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1. BUILDING QUALITY CONTROL & QUALITY ASSURANCE

1.1 CONSTRUCTION PROJECTS QUALITY CONTROL (QC):

SCA institutes the concept of Quality Control (QC) of construction projects to underscore the importance of durability and economy (i.e. efficient usage of resources) in such interventions. Indeed, all built structures must meet latest codes and standards set both nationally and internationally.

QC rests upon considerations related to design and criteria for choosing a set of design principles over others and practical rules. QC takes into account local methods, and facilitates adaptation in accordance with construction codes, technical specifications when testing material, and workmanship standards.

Quality Control is achieved through Quality Assurance (Q.A.) systematized in the following 3 strategies:

1- Specification of acceptable materials for construction

2- Defining various design criteria (specifications), practical rules and prioritization of sound Construction practices.

3- Ensuring workmanship through systems that promote compliance with design such as contractual bindings to detailed technical specification defined for both parties, within overall parameters of quality control.

1.2 CONSTRUCTION PROJECTS' QUALITY ASSURANCE (QA):

Construction Quality Assurance implies a system guiding the implementation of construction projects in order to ensure overall quality of the final product that entails detailed inspection of all construction material and activation of standardized construction methods.

Before casting Reinforced Concrete (RC), elements or other construction processes field senior engineer or site engineer should check all construction materials, ensuring that they are according to standards and specifications suggested by Construction norms and spelt out in the contract. If in case, some construction materials are rejected, site inspectors should recheck replacements.

Quality Assurance also systematizes the order of work, with project duration and time for each activity, especially concreting, reinforcement and shuttering clearly spelt out.

It is required to check the previous completed processes of work prior to start next steps in order to notice the deficits of completed steps of project works.

- Quality Assurance (QA) is also part of project documentation
- For Q.A., all project requirements are clearly communicated to the contractor, and a designated person responsible for ensuring QA in accordance with all specifications and criteria monitors the work.
- The responsibility of all staff should be described in detailed job descriptions

QA shall indicate all the requirements relating to design/drawings (if so) and quality tests for construction works. QA will be carried out as per desired frequency by site engineers and strictly followed up by staff responsible for QC and QA. Thereof, testing facilities will be established at all sites, along with putting into place all relevant and applicable codes, specifications and standards
as well as the acceptance criteria for each of the relevant items of work, materials used and processes employed, modes of measurements, etc.

2. GENERAL SPECIFICATIONS FOR SCA CONSTRUCTION PROJECTS:

Project Specification is the document that clearly states the requirements with which the product or service has to conform. This document should refer to or include drawings, patterns or other relevant documents.

2.1 SPECIFICATION FOR CONSTRUCTION MATERIAL:

1. The construction materials must be of best quality (Locally purchased from market).
2. Stone should be from the mountain, volcanic and metamorphic rocks are preferred for construction works due to their hardness and strength.
3. Gravel must be clean and active with different sizes having corners.
4. The sand must be clean, active and fine.
5. The cement should be fresh, 50kg weight/bag and produced from a famous company (DG and Stalin should be preferred in case of nonexistence in the market the brand should be selected by Construction Team).
6. Steel bars for RCC should be deformed, not rusted and of the best quality with high grade Uzbekistani (Tashkent) made recommended for usage, using Tajik and Iranian or any unknown brands steel bars should be avoided from use in the concrete works.
7. Doors and Windows should be made of dry Khar (Russian) or best quality Archa (Afghanistan). Ministry of Education suggests use of Khar wood as standard for carpentry and all other wooden works.
8. Use 4mm thick glass for windows.
9. Hardware for doors and windows should be of the best quality.
10. Painting material should be fresh and from well-known companies.
11. The electrical materials (cables, joint Boxes, etc.) should be of the best quality from well-branded companies which should be selected by Construction Team).
12. The WASH materials (Hand pump & its accessories, PE pipe for piped schemes and other required equipment) should be of the best quality.
13. The hygiene kits (Soap, soap pot, toothpaste, toothbrush, nail cutter and other) should be of best quality.

2.2 TESTING & SELECTION CRITERIA OF MATERIALS

A simple Construction material testing procedure can be done in the field as described below; however, more detailed testing has to be done by a trained person.

2.2.1. CEMENT

Cement is the binding material for the ingredients of concrete. Generally, Ordinary Portland cement is used in most cases and will be tested before use. Attributes to be tested are as follows:

i) Fineness
ii) Setting time
iii) Strength test by using mortar cube specimens

However, the quality of cement can mainly be assured by performing the following field tests:
2.2.1.1. FEEL TEST:

Plunge the hand into a bag of cement and rub the cement between the thumb and forefinger. If it feels cool but not warm and does not have a lumpy or gritty feel the cement is good.

2.2.1.2. FLOATING TEST:

Throw a handful of cement into water. If it does not float but sinks, the cement is good.

2.2.1.3. OTHER TEST:

Procedure:

i) Make a thick paste of cement with water on a piece of thick glass. Immerse it under water for 24 hours. If it does not crack, the cement is good.

ii) Make a 1” x 1” x 8” block of cement with water. Immerse it under water for three days. Place it on supports 6 inches apart. Place a weight 30 lbs. uniformly over it. If it shows no sign of failure, the cement is good.

2.2.2. STONE FOR CONSTRUCTION:

Stones used for construction purposes like the building of structures are prepared by breaking raw pieces from large rocks or stones into stone quarry of the appropriate size. The quality of the stone can be assessed by striking the stone lightly with a hammer. A bell-like high sound indicates good quality, and a dull low sound indicates a bad quality one. This test is very important when using sedimentary rocks. Another test can be done by laying the stone in water, take it out after one day, let it dry out, clean it from organic matter and put it back into the water again. Continue with this procedure for at least two weeks. If the stone does not break into pieces or develop cracks, it is considered adequate for construction purposes.

2.2.3. AGGREGATES

In general, inspection of aggregates is required for ascertaining good quality of works and making periodic quality control tests. The sand and gravel used for construction must be free of clay or organic matters. Clay and organic matters reduce the quality of binding in cement, and will swell and shrink, therefore causing cracks in the structure. There are several different field and laboratory tests.

There are two types of aggregates used in construction works.

1. Fine aggregate with size of 4.75 mm and less
2. Coarse aggregate with size of bigger than 4.75 mm

All aggregates shall be hard, durable, chemically inert, clean and free from adherent coatings, organic matter etc. And shall not contain any appreciable amount of clay balls or pellets and harmful impurities e.g. iron pyrites, alkaline, salts, coal, mica, shale or similar laminated materials in such form or in such quantities as to cause corrosion of metal or affect adversely the hardening, the strength, the durability or the appearance of mortar, plaster or concrete. The sum of the percentages of all deleterious material shall not exceed 5%. Fine aggregate must be checked for organic impurities such as decayed vegetation humps, coal dust etc.

Fine aggregate (it consists of natural sand from river or crushed sand from stone) shall conform to the following requirements bellow:

2.2.3.1. HAND TEST
The hand filled with the aggregates to be tested is clenched and then opened again. If the material is clean, it should not stick together in a lump. When the material is rubbed between the hands, the hands should remain almost clean. Otherwise, the silt and foreign material has to be washed out by thorough rinsing with water.

2.2.3.2. SILT OR SEDIMENT TEST

This test estimates the amount of fines (silt and clay sizes) present in the natural sand. This estimate is because, the particles settle in water at a rate proportional to their size.

**Procedure:**
- Fill a measuring cylinder up to about 50 ml mark of a 250 ml measuring cylinder with salt-water solution (one teaspoonful salt to 570 ml).
- Pour the sand until the level of sand is up to the 100 ml mark.
- Add more salt water until it reaches 150 ml.
- Shake the cylinder vigorously.
- Stand the cylinder on a level surface and tap it until the top of the sand is level.
- Leave it to stand till the water clears.
- Measure the volume of the silt - clay layers and the volume of the sand.

The percent of soil content in sand can be calculated from the following relations:

\[
\text{Silt content (\%)} = \frac{\text{Thickness of layer of fines}}{\text{Thickness of layer of sand}} \times 100
\]

If the silt content is more than 5%, the sand is not clean enough for use and must be washed.

2.2.4. STEEL BARS

- For each classification of steel, separate areas shall be earmarked. It is desirable that ends of bars and sections of each class be painted in distinct separate colors.
- Steel reinforcement shall ordinarily be stored in such a way as to avoid distortion and to prevent deterioration and corrosion. It is desirable to coat reinforcement with cement wash before stacking to prevent scaling and rusting.
- Bars of different classification, sizes and lengths shall be stored separately to facilitate issues in such sizes and lengths to minimize wastage in cutting from standard lengths.
- In case of long storage, reinforcement bars shall be stacked above ground level by at least 150 mm.
- Structural steel of different classification, sizes and lengths shall be stored separately. It shall be stored above ground level by at least 150 mm upon platforms, skids or any other suitable supports to avoid distortion of sections. In case of long storage, suitable protective coating of primer paint shall be given to prevent scaling and rusting.

<table>
<thead>
<tr>
<th>Metric bar size</th>
<th>Linear Mass Density (kg/m)</th>
<th>Nominal diameter (mm)</th>
<th>Cross-sectional Area (mm²)</th>
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<td>6.0</td>
<td>0.222</td>
<td>6</td>
<td>28.3</td>
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<td>14.0</td>
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</tr>
<tr>
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<td>------</td>
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</tr>
<tr>
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<td>616</td>
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</tr>
</tbody>
</table>

### 2.2.5. WATER

Water used for mixing and curing shall be clean and free from injurious quantities of alkalis, acids, oils, salts, sugar, organic materials, vegetable growth or other substance that may be deleterious to bricks, stone, concrete or steel. Potable water is generally considered satisfactory for mixing, with having of PH value not less than six.

### 2.2.6. BURNT BRICK AND FILE TEST

The quality requirements of locally burned bricks can be checked as follows:

#### 2.2.6.1. MARKING TEST:

Try to make a mark on the surface of the brick by nail. If it is possible to mark, it is not a good brick; if not, it is very hard and compact.

#### 2.2.6.2. SOUND TEST:

Strike a brick with another brick. If the brick gives clear metallic sound, the brick is good one, if not a bad one.

#### 2.2.6.3. DROPPING TEST:

A good quality brick should not break or crack after dropped from 1 m of height. Always test with the hammer after the brick has been dropped, to ensure that there are no cracks inside.

### 2.2.7. WOOD AND TIMBER

Timber has not only been one of the oldest building materials, but also remained until today as one of the most versatile one. However, timber is an extremely complex material, available in great varieties and forms, with greatly differing properties between regions. Timber is a renewable material. Nevertheless, there is a universal concern about the rapid depletion of forests and the great environmental, climatic and economic disaster that follows. Although construction timber represents only a small fraction of the timber harvested, it should be used thriftily and wastage should be minimized. In addition, reforestation programs should be promoted to fill the gap.

#### SELECTION OF TIMBER

For structural members, which are under high stress, such as purloins and rafters and in trusses, the selection of timber is of great importance. Timber with cracks, knots or with grains that are not longitudinal should not be used. Such timber should only be used in situations with reduced stress, such as wall plates.

