mark. The reading of the B.M is booked on the first line in the back sight column as this 10

Self-Check -7	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say true or false for the following questions below

1. Leveling sheets shall be filed in time-sequential order in site files
2. Serial number and type of the survey instrument used is an example of leveling procedures

Note: **Satisfactory rating above- 2 points** **Unsatisfactory - below 1 points**

Answer Sheet

Score = _____

Rating: _____

Reference

1. ASTM C1315, *Standard Specification for Liquid Membrane-Forming Compounds Having Special Properties for Curing and Sealing Concrete* (www.astm.org)

   ASTM C192 / C192M, *Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory* (www.astm.org)
2. ASTM C31 / C31M, *Standard Practice for Making and Curing Concrete Test Specimens in the Field* (www.astm.org)

Solar PV System Installation and Maintenance

Level-II

Learning Guide -38

Unit of Competence	Carry out Civil Work for PV Installation
Module Title	Carrying out Civil Work for PV Installation
LG Code	EIS PIM2 M09 LO4 LG-38
TTLM Code	EIS PIM2 TTLM 0120V1

LO4.Fabricate cement castings

Instruction Sheet	Learning Guide: - 38

This learning guide is developed to provide you the necessary information, knowledge, skills and attitude regarding the following content coverage and topics:-

- Preparing form work and reinforcements
- Mixing, placing and compacting material to make castings
- Removing and curing casting
- Apply quality requirements

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:-

- Prepare form work and reinforcements
- Mix, place and compact material to make castings
- Remove and cure casting
- Apply quality requirements

Learning Instructions:-

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 6.
3. Read the information written in the information Sheet 1, Sheet 2, Sheet 3, Sheet 4, in pages 86, 91, 96, & 100 respectively.
4. Accomplish the Self-check 1, Self-check 2, Self-check 3, Self-check 4 in pages 93, 95, 99 &103 respectively
5. If you earned a satisfactory evaluation from the “Self-check” proceed to Operation on page 91.
6. Do the “LAP test” on page 92

Information Sheet-1	Preparing form work and reinforcements

1.1. Definition

It is an artificial support provided below and around the precast or cast in situ concrete work.

Forms are extremely important in concrete construction. They mold the concrete to the required size and shape while controlling its position and alignment. Forms are self-supporting structures that are also sufficient to hold the dead load of the reinforcement and fresh concrete and the live load of equipment, workers, and miscellaneous materials in building and designing form work, three major objectives must be considered:

- **Quality-**Forms must be designed and built with sufficient stiffness and accuracy so the size, shape, position, and finish of the cast concrete are attained within the required tolerances.
- Safety-Forms must be built with sufficient strength and factors of safety so they are capable of supporting all dead and live loads without collapse or danger to workers and to the concrete structure.3.
- Economy-Forms must be built efficiently, minimizing time and cost in the construction process and schedule for the benefit of both the contractor and the owner.
- Formwork is commonly made of
  - ✓ Steel
  - ✓ Wood

Formwork construction & casting is of prime importance in concrete industry. It shares a significant amount of concrete cost. (20% to 25%).

When concrete has reached a certain required strength, the form is no longer needed & removed. The operation of removing the form work is known as stripping

1.2. Qualities of formwork

- It should be practically water proof so that it should not absorb water from concrete.
- It should be strong.
- It can be cheaper & reusable
- It should be according to the size of member.
- It should be with minimum shrinkage & swelling.
- It should be stiff enough against its deflection, buckling under load.
- Its contact surface should be uniform.
- It should be light in weight

1.3. Reinforcement

- The reinforcement should be given as mentioned in the reinforcement schedule and detail drawing under the structural drawing.
- Bind and place the reinforcement in the form once it is completed. The reinforcement should be fixed properly with the column reinforcement.

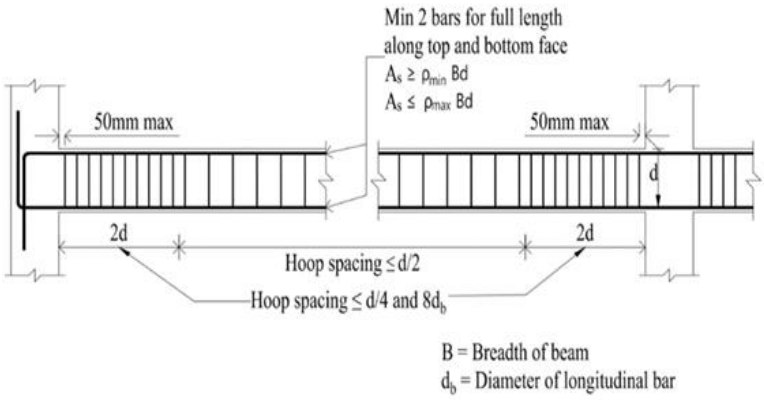

Figure 1: typical beam reinforcement

Types of formwork

- **Form works are mainly of two types:**
  - ✓ Steel formwork
  - ✓ Wooden formwork
- **Steel formwork is made of :**
  - ✓ steel sheets
  - ✓ Angle Iron
  - ✓ Tee Iron
- **Wooden formwork consists of**
  - ✓ Props
  - ✓ Planks battens
  - ✓ Ledgers
  - ✓ Sheeting

1.4. Causes of failure

- Overloading of any props when sufficient number or size of props not provided.
- Failure of shuttering due to excessive vibrations of needle surface vibrators.
- Failure due to improper supervision, inadequate design/ planning of shuttering, centering & concreting activity.
- Failure due to dislocation of props or bracing due to careless movement of labours having access below the formwork of slab or beam.
- Failure due to insufficient cross bracing. Cross bracing improve the stiffness of props against buckling.

Formwork detail for different structural members In concrete construction formwork is commonly provided for the following structural members.

- Foundations
- Wall
- Column
- Slabs & beams
- Stairs

Several considerations are involved in determining an economical form construction, such as:

- Cost and feasibility of adapting materials on hand vs. cost of buying or renting new materials
- Cost of a higher grade of material vs. cost of lower grade of material plus labour to improve for required quality and use
- Selection of more expensive materials that provide greater durability and capability for reuse vs. less expensive materials that have a shorter use-life
- Building on-site vs. building in a central shop and shipping to site (this depends on the site itself and space available, the size of project, the distance of shipping, etc.
-

1.5. Formwork for Foundations

Column Foundations It consists of

- Side Supports
- Side Planks
- Cleats

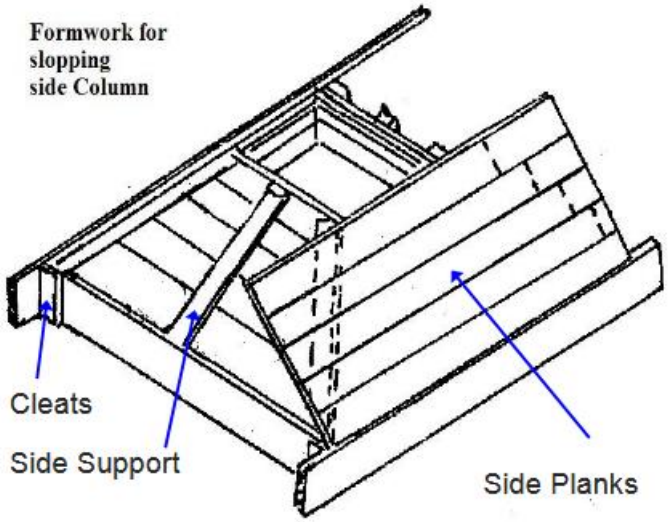

Figure 2:form work foundation

Reinforcement:

- Reinforcements should be free of any materials that may destroy or reduce the bond.
- Steel reinforcement should be stored according to length, size and shape. There should be enough space between piles so that it can be accessed easily and safely.
- A basic test for steel would be specific gravity or density test.

1.6. Site layout and preparation

- Locate the boundary pegs at site; verify if the boundary pegs are in accordance with the coordinates given in the official site plan.
- Clear the construction site of any bushes, trees and obstruction if any.
- Establish bench marks and datum level at site.
- Any deviations at site should be referred back to approving authority.

Setting out

- Study the Architectural and Structural drawings to ensure that gridlines and spacing dimensions are consistent.

- Identify the starter column and clearly market on the ground. After marking all the position of the columns as per the construction drawings, cross check the diagonal distance between individual columns.

- Methods of setting out :
  - ✓ Using surveying instruments like Total Station, Theodolite etc.
  - ✓ Triangulation, builders' square
  - ✓ Line intersection method
  - ✓ Pythagoras theorem (3, 4 and 5) can be adopted to cross check the triangulation of a regular building
    - Provide and fix adequate recovery pegs in suitable locations away from the excavation area.
    - Cross check the final set out by Pythagoras theorem or Intersection Method.