#### 2.2.8. OTHER MATERIALS

Small articles like nails, screws, nuts, bolts, door and window fittings, polishing stones, protective clothing, spare parts of machinery, linings, packing, water supply and sanitary fittings, electrical fittings, insulation board, and other shall be kept in suitable and properly protected storerooms. Valuable small material such as, copper pipes and fittings shall be kept under lock and key.
3. **EQUIPMENT:**

1. All equipment prepared in local raw materials must be the first hand.
2. The equipment imported from abroad must be new, of best quality, and from the famous companies.
3. The size of equipment should be according to the proposed plan.

4. **GENERAL CONSIDERATION FOR STOCKING AND STORAGE**

1. Appropriate Storage also has an effective role in quality of construction material, where for any site; there should be proper planning of the layout for stacking and storage of different materials, components and equipment’s with proper access and proper maneuverability of the vehicles carrying the material. While consideration of planning the layout, the requirements of various materials, components and equipment at different stages of construction is essential.
2. Materials stored at site, depending upon the individual characteristics, and protection from atmospheric actions, such as rain, sun, winds and moisture will avoid the deterioration.
3. Carefully loading, carriage, unloading and stacking will avoid loss or damage to the materials.
4. Materials like timber, coal, paints, etc. shall be stored in such a way that there may not be any possibility of fire hazards. Inflammable materials like kerosene and petrol shall be stored in accordance with the relevant rules and regulations to ensure the desired safety during storage. Stacks shall not be piled so high as to make them unstable under fire fighting conditions and in general, they shall not be more than 4.5 m in height.

4.1 **CEMENT STORAGE ON SITE**

1. Store cement in a building, which is dry, leak proof, and as moisture proof as possible.
2. There should be minimum number of windows in the storage building.
3. Stack the cement bags off the floor on wooden planks in such a way, so that it is about 150 mm to 200 mm above the floor.
4. The floor may comprise of lean cement concrete or two layers of dry bricks laid on well-consolidated earth.
5. Maintain a space of 600 mm all-round between the exterior walls and the stacks. (See figure below).
6. Stack the cement bags close to each other to reduce circulation of air.
7. The height of stack should not be more than 10 bags to prevent the possibility of lumping under pressure.
8. The width of the stack should not be more than four bags length or 3 meters.
9. In stacks more than 8 bags high, the cement bags should be arranged alternately length-wise and cross-wise, to tie the stacks together and minimize the danger of toppling over.
10. Stack the cement bags in such a manner to facilitate their removal and use in the order received.
11. Do not allow hooks to facilitate in a storage of cement. Using hooks has been marked as a detrimental practice for handling of bags as it exposes the cement to the open atmosphere, which may be damp and misty. Hence, to avoid any negative effects of atmosphere to affect the quality of cement, it is best to provide the workers with proper cement handling tools.
12. Keeping of minimum 600mm of space between the exterior walls and the stacks is must.
13. When it is required to store cement for a long period of time or during the monsoon; completely enclose the stack by a water proofing membrane such as polyethylene.
14. The arrangement should be such that it is convenient both for stacking and removal of cement bags and it leaves adequate space for movement and inspection of bags for counting purposes.
15. To make the access easy, a passage of 600 mm should be provided between individual pile.
16. Cement bags should be stacked in a stepwise manner on the wooden plank so that plank is stable and will not topple/overloaded at on one side.
17. It is advisable that, never keep more than 10 cement bags over each other, as this will lead to lumping under pressure. Sometimes it is also difficult to stack one bag over the other as this may cause them to fall down.

18. There would be alternately lengthwise arrangement if the stack were more than eight bags high, and crosswise to tie the stacks together to give the stack better stability and minimize the danger of toppling over.

19. The removal of cement should be in order of its storage period, i.e. to follow the rule of first in, first out.

20. Never remove all bags from the top layer. The bags removal should be from two or three layers in a stepwise manner so that the pile is stable and will not topple.

21. Sometimes ‘warehouse pack or lump’ is due to pressure on the bottom layer of bags and it could be easily prevent by rolling the bags when the cement is getting for use. Roll the bags once or twice to break the lumps if any.

Modern Portland cement is a very finely ground material and as such it is highly hygroscopic, that is to say, it readily absorbs moisture not only in the form of free water but also moisture from the air.

Whereas, it is necessary, to protect it from dampness before usage. Hence, proper arrangements for storing the cement for constructions projects are required. It preserves its quality and fitness for use.

It is found that cement will maintain its quality if moisture is kept away from cement. Absorption of 1 to 2% of moisture has no significant effect on quality of cement. However, if moisture absorption exceeds 5%, the cement becomes useless.

Never store the cement bags with fertilizers or other products, as any contamination can affect the quality and performance of the screed. Different types of cements shall be stacked and stored separately.

Cement bags shall be stacked off on wooden planks floor according to the below figure.
4.2 BRICKS STORAGE ON SITE

- Bricks shall be stacked in regular tiers as and when they are unloaded to minimize breakage and defacement. These shall not be dumped at site.
- Bricks stacks shall be close to the site of work so that least effort is required to unload and transport the bricks again by loading on pallets or in barrows. Building bricks shall be loaded unloaded a pair at a time unless palletized. Unloading of building bricks or handling in any other way likely to damage, the corners or edges or other parts of bricks shall not be permitted.

Bricks shall be stacked on dry firm ground. For proper inspection of quality and ease in counting the stacks shall be 50 bricks long, 10 bricks high and not more than 4 bricks in width, the bricks being placed on edge, two at a time along the width of the stack. Clear distance between adjacent stacks shall not be less than 0.8 m. Bricks of each truckload shall be put in one stack.

4.3 STEEL BARS STORAGE AND PROTECTION

- All steel bars shall be delivered to the site in either straight lengths or cut and bent forms. No reinforcement shall be accepted in long lengths, which have been transported while doubly bent.
- The reinforcing bars shall be stored properly and prior to placing concrete, Reinforcing steel, which is to be embedded, shall be free from rust, dirt, mud, loose scale, paint, oil, or any other foreign substance. If considered necessary by the designer, grit blasting shall be employed to clean bars at no extra cost to the Contract.
- Bent or damaged reinforcing bars, which will cause an impediment to the construction work, shall not be used.

5. CONSTRUCTION IMPLEMENTATION WORKS AND PROCESSES:

5.1 PROFILE AND SETTING

5.2.1. PROFILE OF WORK

- The Site engineer shall conduct the profile work in accordance with the design documents to determine the setting out of location and ground floor level of the building.
- A total station/Automatic Level or Pipe level shall be used for the profile work while the steel measuring tape shall have a length of 50m.
- The collar brace for the profile with its upper end planned shall be horizontally nailed to the post. The positions of the grid lines of the building shall be marked on the collar brace by nails or others and the names of these grid lines shall be clearly indicated.

5.2.2. SITE CLEARANCE:

Upon completion of the profile work, the Site Engineer shall have noted the profile inspection as well as the positions, dimensions and ground floor levels, etc. Before the earth work is started the area coming under cutting and filling shall be cleared of all obstruction, loose stones, shrubs, rank vegetation, grass, bushes and rubbish removed up to a distance of 150 meters outside the periphery of the area under clearance. This work is deemed included in the earthwork item rate and no separate payment will be admissible.
The roots of trees if any shall be removed to a minimum depth of 60 cm below ground level or a minimum of 30 cm below formation level whichever is lower and the hollows filled up with earth level and rammed. This work is deemed included in the earthwork items and no separate payment will be admissible for the work.

5.2.3. BENCHMARKING

- After receiving the profile work inspection, the Engineer shall set the necessary number of benchmarks showing the reference height outside the profile at positions of 1.0 m
from the reference grid lines of the building. These benchmarks shall be made of either concrete or concrete blocks so that they do not travel or sink.

- For setting out, offset lines, which are 1.0 m from the grid lines shall be marked in addition to the marking of the grid lines for easier inspection and confirmation. Base lines shall be marked at the walls or columns at 1.0 m above the design floor level.
- Upon completion of the setting out, the Engineer shall confirm the dimensions and names of the members, etc.

5.2.4. EXCAVATION

1. Excavation shall be conducted by straight cutting or by creating a suitable slope in consideration of the situation and soil around the excavation area. In the case of deep excavation for the septic tank, etc.
2. If the excavation depth exceed 1.5 m from the ground surface, handrails or others to prevent falling shall be set up around the excavation area.
3. The excavation for footings, footing beams and septic tank, etc. shall be conducted up to the depth indicated in the relevant design documents. If the groundwater level is confirmed at a shallow depth from the ground surface, the engineer shall report through the line supervisor to the designer for the instruction.
4. After excavating original ground to subgrade surface, in case that the subgrade conditions are, in opinion of the designer, deemed to be very poor, because of the high water content of subgrade soils, etc., the poor portions shall be removed to the extent directed by the chief engineer, and replaced with approved material and compacted.
5. The excavated bottom surface shall be flat and even, its dimensions shall be so determined not to hamper the formwork for the footings and the footing beams, etc.
6. Any obstacle found during excavation shall be removed. However, should an unexpectedly serious obstacle or dangerous obstacle be encountered, the Contractor shall immediately inform the Consultant of the situation for the instruction.
7. The earthwork shall be classified for all types of soil, boulders, Soft rock and Hard rock.

5.2.5. DRAINAGE

Rainwater and standing water, etc. in the excavated pit, which are deemed to hamper the work, shall be promptly drained out.

5.2.6. BACKFILLING AND FILLING SOIL

1. The surplus soil without organic component produced by excavation can be used as a backfilling material with the approval of the Consultant. Should brought in soil be used for backfilling, the engineer shall check the quality of the soil for its use.
2. Each layer as required of backfilling or filling shall be 150 mm and compacted with suitable moisture by such equipment as a vibration compactor, grader or tamping tool up to the point where the shrinkage settlement of the backfilled soil or banked soil no longer takes place.

5.2.7. DISPOSAL OF SURPLUS SOIL

The surplus soil produced by grading and excavation (grubbing), etc. shall be disposed of by means of levelling at the site. It is necessary to transport such soil out of the site.

5.2.8. FILLING MATERIALS (FOUNDATION WORKS)

Material for filling shall be without organic component and approved by the designer or POs senior engineer and would be gravel, sand or soil (clay soil shall not be use).

5.2.9. BLINDING CONCRETE WORK

1. Some 50 mm thick blinding concrete shall be applied below the footings and footing beams, etc. Where setting-out is required.
2. Compressive strength of blinding concrete shall be 15N/mm² (150Kg/SCM) or more.

3. The mixing of the blinding concrete shall be based on mixing by volume and the standard mixing ratio shall be; cement : sand : coarse aggregate 1:2:4 or (M: 150)

4. The level of the blinding concrete top shall be checked by using a level and the said top surface shall be finished flat.

5.2.10. CONSTRUCTION JOINTS

1. The position of a vertical construction joint shall be the lower end of the thickest beam through which the said column runs through. The position of a horizontal construction joint shall be near the center of the span in the case of a beam or a slab. Each positions of construction joints shall be consulted and approved by the Consultant.