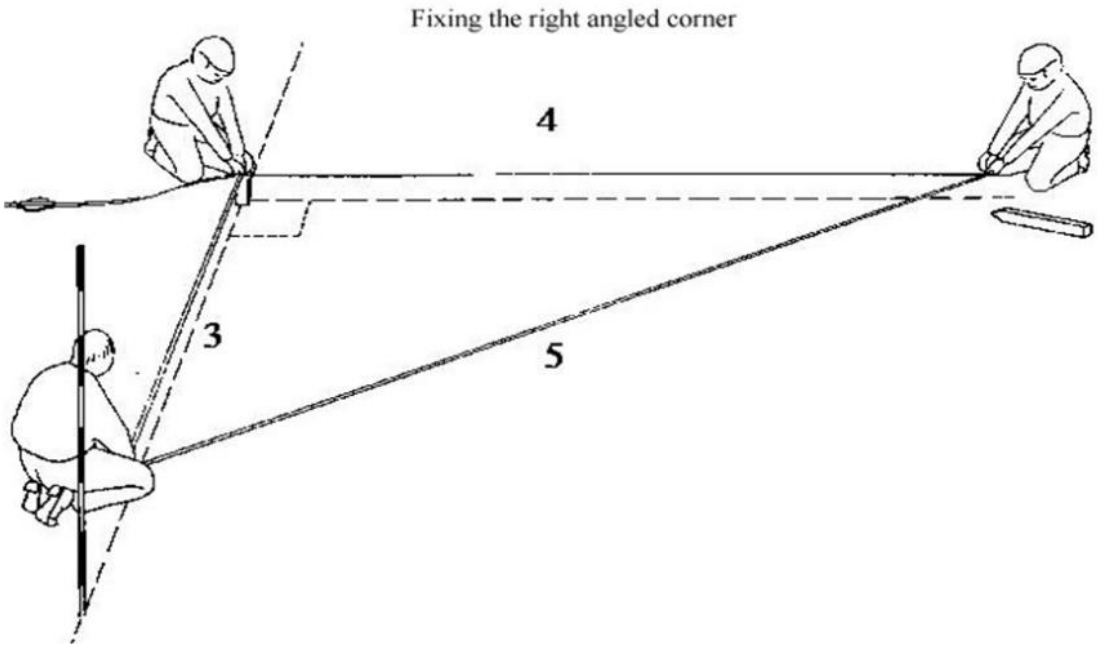

Figure 3: Setting out

Self-Check – 1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say True or False For the Following Question Below

1. Formwork is commonly made of Steel & Wood
2. Formwork construction & casting is of prime importance in concrete industry
3. Steel formwork &Wooden formwork are types Form works
4. Steel formwork is made of steel sheets & Angle Iron
5. Wooden formwork contains Planks battens
6. Column Foundations consists of Side Supports & Side Planks

Note: **Satisfactory rating – 4 points** **Unsatisfactory - below 3 point**

Answer Sheet

Score = _____

Rating: _____

Operation Sheet -1	Formwork for Foundations

Operation Title: Procedure Site layout and preparation

Step -1. Wear appropriate personal protective equipment

Step -2. Prepare and plan work place

Step -3 Select appropriate equipment and tools

Step -4 Perform the given project accurately

Step -5 Locate the boundary pegs at site;

Step-6 verifies if the boundary pegs are in accordance with the coordinates given in the official site plan.

Step-7 Clear the construction site of any bushes, trees and obstruction if any.

Step-8 Establish bench marks and datum level at site.

Step-9 any deviations at site should be referred back to approving authority.

Step-10 Identify the starter column and clearly market on the ground

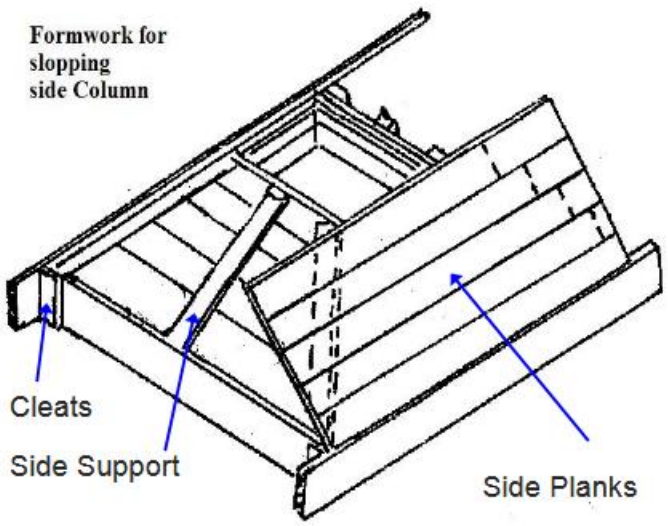

Figure 1: site lay out

LAP Test	Practical Demonstration

Name: _____ Date: _____

Time started: _____ Time finished: _____

Instructions: Given necessary materials, tools and measuring instruments you are required to perform the following tasks within 1 hour.

Task 1. Measure the distance & fixing the right angle at the corner point

2.1 mixing

This part covers procedures for making and curing cylindrical concrete specimens
The following apparatus is required:

- **Vibrator**
  - ✓ with rigid or flexible shafts, preferably powered by electric motors, vibrating at a frequency of 7,000 vibrations per minute or greater, with the outside diameter or side dimension of the vibrating elements at least 3/4 in. (19 mm), and not greater than 1/4 the diameter of the specimen
  - ✓ combined length of the shaft and vibrating element exceeding the maximum depth of the section being vibrated by a minimum of 3 in. (75 mm)
  - ✓ Vibrating-reed tachometer for vibration frequency verification.
- **Tamping rods**
  - ✓ small tools, such as shovels, pails, trowels, wood float, scoops, and rubber gloves
  - ✓ mallet, with a rubber or rawhide head, weighing 1.25 ±0.50 lb. (0.6 ±0.2 kg)
  - ✓ burlap or cotton mats
  - ✓ storage tank, or moist room, as specified in 'Standard Specification for Moist Cabinets, Moist Rooms, and Water Storage Tanks Used in the Testing of Hydraulic Cement and Concrete'
- **Molds**
  - ✓ Molds must be water tight, circular cylinders made of steel, cast iron, or other non-absorbent material, nonreactive with concrete containing port land or other hydraulic cements.
  - ✓ Provide either single-use molds or reusable molds. Single-use molds and caps are made of molded polyethylene or plastic designed to be used a single time. Reusable molds are constructed from a rigid material and designed to be used more than a single time.
  - ✓ The molds must stand with cylindrical axes vertical and the top open, with a nominal inside height equal to twice the nominal inside diameter.