2. A stop-end board or similar shall be used for the construction joint faces to prevent leakage of the cement paste, etc.

3. For the casting of a construction joint face, the laitance at such face shall be removed and seemingly fragile concrete shall be chipped to expose sound concrete prior to casting.

5.2.11. STONE AT FOUNDATION WORKS

1. Before beginning stone works, it is required to check the quality of the stone for foundation work. Ideally, the stone should be sourced from mountainous terrain and approved by the engineer. The stone should be hard, tough, compact and durable. The stone should not have faults and openings, and individual stones for masonry work should generally weigh between 5kg to 40kg. These stones can be of various sizes. If sedimentary stones sourced from riverbeds are being used, they should be appropriately broken, and care taken to ensure that they have at least two flat sides.

2. The grid line of the building and the edge lines of both sides of foundation should be lined on the blinding concrete according to the temporary profile, and then the string lines that indicate the edge of both sides of foundation should be stretched above between the profiles of both ends of the grid line. The engineer will check each guiding line and string line.

3. Random stone masonry shall be assembled properly and installed according to the lines on blinding concrete and guiding strings above. The stones should be laid on a mortar bed and then knocked in the mortar with hammer.

4. Random stone masonry with more than 1m height shall have a straight level course every 60cm and no part shall be raised more than 1.0m above any other part of the work at any time. The height of the masonry laid in one day shall not exceed 1.5m. The site engineer shall check the vertical and horizontal alignments in every 60cm and shall have the proper inspection. More than 3 days interval shall be taken before the vertical continuation of masonry work. The overlap of the stones should be a minimum of 10cm.

5. Cement mortar shall fill in the space between the stones approx. 35% without any empty space, and shall be applied at each straight level of 60cm. The mixing of the cement mortar for filling shall be; Cement 1: Sand 6.or (1:6)

6. The Engineer shall check width and depth at every 20m interval and shall have the inspection of the designer or senior engineer. Maximum permissible tolerance for width is +50mm. Vertical alignment shall be checked by using plum bob and maximum permissible tolerance is + 10mm. Small pieces of stones are used for better seating of shaped stones but they should not be visible at the outside of the wall. It is important that the small pieces of stones be well bonded with mortar all around.

7. Pointing shall be provided only on the exposed surface. All joints shall be neatly pointed and flush pointing shall be used unless otherwise specified. Upon the completion of pointing, the finished pointing surface shall be looked good appearance. The mixing of the cement mortar for pointing shall be; Cement 1: Sand 3 or (1:3)
See the below good & bad stone working.

5.2.12. **BRICK MASONRY WORKS**

1. Bricks for wall masonry work shall be burnt brick in the category A and approved by the senior engineer or Site Engineer.
2. Brick shall be standard size of 210mm Length x 110mm Width x 60mm height, and shear strength shall be more than 70kg/cm².
3. Bricks should be saturated with water before using.
4. The cement shall be normal Portland cement M400 and sand OR fine aggregates shall be MASSA (sand # 1 of Gravel or river sand with a maximum diameter of 5 mm and procured from the approved place by the senior engineer. The fine aggregates to be used for the in-situ mixed concrete shall be screened through a sieve with a 5 mm zinc coated mesh more than 5 cycles to remove such impurities as litter and wood chips, etc.

5.2.13. **CONCRETE PRODUCTION AND ITS COMPOSITION**

Concrete is one of the most durable building materials. It provides superior fire resistance compared with wooden construction and gains strength over time. Structures made of concrete can have a long service life.

There are many types of concrete available, created by varying the proportions of the main ingredients below. In this way or by substitution for the cementsation and aggregate phases, the finished product can be tailored to its application with varying strength, density, or chemical and thermal resistance properties.

Aggregate consists of large chunks of material in a concrete mix, generally a coarse gravel or crushed rocks such as limestone, or granite, along with finer materials such as sand.

Cement, most commonly Portland cement, is associated with the general term "concrete." A range of materials can be used as the cement in concrete.

To produce concrete from most cements (excluding asphalt), water is mixed with the dry powder and aggregate, which produces a semi-liquid that workers can shape, typically by pouring it into a form. The concrete solidifies and hardens through a chemical process called hydration. The water reacts with the cement, which bonds the other components together, creating a robust stone-like material.

Chemical admixtures are added to achieve varied properties. These ingredients may accelerate or slow down the rate at which the concrete hardens, and impart many other useful properties including increased tensile strength, entrainment of air, and/or water resistance.

Here we are talking about two types of concretes Reinforcement and Plain Cement Concretes which are using for horizontal or vertical structures within RDPU Construction projects,

5.2.13.1. **PLAIN CEMENT CONCRETE FOR GENERAL WORK**:

For plain cement concrete work, the specification for materials viz., cement, sand, fine and coarse aggregates and water shall be the same as that specified in reinforced concrete work specification. But the proportion of mix will be nominal ad the ratio of fine and coarse aggregate may be slightly adjusted within limits, keeping the total value of aggregates to a given volumes of cement constant to suit the sieve analysis of both the aggregates. Cement shall on no account be measured by volume, but it shall always be used directly from the bags (i.e. 50kg/ bag). The proportion of cement, sand, aggregate and
water for concrete of proportion 1:5:10, 1:4:8, 1:3:6 & 1:2:4 by volume shall generally consist of quantities as given below:

<table>
<thead>
<tr>
<th>Proportion of Ingredients</th>
<th>Quantity of material used per bag of cement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cement</td>
</tr>
<tr>
<td>1:5:10</td>
<td>1</td>
</tr>
<tr>
<td>1:4:8</td>
<td>1</td>
</tr>
<tr>
<td>1:3:6</td>
<td>1</td>
</tr>
<tr>
<td>1:2:4</td>
<td>1</td>
</tr>
</tbody>
</table>

Requirement of floor PCC:
- The soil used for backfilling should be cleared from organism chemical compounds!
- The backfilled soil should be compacted thoroughly!
- Bolder stone # 5 should be paved before concrete!
- (1.5 X 1.5)M fiberglass should be used for separation!
- The level of area should be checked before concrete pouring

5.2.13.2. REINFORCEMENT CONCRETE FOR SPECIFIC WORK AND PROCESSING:
Concrete is strong in compression, as the aggregate efficiently carries the compression load. However, it is weak in tension as the cement holding the aggregate in place can crack, allowing the structure to fail. Reinforced concrete adds either steel reinforcing bars, steel fibers, glass fibers, or plastic fibers to carry tensile loads. In addition, rebar cage will be permanently embedded in poured concrete to create a reinforced concrete structure, which the systematic processing of RCC concrete are as following:

Formworks:
Formwork in concrete construction is used as a mold for a structure in which fresh concrete is poured only to harden subsequently. Types of formwork for concrete construction depends on formwork material and type of structural element.
The construction of formwork takes time and involves expenditure up to 20 to 25% of the cost of the structure or even more. The operation of removing the formwork is known as stripping. Stripped formwork can be reused.
- The material for shuttering shall be waterproofed plywood of not less than 12 mm thick or new wooden planks, which are commonly used in the project area. In the case of an exposed concrete finish, new material of waterproofed plywood of not less than 12 mm thick shall be used.
- The material for supporting shall be steel pipe or square timber, which is commonly used in the project area. The materials for shuttering and supporting may be re-used up to 3 times. However, prior to their use, the forms must be cleaned and the absence of any flaws or cracks, etc. must be confirmed.

Timber; used for shuttering for exposed concrete work should have smooth and even surface on all faces, which are exposed to concrete.
Timber is the most common material used for formwork. The disadvantage with timber formwork is that it will warp, swell and shrink. Application of water impermeable cost to the surface of wood mitigates these defects.
A good formwork should satisfy the following requirements:
1. It should be strong enough to withstand all types of dead and live loads.
2. It should be rigidly constructed, efficiently propped, and braced both horizontally and vertically, to retain its shape.
3. The joints in the formwork should be tight against leakage of cement grout.
4. Construction of formwork should permit removal of various parts in desired sequences without damage to the concrete.
5. The material of the formwork should be cheap, easily available and should be suitable for reuse.
6. The formwork should be set accurately to the desired line and levels should have plane surface.
7. It should be as light as possible.
8. The material of the formwork should not warp or one-sided when exposed to the elements.
9. It should rest on firm base.

**Normal sizes of members for timber formwork**

<table>
<thead>
<tr>
<th>Description of structural member</th>
<th>Period of time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheeting for slabs, beam, column side and beam bottom</td>
<td>25 mm to 40 mm thick</td>
</tr>
<tr>
<td>Joints, ledges</td>
<td>50 x 70 mm to 50 x 150 mm</td>
</tr>
<tr>
<td>Posts</td>
<td>75 x 100 mm to 100 x 100 mm</td>
</tr>
</tbody>
</table>

**Resin bonded plywood sheets**: are attached to timber frames to make up panels of required sizes. The cost of plywood formwork compares favorably with that of timber shuttering and it may even prove cheaper in certain cases in view of the following considerations:

1. It is possible to have smooth finish in which case on cost in surface finishing is there.
2. By use of large size panels, it is possible to effect saving in the labor cost of fixing and dismantling.
3. Number of reuses are more as compared with timber shuttering.

**Steel framework**: consist of panels fabricated out of thin steel plates stiffened along the edges by small steel angles. The panel units can be held together with suitable clamps or bolts and nuts. The panels can be fabricated in large number in any desired modular shape or size. Steel forms are largely used in large projects or in situations, where large number reuses of the shuttering is possible. This type of shuttering is considered most suitable for circular or curved structures.

**Comparison of Steel forms with timber form**:  
1. Steel forms are stronger, durable and have longer life than timber formwork and their reuses are more in number.
2. Steel forms can be installed and dismantled with greater ease and speed.
3. The quality of exposed concrete surface by using steel forms is good and such surfaces need no further treatment.
4. Steel formwork does not absorb moisture from concrete.
5. Steel formwork does not shrink or warp.

**The sequence of orders and method of removal of formwork are as follows**:  
1. Shuttering forming the vertical faces of walls, beams and column sides should be removed first as they bear no load but only retain the concrete.
2. Shuttering forming soffit of slabs should be removed next.
3. Shuttering forming soffit of beams, girders or other heavily loaded shuttering should be removed in the end.

Rapid hardening cement, warm weather and light loading conditions allow early removal of formwork. The formwork should under no circumstances be allowed to be removed until all the concrete reaches strength of at least twice the stresses to which the concrete may be subjected at the time of removal of formwork. All formworks should be eased gradually and carefully in order to prevent the load being suddenly transferred to concrete.

**Table: Period of removal of formwork**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Description of structural member</th>
<th>Period of time</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Walls, columns and vertical sides of beams</td>
<td>1 to 2 days</td>
</tr>
<tr>
<td>2</td>
<td>Slabs (props left under)</td>
<td>3 days</td>
</tr>
<tr>
<td>3</td>
<td>Beam soffits (props left under)</td>
<td>7 days</td>
</tr>
<tr>
<td>4</td>
<td>Removal of props to slabs</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(a) For slabs spanning up to 4.5 m</td>
<td>7 days</td>
</tr>
</tbody>
</table>
Rebar fixation works and methods:

**Tie your rebar.** This is the primary focus of this article. Tying the bars so that they remain in their correct respective positions is critical to achieve the desired strength of the completed concrete structure.