2.2 Molding Test Specimens

Table 4: moulding

The following table describes the procedure for molding test specimens.

Molding Concrete Test Specimens	
Step	**Action**
1	♦ Mold specimens promptly on a level, rigid, horizontal surface, free from vibration and other disturbances, at a place as near as practical to the location where they are to be stored during the first 24 hr. ♦ If it is not practicable to mold the specimens where they are to be stored, move them to the place of storage immediately after striking off. ♦ When moving specimens made in single use molds, lift and support the specimens from the bottom of the molds with a large trowel or other flat device.
2	♦ Place the concrete in the molds using a scoop or shovel, in layers of approximately equal volume. ♦ Move the scoop around the top edge of the mold as the concrete is discharged to ensure a symmetrical distribution of the concrete and minimize segregation of the coarse aggregate within the mold. ♦ In placing the final layer, try to add an amount of concrete that will exactly fill the mold after compaction. ♦ Do not add nonrepresentative concrete to an under-filled mold.

Self-Check – 2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

II. Say True or False For the Following Question Below

1. Vibrator is rigid or flexible shafts, preferably powered by electric motors
2. Molds must be water tight, circular cylinders made of steel, cast iron, or other non-absorbent material
3. Vibrating-reed tachometer for vibration frequency verification

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 point**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-3	Removing and curing casting

3.1 Introduction Curing casting

Curing plays an important role on strength development and durability of concrete. Curing takes place immediately after concrete placing and finishing, and involves maintenance of desired moisture and temperature conditions, both at depth and near the surface, for extended periods of time. Properly cured concrete has an adequate amount of moisture for continued hydration and development of strength, volume stability, resistance to freezing and thawing, and abrasion and scaling resistance.

The length of adequate curing time is dependent on the following factors:

- Mixture proportions
- Specified strength
- Size and shape of concrete member
- Ambient weather conditions
- Future exposure conditions

- There are three main functions of curing:
  Maintaining mixing water in concrete during the early hardening process
  - ✓ **Ponding and immersion**
    Ponding is typically used to cure flat surfaces on smaller jobs. Care should be taken to maintain curing water temperature at not more than 20 degrees Fahrenheit cooler than the concrete to prevent cracking due to thermal stresses. Immersion is mainly used in the laboratory for curing concrete test specimens.
  - ✓ **Spraying and fogging**
    Spraying and fogging are used when the ambient temperatures are well above freezing and the humidity is low. Fogging can minimize plastic shrinkage cracking until the concrete attains final set.
  - ✓ **Saturated wet coverings**
    Wet coverings saturated with water should be used after concrete has hardened enough to prevent surface damage. They should be kept constantly wet.
  - ✓ **Left in Place Forms**
    Left in place forms usually provide satisfactory protection against moisture loss for formed concrete surfaces. The forms are usually left in place as long as the construction schedule allows. If the forms are made of wood, they should be kept moist, especially during hot, dry weather.

3.2 Reducing the loss of mixing water from the surface of the concrete

- Covering concrete with impervious paper or plastic sheets
  impervious paper and plastic sheets can be applied on thoroughly wetted concrete. The concrete surface should be hard enough to prevent surface damage from placement activities.
- Applying membrane-forming curing compounds
  Membrane-forming curing compounds are used to retard or reduce evaporation of moisture from concrete. They can be clear or translucent and white pigmented.

3.3 **Accelerating strength gain using heat and additional moisture**

- **Live steam**
  Live steam at atmospheric pressure and high-pressure steam in autoclaves are the two methods of steam curing. Steam temperature for live steam at atmospheric pressure should be kept at about 140 degrees Fahrenheit or less until the desired concrete strength is achieved.
- **Heating coils**
  heating coils are usually used as embedded elements near the surface of concrete elements. Their purpose is to protect concrete from freezing during cold weather concreting.
- **Electrical heated forms or pads**
  Electrical heated forms or pads are primarily used by precast concrete producers.
- **Concrete blankets**
  Concrete insulation blankets are used to cover and insulate concrete surfaces subjected to freezing temperatures during the curing period. The concrete should be hard enough to prevent surface damage when covering with concrete blankets. PV end-of-life management also offers opportunities relating to each of the 'three Rs' of sustainable waste management:
- **Reduce**: as research and development (R&D) and technological advances continue with a maturing industry, the composition of panels is expected to require less raw material. Today, two-thirds of globally manufactured PV panels are crystalline silicon (c-Si). These are typically composed of more than 90% glass, polymer and aluminum, which are classified as non-hazardous waste. However, the same panels also include such hazardous materials as silver, tin and lead traces.

  Thin-film panels, by comparison, are over 98% non-hazardous glass, polymer and aluminum, combined with around 2% copper and zinc (potentially hazardous) and semiconductor or other hazardous materials. These include indium, gallium, selenium, cadmium, tellurium and lead. Hazardous materials are typically subject to rigorous treatment requirements with specific classifications depending on the jurisdiction. By 2030, given current trends in R&D and panel efficiency, the raw material inputs for c-Si and thin-film technologies could be reduced significantly. This would decrease the use of hazardous and rare materials in the production process and consequently improve the recyclability and resource recovery potential of end-of-life panels.

- **Reuse:** rapid global PV growth is expected to generate a robust secondary market for panel components and materials. Early failures in the lifetime of a panel present repair and reuse opportunities. Repaired PV panels can be resold on the world market at a reduced market price. Even partly repaired panels or components might find willing buyers in a second-hand market. This secondary market presents an important opportunity for buyers in countries with limited financial resources which still want to engage in the solar PV

- **Recycle:** As current PV installations reach the final decommissioning stage, recycling and material recovery will be preferable to panel disposal. The nascent PV recycling industry typically treats end-of-life PV panels through separate batch runs within existing general recycling plants. This allows for material recovery of major components. Examples include glass, aluminium and copper for c-Si panels that can

be recovered at cumulative yields greater than 85% of total panel mass. In the long term, dedicated panel recycling plants can increase treatment capacities and maximize revenues owing to better output quality and the ability to recover a Preferred options for PV waste management Most preferred Least

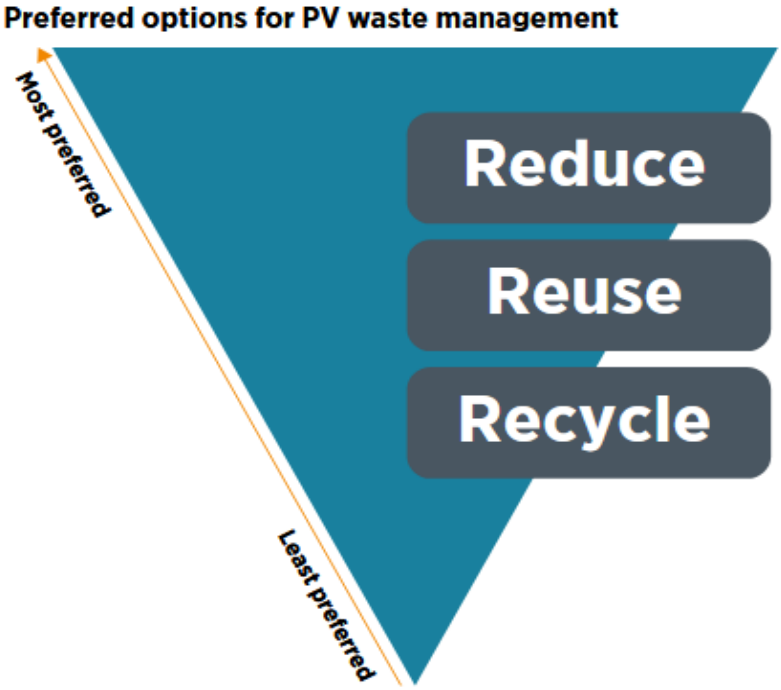

Figure 1: recycle

Self-Check – 3	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say True or False For the Following Question Below

1. Curing plays an important role on strength development and durability of concrete
2. Ponding is typically used to cure flat surfaces on smaller jobs
3. Spraying and fogging are used when the ambient temperatures are well above freezing and the humidity is low
4. Left in place forms usually provide satisfactory protection against moisture loss for formed concrete surfaces
5. Heating coils are usually used as embedded elements near the surface of concrete elements

Note: **Satisfactory rating – 3 points** **Unsatisfactory - below 2 point**

Answer Sheet

Score = _____

Rating: _____

4.1 Apply quality requirements:

Solar module quality assurance involves testing and evaluating solar cells to ensure the quality requirements of them are met. They must constantly and consistently deliver the power expected. In addition, modules are exposed to a wide array of weather conditions along with usage in differ climates.

Quality requirement is a common term in project management In a nutshell, that defines the expectations of the customer for quality, the internal processes as well as the attributes of products that indicate whether the quality factors are satisfied or not.

Quality management standards are details of requirements, specifications, guidelines and characteristics that products, services and processes should consistently meet in order to ensure: their quality matches expectations. they are fit for purpose. They meet the needs of their users.

- A good formwork should satisfy the following requirement
  - ✓ Easy removal
  - ✓ Economy
  - ✓ Strength
  - ✓ Rigidity
  - ✓ Less leakage
  - ✓ smooth surface
  - ✓ Light weight
  - ✓ Quality
  - ✓ supports
- **Easy removal**

  The design of formwork should be such that it can be removed easily. With least amount of hammering. The removal of formwork should cause least injury to the surface or edges of the concrete
- Economy : As the formwork does not contribute anything to the stability of the finished structure, it should therefore, be made economical by reducing the cost through proper design and construction
- Strength the formwork should be strong enough to withstand all loads coming on it, such as dead load of concrete. And live load during its pouring. Compaction and curing. The loads on formwork should be estimated carefully. The over-estimation of loads result in expensive formwork and the under estimation of loads results in the failure of formwork.