<table>
<thead>
<tr>
<th>(b) For slabs spanning over 4.5 m</th>
<th>14 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>Removal of props to beams and arches</td>
</tr>
<tr>
<td>(a) Spanning up to 6 m</td>
<td>14 days</td>
</tr>
<tr>
<td>(b) spanning over 6 m</td>
<td>21 days</td>
</tr>
</tbody>
</table>

Place **each rebar in its respective position according to the layout described in the previous steps.** The *layout bars* (or mark bars) can be marked with a soapstone marker, a paint pen, a piece of lumber crayon, or with spray paint.

**Select the appropriate type of tie you will use.** For the *bag ties* (*Snap Ties*, not to be confused with the snap ties described later). For ordinary slab mats, where the force of the concrete interacting with the rebar during its placement is minimal, and movement of the mats is unlikely, using a simple, single twist of wire around each rebar intersection, twisted together tightly, will suffice. This tie is known as a *snap tie*, and can be made with the snap tie precut ties and a *spinner*, noted earlier. It can also be done easily with a pair of 9-inch (22.9 cm) lineman’s pliers and bulk wire held on the rod buster’s work belt in a *wire reel*. For other applications where the force of the concrete placement may displace the rebar, or where more strength is needed to hold bars in the proper configuration, ties that are more complicated may be used. Here are some of them, with a simplified description of how they are made:

- **Figure 8 ties** - These are made by pulling the wire around the rear (from the rod buster) bar, diagonally across the front bar, back around the rear bar, diagonally in the opposite direction across the front bar, and then twisting back around the beginning wire. You then cut the wire feeding off the reel, and bend the cut ends back towards the tie so no sharp ends project from the tie. These ties will help hold perpendicular bars tightly together while helping to prevent them from *racking*, or moving diagonally.
• **Saddle ties** - Similar to the figure 8 tie, you begin by passing the wire feeding from your reel behind the rear bar, then across the front bar staying parallel to the bar. You then pass it behind the rear bar again, back around the front bar on the opposite side. You now twist the ends together, cut the feed wire, and bend the cut ends back. This tie is often used when tying rebar for walls or other vertical application where the rod buster will actually climb on the rebar framework to access higher portions of the wall. The figure 8 and saddle tie can often be interchanged, however, technically speaking; there are advantages to each one in certain circumstances.

• Combinations of figure 8 and saddle ties with additional wraps around vertical rebar’s can be used to increase the hold of the tie so bars cannot slip downward when weight is applied to them or the plastic concrete is dropped into the form.

![Image of saddle tie](image)

**Use your pliers for tying these ties efficiently.** For all the above-mentioned ties, you pull the feeding end from the wire reel with your non-dominant (hereafter regarded as left, please reverse for right-handed persons) hand. Grip the end of the wire with your pliers in your right hand, and poke, or push it behind the rebar described in the first step of your chosen tie. Bend or angle the end toward the place you will be grabbing the end in the next step of the tie, then reach from that side, grip it again with the pliers, pull it toward the next place you will route it to, pulling enough slack wire to complete the tie. Hold resistance on the wire with your left hand, so the wire bends snugly against the bar you are wrapping in each stage of the tie. Release the wire so that the pliers can be used to grip it, and do so, pulling the end around the bar and twist the two ends of the wire together. Pull or tug the wire with the pliers so the tie is tight.

![Image of pliers tying rebar](image)

**Tie all the bars required in their correct positions.** Check your plans to make sure each component of the reinforcement is in place. Often, in structural concrete reinforcement, you will find several elements that interface together in addition to the basic rebar mat discussed so far. Here are a few to note:

**Block dowels or Spacing of Reinforcing Bars**

1. The spacers shall be made of mortar and their dimensions shall be 40 mm x 40 mm x specified
Cover thickness. Wires cast into the blocks for tying in to reinforcement shall be 1.6 mm diameter soft annealed iron wire. Immediately after manufacture, this mortar mix shall undergo wet curing for five days and shall then be covered to prevent dust and soil entering it until it is ready for use 28 days after manufacture. Spacers, which are not immediately used, shall be stored in bags, etc. Mixing ratio of mortar shall be; cement: sand 2

2. The engineer shall be able to use steel or polyethylene spacer.
3. The spacing between neighboring reinforcing bars shall be capable of securing clearance between the reinforcing bars or wider as described below.

- Nominal diameter (d) ≤ 14 mm clearance/ cover : 25 mm
- 16 mm ≤ nominal diameter (d) ≤ 22 mm clearance/cover : 35 mm

Chair or support your rebar. Once the mat or cage is assembled, you must hold it in position so the concrete will cover it completely. Rebar chairs or concrete brick are often used for this purpose. Place these positioners at a spacing that will not allow the rebar to bend or deflect enough to reduce the coverage you wish to obtain with the concrete you place in your forms. For a 12-inch (30.5 cm) thick footing, the rebar mat is usually placed about 4 inches (10.2 cm) from the bottom of the concrete, and side clearances range from 2 to 4 inches (5.1 to 10.2 cm).

Observe the rebar configuration while the concrete is placed. If shifting occurs, support the rebar’s with a handled tool like a shovel wedged so that you can achieve sufficient advantage to hold its position, or alter the direction of flowing concrete so force is applied in the opposite direction.

A. BAR TYING REQUIREMENTS

Rebar is tied together, using wire, to hold it in place.

To the right is a diagram of typical ties:

Detail A: "Snap Tie" (diagram upper left) is the simplest and is usually used for rebar in a flat horizontal position.
**Detail B:** "Wrap and Snap Tie" (diagram upper right) is normally used when tying vertical wall reinforcement to hold the bars securely into place.

**Detail C:** "Saddle Tie" (diagram bottom left) is more complicated than snap ties or wrap and snap ties. They are commonly used for securing ties to column corner bars and stirrups to beam corner bars.

**Detail D:** "Wrap and Saddle Tie" (diagram bottom middle) is similar to the saddle tie except that the wire is wrapped 1-1/2 times around the first bar, then completed like Detail C.

**Detail E:** "Figure Eight Tie" (diagram bottom right) can be used on walls in lieu of the saddle or wrap and snap ties. This type of tie is used to secure heavy mats.

**PROCESSING**

1. The reinforcing bars shall be processed according to the dimensions and shape, set forth in the design drawings.
2. Cutting of the reinforcing bars shall be conducted by a shear cutter or power saw, etc. and gas cutting shall not be conducted.
3. A hook shall be created at the end of the main reinforcing bars for the four corner columns at the highest floor, which form the main structure, the base bars for the footings, hoops and stirrups.
4. The below table shall be referred to for the inner diameter for the bent reinforcing bars and their application positions.

**Table 4-1 Inner Diameter of Bent Reinforcing Bars and Places of Application**

<table>
<thead>
<tr>
<th>Bending Angle</th>
<th>Bending Drawing</th>
<th>Inner Diameter of Bent Section (D)</th>
<th>Hook Length (L)</th>
<th>Place of Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>End Part</td>
<td>180°</td>
<td>Nominal Diameter ≤ 16 mm</td>
<td>Nominal Diameter &gt; 19 mm</td>
<td>4d</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≥ 4d</td>
<td>≥ 5d</td>
<td>Main reinforcing bars for the top section of four Corner columns on the highest floor</td>
</tr>
</tbody>
</table>
5. At each site, the Contractor shall manufacture hoop and stirrup samples conforming to the dimensions set forth in the design drawings and shop drawings, bent bar samples attached with a hook, anchor of the stipulated length for each nominal diameter, and shall have them inspected by the Consultant. Those samples passing the inspection shall be displayed for easy recognition in the steel bending yard and shall be used to check the processing accuracy.

6. The required accuracy of bar processing shall be ±15 mm of the dimensions set forth in the design drawings and shop drawings in the case of main reinforcing bars and ±5 mm for the hoops and stirrups.

### ASSEMBLY

1. For the assembly of the reinforcing bars, the splicing points of the reinforcing bars and key cross points of the main reinforcing bars, hoops and stirrups shall be tied.

2. The outer main reinforcing bars for the beams shall be placed inside the main reinforcing bars for the columns and the outer main reinforcing bars for the beams and the main reinforcing bars for the columns shall be tied at the crossing points. The main reinforcing bars for the non-main structural columns or additional columns shall be placed inside the outer main reinforcing bars for the beams and shall be tied at the crossing points.

3. The tying of the reinforcing bars shall be conducted using a steel wire of a minimum diameter of 0.8 mm, and the ends of the wire turned into the body of concrete.

4. The first and last stirrups for the beams shall be placed 50 mm from the main reinforcing bars for the columns and other stirrups in between shall be placed at a spacing of or shorter than the design pitch. In the case of binders of which the supported ends are beams, the first and last stirrups shall be placed 50 mm from the main reinforcing bars for the supported end beams.

5. The first hoops for the columns at each floor shall be placed 50 mm from the main reinforcing bars for the upper end of the floor beams for the said floor while the last hoops shall be placed 50 mm from the main reinforcing bars for the lower end of the floor beams for the above floors. Other hoops in between shall be placed at a spacing of or shorter than the design pitch.

6. The distance between the column hoops for the crossing sections of the columns and beams (panel zones) shall not exceed 300 mm.

7. Spacers shall be placed at both sides of the column hoops and beam stirrups and at the bottom of the beam to secure thickness of cover for the reinforcing bars. These spacers shall have a distance of approximately 1.0 m and shall be arranged in a staggered fashion.

8. Concrete shall not be placed in any member until reinforcement placement has been approved by the senior engineer.

9. If a main reinforcing bar is found to be out of place from the designated position up to 25 mm because of setting-out after placing the concrete, the Contractor shall inform the Consultant, followed by positional correction of the main reinforcing bar in the following manner.
   - a. The concrete around the subject main reinforcing bar for positional correction
shall be removed by some 50 mm from the concrete surface and the main reinforcing bar shall be bent from that position.
b. The bending gradient of the main reinforcing bar shall be no larger than 0.2 in the horizontal direction to the value of 1 in the vertical direction, i.e. approximate bending angle of 11°, and the main reinforcing bar shall be adjusted to the correct position. Bending angle in slabs main bars will be 30Deg. Moreover, for beams will be 30-45 Deg.
c. An additional hoop shall be placed at the end of the bending part apart from the design pitch.

**SPLICING AND ANCHORING**

Splicing of the reinforcing bars shall be conducted by lap splicing and the lapped splices shall not have hooks.

Table 4-2 shall be referred to for the length and positions of the splices.

![Neighboring splices](image)

While the all processes are completed and the concrete got its required strength the shuttering removed, the finishing processes will start from plastering.

**Mixing and processing & Quality of concrete**

The correct mixture is an important first step in the processing of concrete, which also includes transporting, placing, compacting and curing. All these factors are very important and influence greatly the strength and quality of concrete.

Hand mixing does not require much equipment, but a lot of labor. A batch to be hand mixed should not be larger than about 0.5 m³. Concrete should never be mixed on soil because of the proved danger of contamination by organic matters. A levelled platform has to be prepared to prevent water or fluid material from flowing out of the mixture. The following points must be kept in mind when hand mixed concrete foreseen:

- Concrete should always be mixed on a level and clean platform, which is sprinkled with water before mixing starts.
- Spread the first layer (sand) and the second layer (stones) on the platform, and then spread the cement on top.
- Mix the material dry until there is a uniform appearance. Therefore, at least three times of mixing necessary.
- The material is then shoveled into a flat heap with a hollow in the center into which about half the required water is poured.
- Then the final step of the mixing procedure starts by shoveling the material from the edges to the center, emptying each full shovel and then turning it over again. Add water as necessary to obtain required consistency as the material is turned over again.

The standard concrete type, mix proportions, water cement ratio and slump
<table>
<thead>
<tr>
<th>Grade</th>
<th>Strength: N/mm²/Kg/cm²</th>
<th>Cement: Sand: Coarse Aggregate</th>
<th>Water Cement ratio</th>
<th>Slump (mm)</th>
<th>Uses</th>
</tr>
</thead>
<tbody>
<tr>
<td>M100</td>
<td>15/150</td>
<td>1:3:6</td>
<td>0.6-0.7</td>
<td>50-70</td>
<td>Blinding</td>
</tr>
<tr>
<td>M150</td>
<td>20/200</td>
<td>1:2:4</td>
<td>~ 0.6</td>
<td>50-70</td>
<td>PCC Flooring</td>
</tr>
<tr>
<td>M200</td>
<td>25/250</td>
<td>1:1:5:3</td>
<td>0.55-0.6</td>
<td>50-70</td>
<td>RCC structural concrete</td>
</tr>
</tbody>
</table>

**Note:** The mix proportion of cement, fine aggregate and coarse aggregate shall be by dry volume.

The processing of concrete can be divided into four phases:

- **Phase 1:** Transporting,
- **Phase 2:** Placing and casting,
- **Phase 3:** Compacting
- **Phase 4:** Curing

**Requirement of RCC Works:**

- Provide all required concrete raw material before concrete pouring.
- Materials should be mixed according to the mixed design.
- Standard Bushel should be used for mixing of concrete (Box of size 40 cm X 35cm X 25cm)
- Concrete should be mixed by mixer machine!
- Reinforcement should be accurately checked before concrete pouring!
- Supports should be used under reinforcement for protective cover!
- Slump test should be done before concrete pouring, and the desired slump for slab, beam and columns should not be more than 7 cm!
- Vibrator machine should be used for 5 secant in every point!
- A carpenter should be always present under shuttering during concrete pouring.

Each different part of a structure may use a different strength of concrete. There exist several different methods to test the quality of concrete. The test procedures of these methods are quite complicated, and require a laboratory with expensive infrastructures.

Therefore, in this manual only rough testing is described.

**Workability of Concrete**

To determine the workability of concrete, slump value is required. Slump is an indirect measure of workability of concrete. It is measured both in the laboratory and in the field.

**Equipment Required for Concrete Slump Test:**

Mold for slump test, non-porous base plate, measuring scale, temping rod. The mold for the test is in the form of the frustum of a cone having height 30 cm, bottom diameter 20 cm and top diameter 10 cm. The tamping rod is of steel 16 mm diameter and 60cm long and rounded at one end.
Test Procedure:

1. Clean the internal surface of the mold and apply oil.
2. Place the mould on a smooth horizontal non-porous base plate.
3. Fill the mould with the prepared concrete mix in 4 approximately equal layers.
4. Tamp each layer with 25 strokes of the rounded end of the tamping rod in a uniform manner over the cross section of the mould. For the subsequent layers, the tamping should penetrate into the underlying layer.
5. Remove the excess concrete and level the surface with a trowel.
6. Clean away the mortar or water leaked out between the mould and the base plate.
7. Raise the mould from the concrete immediately and slowly in vertical direction.
8. Measure the slump as the difference between the height of the mould and that of height point of the specimen being tested.

![Concrete Slump Test Procedure](image)

**Figure-2: Concrete Slump Test Procedure**

**NOTE:**

The above operation should be carried out at a place free from Vibrations or shock and within a period of 2 minutes after sampling.

**The following values of slump are generally accepted:**

<table>
<thead>
<tr>
<th>Allowable slump</th>
<th>Degree of workability</th>
<th>Suitable works</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-25 mm</td>
<td>Very low</td>
<td>Pre-cast and vibrated concrete work in roads &amp; piles</td>
</tr>
<tr>
<td>25-50 mm</td>
<td>Low</td>
<td>Road works, mass concrete in foundation, lightly reinforced section</td>
</tr>
<tr>
<td>50 - 100 mm</td>
<td>Medium</td>
<td>Slabs, normal concrete in foundation, heavily reinforced section.</td>
</tr>
<tr>
<td>100 – 200 mm</td>
<td>High</td>
<td>Cast in situ pile.</td>
</tr>
<tr>
<td>Above 200 m</td>
<td>Very high</td>
<td>Unacceptable</td>
</tr>
</tbody>
</table>

**3.1.1. PLASTERING – THINGS EVERY ENGINEER SHOULD KNOW**

**WHAT IS PLASTERING?**

Plastering is done to achieve the following objects:
- To protect the external surfaces against penetration of rainwater and other atmospheric agencies.
- To give smooth surface in which dust and dirt cannot lodge.
- To give decorative effect.
- To protect surfaces against vermin.
- To cover inferior materials or defective workmanship.

**REQUIREMENTS OF GOOD PLASTER**
The plaster material should fulfill the following requirements:

- It should adhere to the background, and should remain adhered during all variations in seasons and other atmospheric conditions.
- It should be hard and durable.
- It should possess good workability.
- It should be possible to apply it during all weather conditions.
- It should be cost efficient.
- It should effectively check penetration of moisture.

**TYPES OF MORTARS FOR PLASTERING**

The selection of type of plaster depends upon the following factors:

- Availability of binding materials.
- Durability requirements.
- Finishing requirements.
- Atmospheric conditions and variations in weather.
- Location of surface (i.e. exposed surface or interior surfaces).

Cement mortar is the best mortar for external plastering work since it is practically non-absorbent. The mix proportion (cement and sand) may vary from 1:4 to 1:6. Sand used for plastering should be clean, coarse and angular.

**NUMBER OF COATS OF PLASTER**

The background over which plastering is to be done depend upon the type of wall construction, such as random rubble (R.R.) masonry, coursed rubble masonry, brick masonry. Cement plaster is applied either in two coats or in three coats, the former being more common.

<table>
<thead>
<tr>
<th>Background</th>
<th>No of Coats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone work</td>
<td>3 or 2</td>
</tr>
<tr>
<td>Brick work or hollow blocks</td>
<td>2 or 1</td>
</tr>
<tr>
<td>Concrete cast in situ</td>
<td>2 or 1</td>
</tr>
</tbody>
</table>

Note: If plastering is done in single coat only, its thickness should not exceed 12 mm nor should it be less than 6 mm.

<table>
<thead>
<tr>
<th>Description</th>
<th>Cement</th>
<th>Sand</th>
<th>Coating thickness (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stone Foundation Filling</td>
<td>1</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Stone Foundation Pointing</td>
<td>1</td>
<td>3</td>
<td>-</td>
</tr>
<tr>
<td>Brick Wall Bond</td>
<td>1</td>
<td>6</td>
<td>-</td>
</tr>
<tr>
<td>Wall Finish on Brick/Stone/Concrete</td>
<td>1</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>Ceiling on Concrete Slab</td>
<td>1</td>
<td>3</td>
<td>15</td>
</tr>
<tr>
<td>Blackboard</td>
<td>1</td>
<td>3</td>
<td>20</td>
</tr>
</tbody>
</table>

1. **Single coat plaster**
   This is used only in inferior quality work. It is applied similarly as two-coat plaster except that the rendering coat, as applied for two-coat plaster, is finished off immediately after it has sufficiently hardened.

2. **Two coat plaster**
   The following procedure is adopted:
• The background is prepared by raking the joint to a depth of 20 mm, cleaning the surface and well watering it.
• If the surface to be plastered is very uneven, a preliminary coat is applied to fill up the hollows, before the first coat.
• The first coat or rendering coat of plaster is applied, the thickness being equal to the specified thickness of plaster less 2 to 3 mm. In order to maintain uniform thickness of plaster, 15 cm x 15 cm size. Two dots are so formed in vertical line, at a distance of about 2 m, and are plumbed by means of a plumb. A number of such vertical screeds are formed at suitable spacing. Cement mortar is then applied on the surface between the successive screeds and the surface is properly finished.
• Before rendering hardens, it is suitably worked to provide mechanical key for the final or finishing coat. The rendering coat is troweled hard forcing mortar into joints and over the surface. The rendering coat is kept wet for at least 2 days, and then allowed to dry completely.
• The thickness of final or finishing coat may vary between 2 and 3 mm. Before applying the final coat, the rendering coat is dampled evenly. The final coat is applied with wooden floats to a true even surface and finished with steel trowels. As far as possible, the finishing coat should be applied starting from top towards bottom and completed in one operation to eliminate joining marks.

3. Three coat plaster
The procedure for applying three-coat plaster is similar to the two-coat plaster except that an intermediate coat, known as floating coat is applied. The purpose of this coat of plaster is to bring the plaster to an even surface. The thickness of rendering coat, floating coat and finishing are kept 9 to 10 mm, 6 to 9 mm and 2 to 3 mm respectively. The rendering coat is made rough. The floating coat is applied about 4 to 7 days after applying the first coat. The finishing coat may be applied about 6 hours after the application of floating coat.

PREPARATION OF BACKGROUND
For plastering new surfaces, all masonry joints should be raked to a depth of 10 mm in brick masonry and 15 mm in stone masonry for providing key to the plaster. All mortar droppings and dust, and laitance (in case of freshly laid concrete) should be removed with the help of stiff wire brush. Any unevenness is levelled before rendering is applied. For finish applied in three coats, local projections should not be more than 10 mm proud of general surface and local depressions should not exceed 20 mm. For two-coat plaster, these limitations are 5 mm and 10 mm respectively. The surface should be washed with clean water and kept damp uniformly to produce optimum suction. In no case should the surface be kept so soaked that it causes the green mortar to slide off, or so dry that it causes strong suction, which withdraws moisture from mortar and makes it weak, porous and friable. If plaster is to be applied on old surface, all dirt, oil, paint etc. should be cleaned off. Loose and crumbling plaster layer should be removed to its full thickness, the surface of the background should be exposed, and joints properly raked. The surface should be washed and kept damp to obtain optimum suction.