- Rigidity The formwork should rigid (stiff) enough so that deflection is minimum. for visible surface in completed the work. The deflection limited to 1/300 of span and for hidden surface. It is limited 1/150 of span. It should be noted that a rigid formwork will be robust and stiff enough to allow repeated us
-
- Less leakage The formwork should be so arranged that there is minimum of leakage through the joints. This is achieved providing tight joints between adjacent sections of the formwork.
-
- Smooth surface The surface of the formwork should be smooth, and it should afford easy stripping This is achieved by applying crude oil or soft soap solution to the inside surface of formwork

4.2 A good formwork should satisfy the following requirements:

- It should be strong enough to withstand all types of dead and live loads.
- It should be rigidly constructed and efficiently propped and braced both horizontally and vertically, so as to retain its shape.
- The joints in the formwork should be tight against leakage of cement grout.
- Construction of formwork should permit removal of various parts in desired sequences without damage to the concrete.
- The material of the formwork should be cheap, easily available and should be suitable for reuse.
- The formwork should be set accurately to the desired line and levels should have plane surface.
- It should be as light as possible.
- The material of the formwork should not warp or get distorted when exposed to the elements.
- It should rest on firm base

Self-Check – 4	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say True or False For the Following Question Below

1. Quality management standards are details of requirements, specifications, guidelines and characteristics
2. Quality requirement that defines the expectations of the customer for quality
3. The formwork should be set accurately to the desired line and levels should have plane surface

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 point**

Score = _____

Rating: _____

Answer Sheet

Reference

1. Guide to Curing Concrete, ACI 308R-01 (www.concrete.org)
2. ASTM C309, Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete (www.astm.org)

Solar PV System Installation and Maintenance

Level-II

Learning Guide -39

Unit of Competence	**Carry out Civil Work for PV Installation**
Module Title	**Carrying out Civil Work for PV Installation**
LG Code	EIS PIM2 M09 LO5 **LG-39**
TTLM Code	EIS PIM2 **TTLM 0120v1**

L05. Clean up Work area

Instruction Sheet	Learning Guide:-39

This learning guide is developed to provide you the necessary information regarding the following **content coverage** and topics

- Clearing work area
- Inspecting plant, tools and equipment

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, **you will be able to:-**

- Clear work area
- Inspect plant, tools and equipment

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below 3 to 4.
3. Read the information written in the information Sheet 1& Sheet 2 in page 107 & 113 respectively.
4. Accomplish the Self-check 1& Self-check 2, in page 112 & 115 respectively

Information Sheet-1	Cleaning work area

1.1 Introduction Cleaning

Is the process of removing unwanted substances, such as dirt, infectious agents, and other impurities, from an object or environment. Cleaning occurs in many different contexts, and uses many different methods. Several occupations are devoted to cleaning.

Housekeeping is not limited to keeping the place clean; it is also concerned with keeping equipment and materials in good repair and in their proper place. Good housekeeping is essential to preventing losses or injuries every injury caused by housekeeping can be prevented if everyone helps to keep the work area clean.

Important to clean your work area

The workplace environment influences employees' productivity, performance and well-being. No matter the industry, maintaining a clean workplace may help keep staff members safe, healthy and efficient. However, busy production schedules and increasing workloads may cause standards to dip.

Why should we pay attention to housekeeping at work?

Effective housekeeping can help control or eliminate workplace hazards. Poor housekeeping practices frequently contribute to incidents. If the sight of paper, debris, clutter and spills is accepted as normal, then other more serious hazards may be taken for granted.

Housekeeping is not just cleanliness. It includes keeping work areas neat and orderly, maintaining halls and floors free of slip and trip hazards, and removing of waste materials (e.g., paper, cardboard) and other fire hazards from work areas. It also requires paying attention to important details such as the layout of the whole workplace, aisle marking, the adequacy of storage facilities, and maintenance. Good housekeeping is also a basic part of incident and fire prevention.

Effective housekeeping is an ongoing operation: it is not a one-time or hit-and-miss cleanup done occasionally. Periodic "panic" cleanups are costly and ineffective in reducing incidents.

1.2 What is the purpose of workplace housekeeping?

Poor housekeeping can be a cause of incidents, such as:

- tripping over loose objects on floors, stairs and platforms
- being hit by falling objects
- slipping on greasy, wet or dirty surfaces
- striking against projecting, poorly stacked items or misplaced material
- cutting, puncturing, or tearing the skin of hands or other parts of the body on projecting nails, wire or steel strapping

To avoid these hazards, a workplace must "maintain" order throughout a workday. Although this effort requires a great deal of management and planning, the benefits are many.

What are some benefits of good housekeeping practices?