Recommended Mortar Mixes for Different Situation

<table>
<thead>
<tr>
<th>S. No</th>
<th>Situation</th>
<th>Composition of Mortar</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>External Plaster in localities where rainfall is less than 500 Mm per year and where sub- Soil water is not within 2.5 m Below the ground surface:</td>
<td>1 cement 6 sand</td>
</tr>
<tr>
<td>2</td>
<td>External plaster in localities where rain fall is more than 1300 mm per year and where subsoil water is not within 2.5m below ground surface:</td>
<td>1 cement 4 sand</td>
</tr>
<tr>
<td>3</td>
<td>External plaster in localities where the subsoil water is within 2.5 m of the ground</td>
<td>1 cement 3 sand</td>
</tr>
</tbody>
</table>

Note: the ratio of lime varies with percentage purity of lime and these ratios may be suitably adjusted depending upon local practice.
DEFECTS IN PLASTERING

The following defects may arise in plasterwork:

1. **Blistering of plastered surface**

   This is the formation of small patches of plaster swelling out beyond the plastered surface, arising out of late slaking of line particles in the plaster.

2. **Cracking**

   Cracking consists of formation of cracks or fissures in the plasterwork resulting from the following reasons:
   
   - Imperfect preparation of background.
   - Structural defects in building.
   - Discontinuity of surface.
   - Movements in the background due to its thermal expansion or rapid drying.
   - Movements in the plaster surface itself, either due to expansion (in case of gypsum plaster) or shrinkage (in case of lime sand plaster).
   - Excessive shrinkage due to application of thick coat.
   - Faulty workmanship

3. **Crazing**

   It is the formation of a series of hair cracks on plastered surface, due to same reasons, which cause cracking.

4. **Efflorescence**

   The whitish crystalline substance appears on the surface due to presence of salts in plaster-making materials as well as building materials like bricks, sand, cement etc. and even water. This gives a very bad appearance. It affects the adhesion of paint with wall surface.

   Efflorescence can be removed to some extent by dry brushing and washing the surface repeatedly.

5. **Flaking**

   It is the formation of very loose mass of plastered surface, due to poor bond between successive coats.

6. **Peeling**

   It is the complete dislocation of some portion of plastered surface, resulting in the formation of a patch. This also results from imperfect bond.

7. **Popping**

   It is the formation of conical hole in the plastered surface due to presence of some particles, which expand on setting.

8. **Rust stains**

   These are sometimes formed when plaster is applied on metal laths.

9. **Uneven surface**
This is obtained purely due to poor workmanship.

3.1.2. POINTING

The reasons for pointing the surface of block work are to increase its weather resistance and to give a neat looking finish to the work. The best method is to finish the masonry work first and then to make the pointing work with a 1:2 cement mortar later. The joints must be racked out to a depth of about 1 to 1.5 cm, brushed, washed and filled with 1 part cement and 2 parts sand mortar. It will help to avoid that rainwater penetrates into the structure through the horizontal or vertical mortar bed layers. Because the mortar bed layers are the weakest part of wall, they must be protected properly.

5.2.14. CURING TECHNIQUES

During the curing period, concrete is ideally maintained at controlled temperature and humidity.

Fresh concrete shall be kept continuously wet for a minimum period of 14 days from the date of placing of concrete, following a lapse of 12 to 24 hours after lying concrete. The curing of horizontal surfaces exposed to the drying winds shall however begin immediately the concrete has hardened.

Water shall be applied to unformed concrete surfaces within 1 hour after concrete has set. Water shall be applied to formed surfaces immediately upon removal of forms.

Traditional conditions for curing involve by spraying or ponding the concrete surface with water.

6. ADDITIONAL ACTIVITIES TO BE CARRIED OUT AND REQUIRED TO SUPPORT THE CONSTRUCTIONS

6.1 REPAIR AND REPLACEMENT OF UNSATISFACTORY CONCRETE

Immediately after the shuttering is removed, the surface of concrete shall be carefully gone over and all defective areas called to the attention of Engineer-in-charge who may permit patching of the defective areas or else reject the concrete unit either partially or entirely. Rejected concrete shall be removed and replaced by contractor at no additional expense to the Department. Holes left by form bolts etc. shall be filled up and made good with mortar composed of one part of cement to one and half parts of sand passing through 2.36mm IS sieve after removing any loose stones adhering to the concrete. Mortar filling shall be struck off flush at the face of the concrete. Concrete surface shall be finished as described under the particular item of work.

Superficial honey combed surfaces and rough patches shall be similarly made good immediately after removal of shuttering in the presence of Engineer-in-charge and superficial water and air holes shall be filled in. The mortar shall be well worked into the surface with wooden float. Excess water shall be avoided. Unless instructed otherwise by Engineer-in-charge, the surface of the exposed concrete placed against shuttering shall be rubbed down immediately on removal for shuttering to remove fine or other irregularities, care being taken to avoid damaging the surfaces. Surface irregularities shall be removed by grinding.

If reinforcement is exposes or the honeycombing occurs at vulnerable position e.g. ends of beams or columns, it may be necessary to cut out the member completely or in part and reconstruct. The decision of Engineer-in-charge shall be final in this regard. If only patching is necessary, the defective concrete shall be cut out till solid concrete is reached (or to a minimum depth of 25mm), the edges being cut perpendicular to the affected surface or with a small undercut if possible, anchors, tees or dowels shall be provided in slots whenever necessary to attach the newly concrete securely in place.

An area extending several centimeters beyond the edges and the surfaces of the prepared voids shall be saturated with water for 24 hours immediately before the patching material is placed.
6.2 TYPES OF CRACKS IN CONCRETE STRUCTURES:

The cracks in concrete are occurs in many types which some of them are very critical while some of them are not serious and repairable. The cracks are divided on below types:

6.2.1 STRUCTURAL CRACKS IN CONCRETE:

Structural cracks are those, which result from incorrect design, faulty construction or overloading, and these may endanger the safety of a building and their inmates.

6.2.2 NON STRUCTURAL CRACKS IN CONCRETE:

Non-Structural cracks occur mostly due to internally induced stresses in building materials. These cracks normally do not endanger the safety but may look unsightly, create an impression of faulty work or give a feeling of instability.

6.3 COLD WEATHER CONCRETING & ITS REQUIREMENTS

If concrete freezes it, will results in the disruption of the cement paste matrix causing an irreparable loss in strength. Early freezing can result in a reduction of up to 50 percent in the ultimate strength. Whenever air temperature at the time of concrete placement is below 40 degrees Fahrenheit and freezing temperatures within the first 24 hours after placement are expected, the following general issues should be considered:

When concrete is being managed under cold weather, it must be protected from freezing shortly after being poured. Also concrete must be able to develop required strength for the safe removal of forms while reducing the circumstances where excessive heat must be applied to help concrete develop the required strength. Other important factors that must be considered are the proper curing conditions that prevent cracking and provide the intended serviceability of the structure.

- The average daily air temperature is less than 5°C (40°F) and,
- The air temperature is no greater than 10°C (50°F) for more than one-half of any 24-hour period.

6.3.1 COLD WEATHER CONCRETE RECOMMENDED TIPS

Follow these recommended steps to assure that concrete in cold weather will obtain the required design strength and that you do not have any other issues while the concrete is setting.

- Prior to pour; define the strategies that will be used including materials, forms, testing and other requirements.
- Schedule and determine the cold weather protection measurement of the concrete mix.
- Keep a well-defined temperature record chart including concrete temperature and exterior temperature?
- Never pour concrete over frozen ground, snow, or ice. Use heaters to thaw the ground before pouring concrete.
- Determine if special considerations and strength requirements must be met; if so protect concrete at specific temperatures.
- If heated enclosures are going to be used when placing concrete in cold weather, be sure to know that they must be windproof and weatherproof.
- If combustion heaters are used, vent outside to prevent carbonation.
- Cold weather concrete should have the correct amount of air-entrained voids that will resist freezing and thawing effects.
Concrete in cold weather is **recommended to have a low slump, and minimal water to cement ratio**, to reduce bleeding and decreases setting time.

- Use concrete curing blankets to prevent freezing and keep the concrete at an optimal curing temperature.
- Some masonry materials might need to be heated prior to use, so cement hydration can occur properly.
- Use insulation blankets or heated enclosures to maintain concrete temperatures above 50° degrees Fahrenheit for three to seven days.
- **Do not begin final finishing operations while bleed water is present.**
- Request a heated mix or order 100 lbs. of extra cement for each cubic yard of concrete. This extra cement helps develop early strength.
- Fresh concrete frozen during the first 24 hours can lose 50% of its potential 28-day strength!
- Maintain the concrete temperature above 40° degrees Fahrenheit for at least four more days after the use of the insulation blankets or heated enclosures.
- Be careful! The concrete temperature cannot drop faster than more than 40° Fahrenheit in 24 hours.
- When there is no other option, adding a cement bag to the mix will help.
- Do not seal freshly placed concrete until it has bleed and the setting process has begun.
- It is recommended to place concrete as soon as possible, if the batch plant is too far from the concrete's final destination, additional steps must be taken to reduce setting problems.
- Hot water heaters might not be able to withstand hotter temperatures after the initial batches.
- All masonry materials should be completely covered to prevent wetting by rain or snow.

### 6.3.2 HOW TO MAINTAIN CONCRETE TEMPERATURES DURING COLD WEATHER

Temperatures for placement and protecting concrete in cold weather are established and mandated under ACI 306. The objective of the ACI 306 is to keep concrete warm, over 5 degrees Celsius, for the first 48 hours, where concrete strength development is critical. When concrete is being placed below 5 degrees but is not below freezing point, concrete will take longer to develop the required strength. Note that removing formwork when concrete is too cold or has not reached desired strength, could damage concrete strength, surfaces, and concrete might collapse. Using frost blankets and insulated formwork could be necessary to protect concrete. Insulated forms or temporary covers could provide sufficient insulation in beams, columns, and walls.

### 6.3.3 TIPS ON HOW TO CURE CONCRETE IN COLD WEATHER

Try these recommended tips for curing concrete during winter:

- Maintain a proper water-cement ratio. The water to cement ratio should not be more than 0.40 under freezing conditions.
• If temperatures are too cold, a propane heater and polyethylene enclosure could be used to maintain temperatures hot enough, to avoid freezing point.

• Use Portland cement Type III, cement that helps in setting without reducing concrete’s quality. It is important because high moisture content can induce corrosion problems in steel reinforcement.

• Control chloride ions by suing fly ash, silica fume and furnace slag.

• **Leave forms in place as long as possible.** Corners and edges are most vulnerable and forms will help during the heat release process.

• Removing the blankets suddenly in cold weather can cause a temperature differential to build up between the outside of the concrete and its middle. This can cause cracking from the thermal differential, but typically only in thicker members.

• Concrete under water curing for flatwork applications becomes easy with previous concrete. Pervious Concrete is all coarse aggregates and it contains a negligible percentage of fine aggregates, especially sand. Additives are mixed into it that do not allow water to penetrate inside the concrete surface. Pervious concrete is suitable for constructing pavement, as it does not soak in water but allows gallons of water pass through it without damaging concrete pavement and strength.

• **Wait until all bleed water has evaporated.** Curing concrete in cold weather will produce a slower curing procedure, so the concrete is setting slowly, and bleeding will start later than expected. Be prepared to handle more bleed water than regular concrete placement.

• While concrete is being cured, verify the concrete temperature using an infrared temperature gun.

• To determine how much insulating value you need to keep the concrete at 50°FThe insulation needed is based on concrete thickness, cement content, and the lowest air temperature anticipated for the protection period.

• Seal concrete by applying concrete sealant so water does not seep inside the concrete. Concrete sealants will extend concrete’s life, and will reduce the concrete curing failure. In extremely cold regions, only a breathable concrete sealant must be used, as it will allow the evaporation of water and moisture, helping in fast setting of the concrete.

6.3.4 **MATERIALS NEEDED TO CURE CONCRETE DURING WINTER**

Curing concrete in cold weather can be achieved using different materials depending on the amount of concrete being cured and the surface being protected. These materials when used properly will increase or produce a constant heat of hydration of the concrete. For example:

• Insulating sheets,
• Straw-plastic,
• Heating coils,
• Insulating blankets, and
• Windbreaks.

However, if the temperature is below 20 Degree F, simply abandon the idea of placing concrete because it will lead you nowhere as hydration stops completely at such temperatures.

Conversion of temperature from degrees Fahrenheit (°F) to degrees Celsius (°C) or vice versa

\[ T(°C) = (T(°F) - 32) \times \frac{5}{9} \]

For this reason, ACI Committee 308 recommends the following minimum curing periods:

• ASTM C 150 Type I cement 7 days
• ASTM C 150 Type II cement 10 days
• ASTM C 150 Type III cement 3 days
• ASTM C 150 Type IV or V cement 14 days
• ASTM C 595, C 845, C 1157 cements variable

6.3.5 **CONSIDERATION FOR COLD WEATHER MASONRY**
Masonry work requires special attention when working temperatures are below 40 degrees Fahrenheit. **When temperature drops below this point, masons should act promptly and follow special steps to keep masonry warm and workable.** Masonry work in cold weather produces a slower hydration in the mortar, and when the water freezes, it produces a destructive change in volume causing the mortar expansion. If the mortar contains more than 6% water, the expansion due to freezing will be great enough to crack the mortar.

If the masonry is rewetted, the architect or engineer should specify how the masonry should be wetted and how to test if the procedure worked. Wet or ice-covered unit surfaces prevent development of a good bond between the mortar and unit.

### 6.3.6 HOW COLD WEATHER WOULD AFFECTS MORTAR.

Working under cold or freezing temperatures can cause serious problems if not addressed properly. It is important to keep mortar above 40 degrees Fahrenheit. In addition, you should be able to do it following these steps:

- Do not mix large amounts of mortar mix, so that way water will not be absorbed by the materials and will not frost.
- If temperatures are too low, mortar can be placed on heated surfaces such as metal mortarboards.
- Keep a close eye on mortar temperature to avoid mortar being dried due to excessive heat?

### 6.4 HOT WEATHER CONCRETING & ITS REQUIREMENTS:

All concrete work performed in hot weather shall be in accordance with IS 56, except as herein modified. Admixtures may be used only when approved by Engineer-in-charge. Adequate provision shall be made to lower concrete temperatures by cool ingredients, eliminating excessive mixing, preventing exposure of mixers and conveyors to direct sunlight and the use for reflective paint, on mixers etc. The temperature of the freshly placed concrete shall not be permitted to exceed 300°C.

Consideration shall be given to shading aggregate stock piles from direct rays of the sun and spraying stock piles in water, use of cold water available and burying, insulation, shading d / or painting white the pipe line sand water storage tanks ad conveyances.

In order to reduce loss of mixing water, the aggregates, wooden forms, sub grade, adjacent concrete and other moisture absorbing surfaces, shall be well wetted prior to concreting, placement ad finishing shall be done as quickly as possible.

Extra precautions shall be taken for the protection and curing of concrete. Consideration shall be given to continuous water curing and protection against high temperature and drying hot wind for a period of at least 7 days immediately after concrete has set and after which normal curing procedures may be resumed.

### 6.4.1 PLACING CONCRETE IN HOT WEATHER

Placing concrete in hot weather is defined as the moment when the following conditions occur: High ambient temperature, low relative humidity and/or high wind speed. These conditions are further described and explained under ACI 305. Placing concrete in hot weather affects laboratory test results, showing that higher temperatures affect the compressive strength gain of hardened concrete.

It is important that field test cylinders be protected by shading to prevent evaporation. When placing concrete in hot weather it is important to protect the top layer of concrete, which tends to dry faster than the bottom part. Concrete placed in hot weather will produce higher early strength but as time goes by, the ultimate strength will be lower than expected. Proper mix design can compensate for these conditions, and in combination with protective measures to prevent rapid evaporation, quality concrete can be poured in hot temperatures.

### 6.4.2 TIPS FOR PLACING CONCRETE IN HOT WEATHER

If you are planning to place, concrete in hot weather consider these recommendations:
• Have sufficient labor to manage the concrete when it is being poured and for the finishing process.
• Use a large size and amount of coarse aggregates if hot weather is likely to occur during the concrete placement. Larger size aggregates will minimize the probability of having concrete shrink due to environmental conditions.
• If possible avoid placing concrete at noon or during the afternoon.
• Plan with the batch plant an acceptable delivery concrete temperature so the supplier as can cool materials needed. Aggregates can be cooled down by spraying water over the stockpile.
• Consult with the structural engineer or designer to maximize and implement an effective plan to properly space control joints. When placing concrete in hot weather, control joints should be spaced at smaller intervals than cold weather concrete joints.
• Use sunshades or windbreaks to reduce possible harsh conditions.
• Plan to have indoor slabs poured after all walls and roofs are built.
• When pouring concrete in hot weather keep an evaporative retarder ready on site in case the temperature gets hotter and water is rapidly evaporating.
• Use ice as part of the concrete water mix or use liquid nitrogen to cool the concrete.
• Reduce the mixing time once water has been added to the mix.
• Consider batching and mixing at a jobsite plant.
• Do not add water to the pre-mixed concrete unless it is part of the design.
• All equipment needed to place concrete in hot weather should remain covered until the last moment before using. Keep chutes, conveyors, and accessories under roof if possible and spray some water over them regularly.
• When placing concrete for a slab, first dampen the sub-grade.
• Use cool water to dampen side forms for slabs or walls.
• Do not begin finishing concrete while water is still on the surface.
• Implement the correct curing method to allow the concrete to set uniformly.
• Be ready to receive and place concrete.

6.4.3 PLACING CONCRETE IN HOT WEATHER - PROBLEMS
Placing concrete in hot weather could affect the following:
• Placing concrete in hot weather could increase difficulties in finishing concrete
• Cold joints could be formed due to hot weather decreasing the setting time
• It is expected that strength and durability characteristics may be reduced
• Concrete compression tests could yield lower strength results
• Placing concrete in hot weather could increase the drying shrinkage of the hardened concrete
• It will produce an increased rate of slump
• High heat or hot weather could increase the risk of thermal cracking
• The heat of hydration raises the temperature of the interior of the concrete.
• Plastic shrinkage cracks can be quite deep as the plastic concrete has little capacity to resist shrinkage stresses, and cracks continue to widen and propagate until the shrinkage stresses are relieved.

7. WELLS PRODUCTION

7.1 DRILLED WELLS
Drilled wells are typically created using either top-head rotary style, table rotary, or cable tool drilling machines, all of which use drilling stems that are turned to create a cutting action in the formation, hence the term drilling.
Drilled wells can get water from a much deeper level than dug wells can—often up to several hundred meters. Where the water wells typically range from 3 to 18 meters (9.8–59.1 Ft.) deep, but in some areas can go deeper than 200 meters (655 Ft.).
The oldest form of drilling machinery is the cable tool, still used today. Specifically designed to raise and lower a bit into the borehole, the spudding of the drill causes the bit to be raised and dropped onto the bottom of the hole and the design of the cable causes the bit to twist at approximately ¼ revolution per drop, thereby creating a drilling action.
At the bottom of wells, based on formation, a screening device, filter pack, slotted casing, or open borehole is left to allow the flow of water into the well. Constructed screens are typically used in unconsolidated formations (sands, gravels, etc.), allowing water and a percentage of the formation to pass through the screen. Allowing some material to pass through creates a large area filter out of the rest of the formation, as the amount of material present to pass into the well slowly decreases and is removed from the well. Rock wells are typically cased with a PVC liner/casing and screen or slotted casing at the bottom; this is mostly present just to keep rocks from entering the pump assembly. Some wells utilize a filter pack method, where an undersized screen or slotted casing is placed inside the well and a filter medium is packed around the screen, between the screen and the borehole or casing. This allows the water to be filtered of unwanted materials before entering the well and pumping zone.

WELLS DRILLING PROCEDURE

A well is a man-made hole dug into the ground to get to a liquid. The most commonly sought liquid is water: About 97 percent of the world’s fresh water is found in underground aquifers. Water wells may be dug simply to monitor water quality or to heat or cool, as well as to provide drinking water when treated. Drilling a well may be done in one of several ways, as described below, and there are things to consider before drilling a well.

PLANNING:

1. Consider the costs and benefits of drilling a well against piping or shipping water in. Drilling a well involves a higher initial cost than connecting to a public water supply, as well as risks of not finding enough water or water of sufficient quality and ongoing costs to pump the water and maintain the well. However, some water districts may make residents wait years before they can be connected to a public supply, thus making well drilling a viable option where there is enough groundwater at a reasonable depth.

2. Know the specific location of the property where the well is to be drilled. You will need to know the section, township, range and quarters to access land and well records through your state's geological survey.

3. Find out what previous wells have been drilled on the property. Geological survey will record the depths of previous wells in the area whether or not they found water. You can access these records in person, by telephone or online. These records can help you determine the depth of the water table, as well as the location of any confined aquifers.

4. Most aquifers are at the depth of the water table; these are called unconfined aquifers, as all the material above them is porous. Confined aquifers are covered by nonporous layers, which, although they push the static water level above the top of the aquifer, are more difficult to drill into.

5. Consult geological and topographic maps. Although less useful than well-drilling records, geological maps can show the general location of aquifers, as well as the rock formations in an area. Topographic maps show the surface features and their elevations that can be used to plot Well locations. Together, they can determine whether an area has sufficient groundwater to make drilling a well viable.

6. Water tables are not uniformly level, but follow ground contours to some extent. The water table is nearer the surface in valleys; particularly those formed by rivers and creeks, which is harder to access at higher elevations.

7. Ask people who live near the property. Many older wells have no documentation, and even if records exist, someone who lived nearby may remember how much water those wells produced.

8. Get assistance from a consultant. Your state’s geological survey personnel may be able to answer general questions and direct you to resources beyond those mentioned here. If you need more detailed information than what they can provide, you may need the services of a professional hydrologist.

9. Get whatever well-drilling permits you need. Consult the appropriate municipal and state
agencies to find out what permits you need to obtain before drilling and any regulations that govern drilling wells.

**DRILLING THE WELL:**

1. **The well might be drilled away from any potential contaminants.** Animal feedlots, buried fuel tanks, waste disposal and septic systems can all pollute groundwater. Wells should be drilled in places where they can easily be reached for maintenance, and located at least 5 feet (1.5 meters) from building sites.