Effective housekeeping results in:

- reduced handling to ease the flow of materials

- fewer tripping and slipping incidents in clutter-free and spill-free work areas
- decreased fire hazards
- lower worker exposures to hazardous products (e.g. dusts, vapours)
- better control of tools and materials, including inventory and supplies
- more efficient equipment cleanup and maintenance
- better hygienic conditions leading to improved health
- more effective use of space
- reduced property damage by improving preventive maintenance
- less janitorial work
- improved morale
- improved productivity (tools and materials will be easy to find)

1.3 How do I plan a good housekeeping program?

A good housekeeping program plans and manages the orderly storage and movement of materials from point of entry to exit. It includes a material flow plan to ensure minimal handling. The plan also makes sure that work areas are not used as storage areas by having workers move materials to and from work areas as needed. Part of the plan could include investing in extra bins and more frequent disposal.

The costs of this investment could be offset by the elimination of repeated handling of the same material and more effective use of the workers' time. Often, ineffective or insufficient storage planning results in materials being handled many times and being stored in hazardous ways. Knowing the workplace layout and the movement of materials throughout it will help when planning work procedures.

Worker training is an essential part of any good housekeeping program. Workers need to know how to work safely with the products they use. They also need to know how to protect other workers such as by posting signs (e.g., "Wet - Slippery Floor") and reporting any unusual conditions.

Housekeeping order is "maintained" not "achieved." Cleaning and organization must be done regularly, not just at the end of the shift. Integrating housekeeping into jobs can help ensure this is done. A good housekeeping program identifies and assigns responsibilities for the following:

- clean up during the shift
- day-to-day cleanup
- waste disposal
- removal of unused materials
- inspection to ensure cleanup is complete

Do not forget out-of-the-way places such as shelves, basements, sheds, and boiler rooms that would otherwise be overlooked.

The final step to any housekeeping program is inspection. It is the only way to check for deficiencies in the program so that changes can be made. Examples of checklists include inspecting offices and manufacturing facilities.

There are three reasons why keeping the job site clean can improve your work activities

Figure 6: cleaning

1.4 A Productive & Safe Work Environment

First, you and your employee's safety is top priority. If you're working on a big job, like a remodel or a small installation, you'll likely have materials and tools around. It's tempting to leave items where they land as you work to save time, however, imagine what could happen if someone trips over a cord or wood debris? Or, the damage that could be done if someone steps on a loose nail? This is not only an injury waiting to happen, but a liability as well. By keeping a clean and clear work area, you can provide a safe one as well.

A clean workspace has productivity and efficiency benefits as well. By keeping a clean workspace, you become more focused on the task at hand, freeing yourself of the distractions other messes may bring. It also allows you and other workers to find tools quicker without having to search under and over things to find what they're looking for.

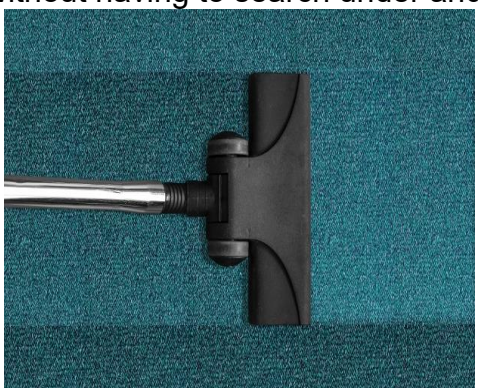

Figure 3: Safe Work Environment

- **Customer Loyalty & Referrals**

Even if a work is in progress, if a customer sees a messy job site, they can't see the work you're doing. This is especially true in remodels or additions, where the customer is making a large sacrifice for the work done on their home. If they see a mess spreading into the livable part of their house, they may react poorly. In addition, people often associate cleanliness with quality. If they see a job site that is a mess, they might think less of the quality of work you're providing.

A clean workspace will result in happy customers, who are likely to call you next time they need work done or will be happy to refer you to others. Part of your job is not just the hands-on labor, but providing a great customer experience. Taking a few minutes could result in more leads from referrals.

- **Better Reviews**

Customer reviews are valuable. Ninety percent of consumers read online reviews before calling a contractor, according to Zuberance.

Be sure to thoroughly clean up the job site when the job is completely done, so the customer can fully see the home improvement. A messy job site will leave the work looking unfinished and leaving a mess behind won't reflect well on your services. Customers will likely share their displeasure during their review. The reviews that are left about your work can help or hurt your business. Don't let a messy job site be the reason you don't win the job.

Figure 4: better view

- Job Site Cleaning Tips

  Now that we understand the importance of a clean jobs site, how can you put it into practice? Being diligent about keeping a clean and organized job site will help you in the long run.
- Scheduled Cleaning Times
- Pick two times during the workday to stop and straighten up. At the end of the day, this will make cleaning less of a burden and easier to manage. If you're able, make a checklist of the things that need to be cleaned up so you don't miss a thing.
- Lead by Example

  Employees making a mess? Show them that keeping a clean area is important to you by following the standards you have set and reminding them of it. Many younger workers may not understand the value in keeping a clean space. Inform them that it's an important part of the job and set the standard for them.
- **Have A Place for Everything**

One of the things contractors lack on the job is proper organization. Invest in proper tool storage and utility buckets. More importantly, be sure to use them!

For bigger jobs, a job box is a good investment, especially if there're multiple trades working on-site. This helps everyone keep track of their own tools. Always remember to mark what tools are yours so there is no confusion.

- **Keep Cleaning Supplies Available**

Provide garbage cans and bags for workers to have a place to throw their scraps and garbage. For bigger jobs, renting a dumpster is a smart idea. If you work on big jobs regularly, consider investing in a dump trailer to haul your own garbage. This may seem like a large cost, but will save money over time.

At the end of the job, you'll feel less inclined to make the space look spotless if you don't have the proper materials. Invest in some window cleaner, a vacuum and a broom to help leave the area how you'd like it to be seen by the customer.

Self-Check -1	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say True or False For the Following Question Below

5. Cleaning is the process of removing unwanted substances
6. Effective housekeeping can help control or eliminate workplace hazards
7. tripping over loose objects on floors, stairs and platforms is the result of poor housekeeping
8. decreased fire hazards is results of Effective housekeeping

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 point**

Answer Sheet

Score = _____

Rating: _____

Information Sheet-2	Inspecting plant, tools and equipment

2.1 Inspecting plant, tools and equipment

Tools, instruments and equipment that are poorly maintained, inappropriately used or not fit for purpose can cause injuries, for example:

- Inadequately insulated tools and test instruments
- Incorrectly rated instruments.

Unrestrained tools may fall into energized switchboards and compromise the integrity (including safety) of the equipment. The use of lanyards around wrists, tool holders and restraints such as tool pouches and baskets may be used to address these risks. The tools, instruments and equipment used by electrical workers often have special design characteristics, for example many are insulated.

Inadequate maintenance may lead to serious electrical risks, for example insulating medium might conceal a mechanical defect that could cause an open circuit in a testing device. Insulated tools and equipment must be suitable for the work and be maintained in good working order, including by regular maintenance, inspection and testing. Where any doubt exists that the insulation of tools and equipment might not be adequate they should not be used. Maintenance and inspection should be carried out according to manufacturer's instructions.

A person conducting a business or undertaking (PCBU) who carries out electrical work must ensure the electrical safety of all persons and property likely to be affected by the electrical work. A PCBU must have procedures in place to ensure that tools, testing equipment and personal protective equipment are regularly inspected and tested.

This requirement ensures that workers carrying out the work are electrically safe and that the work, when completed, is electrically safe.

2.2 Visual inspection

All tools, testing equipment and PPE should be visually inspected before each use for signs of damage.

PCBUs should have 'pre-start' visual inspection procedures in place to ensure that equipment such as, tools, PPE, rubber mats and LV rescue kits are in good working order before use.

Testing equipment should be checked for damage to insulated leads and probes and needs to be confirmed as working before use.

- **Testing of equipment**

Testing equipment should be tested regularly to ensure the level of protection required.

Test instruments that are to be used or connected to electrical equipment should meet the following conditions:

- be suitable for the work in terms of their function, operating range and accuracy
- be in good condition and working order, clean and have no cracked or broken insulation. Particular care must be taken regarding the condition of the insulation on leads, probes and clips of test equipment
- pose no danger of electrocution to workers or damage to the electrical equipment during testing
- have suitably insulated leads and connection probes that enable connection or contact with energized parts to be made with minimal risk to the electrical worker
- Provide suitable protection against hazards arising from over-voltages that may arise from or during the testing or measurement process.

2.3 Testing intervals will depend on several factors including:

- the frequency of use
- the environment in which it is being
- Manufacturer’s advice.

For example, a multimeter used in a workshop environment may be subject to less damage that a multimeter carried in the back of a work van.
In absence of manufacturer's advice PCBUs should refer to a competent person with the knowledge and skills required for testing the particular type of equipment.
Items that have been misused or damaged should not be used until they have been re-retested and confirmed as functioning correctly**.**
Test equipment used for measurements such as earth continuity and insulation resistance should be regularly tested to confirm they are working correctly.
Some equipment such as multi meters may be able to be tested in-house, by using a calibrated resistor test block. Other equipment such as fault loop impedance testers or RCD testers may require specialist testing.

Self-Check -2	Written Test

Directions: Answer all the questions listed below. Use the Answer sheet provided in the next page:

I. Say True or False For the Following Question Below

1. Testing equipment should be tested regularly to ensure the level of protection required
2. Test equipment used for measurements such as earth continuity and insulation resistance
3. adequate maintenance may lead to serious electrical risks

Note: **Satisfactory rating – 2 points** **Unsatisfactory - below 1 point**

Answer Sheet

Score = _____

Rating: _____

References

1. Steve Kosmatka et al, Design and Control of Concrete Mixtures, 15th Edition, EB001, PCA Engineering Bulletin EB 001, Portland Cement Association , Skokie, IL 2002
2. *Specifications for Structural Concrete*, ACI 301 (www.concrete.org)