2. **Choose the appropriate construction method.** Most wells are drilled out, but wells may also be dug or driven, if conditions warrant. Drilled wells may be bored with an auger or rotary tool, smashed out with a percussion cable or cut with high-pressure jets of water.

   - **Wells are dug** when there is sufficient water near the surface and no intervening dense rock. After a hole is made with shovels or power equipment, a casing is lowered into the aquifer, and the well is then sealed against contamination. As they are shallower than driven or drilled wells, they are more likely to go dry when drought lowers the water table.

   - **Wells are driven** by attaching a steel driving point to a stiff screen or perforated pipe, which is connected to solid pipe. An initial hole wider than the pipe is dug, and then the assembly is pounded into the ground, with occasional turnings to keep the connections tight, until the point penetrates the aquifer. Wells can be hand-driven to depths of 30 feet (9 meters) and power-driven to depths of 50 feet (15 meters). Because the pipe used is of small diameter (1.25 to 12 inches, or 3 to 30 centimeters), multiple wells are often driven to provide sufficient water.

   - **Augers** can be either rotating buckets or continuous stems and can be turned either by hand or with power equipment. They work best in soils with enough clay to support the auger and do not work well in sandy soil or dense rock. Auger-bored wells can be drilled to depths of 15 to 20 feet (4.5 to 6 meters) by hand and up to 125 feet (37.5 meters) with power augers, with diameters ranging from 2 to 30 inches (5 to 75 centimeters).

   - **Percussion cables** work like pile drivers, with bit or tool moving up and down on a cable to pulverize the ground being drilled into. As with rotary cable drills, water is used to loosen and remove intervening materials. Percussion cables can drill to the same depths as rotary drills, albeit more slowly and at higher cost, but they can smash through materials that would slow rotary bits.

   - **High-pressure water jets** use the same equipment as rotary drills, without the bit, as the water both cuts the hole and lifts out drilled material. This method takes only minutes, but jet-drilled wells can be no more than 50 feet (15 meters) deep, and the drilling water needs to be treated to prevent it from contaminating the aquifer when the water table is penetrated.

**FINISH THE WELL.**

Once the well is drilled, casing is inserted to prevent the water from wearing away and being contaminated by the sides of the well. This casing is usually narrower in diameter than the well borehole itself and sealed in place with a grouting material, commonly either clay or concrete. Casing usually runs to a depth of at least 18 feet (5.5 meters) and may run the entire length of a well drilled in loose, sandy soils. Screens to filter out sand and gravel are inserted in the casing, then the well is capped with a sanitary seal and, unless the water is already under pressure, a pump is attached to bring the water to the surface.

**7.2 HAND PUMPS TYPES AND SPECIFICATIONS:**

The Indus, Kabul and Pamir Pumps are conventional levered action hand pumps. They are designed for heavy-duty use, serving communities of 300 persons. The maximum recommended lift is 15 m for the Kabul Pump, 45 m for the Indus Pump and 60 m for the Pamir Pump. The pumps are not fully corrosion resistant; rods are subject to rusting. The Indus, Kabul and Pamir Pumps are public domain
pumps defined by RWSN specifications, only used in Afghanistan and Pakistan. They are easy to install and have excellent potential for community-based maintenance.

The Indus, Kabul and Pamir Pumps are conventional levered action hand pumps. The configuration includes an “open top” cylinder: the piston can be removed from the cylinder without dismantling the rising main. The foot valve is retractable with a fishing tool.

Technical data

<table>
<thead>
<tr>
<th>Depths to be used:</th>
<th>10-60 m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylinder diameter:</td>
<td>50.0 mm,</td>
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<tr>
<td>Maximum Stroke:</td>
<td>225 mm,</td>
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<tr>
<td>Approx. discharge (75 watt input):</td>
<td></td>
</tr>
<tr>
<td>at 10 m head:</td>
<td>1.4 m³/hour,</td>
</tr>
<tr>
<td>at 15 m head:</td>
<td>1.1 m³/hour,</td>
</tr>
<tr>
<td>at 20 m head:</td>
<td>0.9 m³/hour,</td>
</tr>
<tr>
<td>at 30 m head:</td>
<td>0.7 m³/hour,</td>
</tr>
<tr>
<td>Pumping lift:</td>
<td>10 - 45 m,</td>
</tr>
<tr>
<td>Population served:</td>
<td>~ 300 people,</td>
</tr>
<tr>
<td>Households:</td>
<td>15 - 25 hh,</td>
</tr>
<tr>
<td>Water cons.:</td>
<td>15-50 lit/per capita, based on MRRD</td>
</tr>
<tr>
<td>Type of well:</td>
<td>Borehole or dug well.</td>
</tr>
</tbody>
</table>

Possible composition of a selected Indus Pump:

- Pump head type: B
- Pump stand type: C
- Rising main arrangement: A
- Cylinder arrangement: A
- Pump rod arrangement: C
7.3 CONSTRUCTION, OPERATIONS AND MAINTENANCE

Pump head, handle and pump stand are made of galvanized steel, pump rods of mild steel, rising main of PVC-U pipe (Ø63 mm), cylinder of PVC-U pipe with brass liner (Ø50 mm), plunger and foot valve are of plastic. These pumps are not fully corrosion resistant; the rods are subject to corrosion. All parts of these pumps have a potential for local manufacturing in Afghanistan and Pakistan. Local companies who manufacture PVC-U pipes and have the knowledge of processing Construction plastics are able to produce the “down-hole components”. The cost of the tooling is high and therefore the number of manufacturer will be limited.

Installation of the Indus pump is not difficult and does not need any lifting equipment. It is however recommended that a well-trained crew with the necessary skills perform the installation. This pump has an excellent “Community Management Potential”, it is reliable, easy to repair by a village caretaker and popular with the communities.
Standard Apron drawings certified by MRRD and UNICEF (The Updated Apron Design from MRRD and UNICEF)
8. CONSTRUCTION SAFETY

Construction is one of the most dangerous occupations in the world, incurring more occupational fatalities than any other sector in all over the world.

The purpose of construction safety is to decrease the risks and accidents in the project site and ensure safe construction working space for workers, project technical staffs and related employees.

Usage of proper safety equipment such as harnesses and guardrails and procedures such as securing ladders and inspecting scaffolding can curtail the risk of occupational injuries in the construction industry.

The following safety rules should seriously be followed by contractors and SCA Construction colleagues regarding Good and Safe Construction activities in the projects:

1. Report to work free of the effect of alcohol or drugs.
2. Do not string cords across the floor where people may trip.
3. Wear proper safety footwear on the job!
4. Make sure scaffolds are set correctly, level and with guardrails!
5. Always wear safety gloves when working with mortars, fixing tools, installation of components, etc.
6. All skilled and skilled labors should wear safety cloths and hats where recommended by Construction Team.
7. Any field accident related to the construction activities should be reported regularly to next supervisors.
8. First Aid Kit should always keep available in the project site.
9. The working site should be regularly check by Project in charge in terms of clearance and threats.
10. All Explosive material should be stored separately from other goods.
11. All holes more than 5 feet (150cm) should be sloped in tranches forms.
12. Site Engineer is responsible for making all newly coming staff aware about rules to be followed and safety precautions to be adopted at the project site.
13. Unskilled and Unprofessional workers should not be allowed to use heavy machineries, and only qualified operators should have access to such machinery.
14. Necessary Documents safety is one of the Site Engineer responsibility to be consider.
15. Consideration of Personal Safety is first, Sources and Environment’s safety are in the next stage.

9. PROJECT SIGN BOARDS

Marble signboard:

The horizontal length is used 100 cm for standard writing format, while the vertical length is 80 cm. these dimensions to be used in all demand of the project marble signboard.
10. PROJECT FOLLOW-UP

10.1. SUPERVISION:

Qualitative and quantitative supervision is very important to be carried out regularly during the construction phase of the project.

1. Initially, the site engineer/Supervisor will have to mobilize the project personnel and all project activities on daily basis for all construction and WASH projects.
2. Head of Construction POs should supervise the on-going activities, construction materials, expenditure, personnel, work quality and quantity the community contribution as outlined in the project planning.

3. All required site books must be kept on site, one for registration of material in detail and the second for visitors to write their comment and advises, the third should be used for stock ledger and the fourth one is used as attendance record. The site stock ledger must be kept updated at all time.

10.2 MONITORING:

1- A combined group of staff from KMO Construction should monitor the project regularly.

2- The Construction Project Manager and his/her Deputy should supervise the project at least twice during project implementation period.

3- The Senior Engineer and Field Engineer should regularly monitor projects implementation on a monthly basis (21-25 of each month).

A. Construction team will monitor the project based on its planning. The following points will be monitored:

   - Basic project documents (drawings, work plan, volume of work and budget balance).
   - Progress of the specific tasks/activities against the work plan and SCA policy.
   - The project budget against the implementation costs.
   - The project personnel / field worker.
   - The community involvement / contribution.
   - The project materials supplied and spent by the site staff based on proposed plan.
   - The project will be monitored as agreed in the basic project documents and as required by the SCA Management and donors.

B. All deliveries to Construction projects should be signed by project storekeeper, project offices logistic representative, endorsed by site engineer, and verified by Field Senior Engineer.

C. SCA trucks should be utilized as much as possible, and if not, reputable commercial transport companies should be utilized. In both cases, the supplier should accompany the transport. The logistics should give the first priority to the Construction Project supplies due to seasonal activities.

D. All returned goods from project sites should be stored in the main warehouse and immediately entered in to registration book upon arrival. For stackable goods, finance should be informed.

E. For verification purposes, the signature of all project engineers including project based and other authorized Construction staff after recruitment should be introduced to Project Office finance unit. The delivery sheets are only accepted after signature of authorized person and endorsement of Construction Unit Senior Staff.

The local authority should be invited by head of Construction in Project Offices to the project occasionally to see the SCA Construction activities and motivate the villagers for active community participation (at least twice during project period) as well Community Lead projects should be monitored by CPM during implementation.

Note: in the projects with hazards (security problem or any other problem and Construction Unit of SCA cannot monitor) the third party monitor should be selected and have to monitor the project in accordance to the TOR, which will be prepared for monitoring.

10.3 REPORTING:

Bi-weekly progress report should be regularly prepared by site engineers or field senior engineer and submitted to Senior Engineer on Wednesdays. The monthly progress report must be submitted with
updated photos of each project (sent within 25th to 28th of each month) to KMO EU until the end of the project. Within one month after completion, the project office senior staff should submit a final report to KMO Construction Unit.

Fallowing Tools should be used for reporting:

- Standard Reporting Formats.
- Camera with high quality.
- GPS when requested or as per need.

10.4 EVALUATION:

As all projects need to be evaluated by concerned unit, thus it will be the role of M&E to coordinate this along with the Construction team.

BROAD MEASURES FOR QUALITY CONTROL OF CONSTRUCTION PROJECTS

- Thorough study of agreement, design, drawings, specification
- Availability of agreement/drawings/publications with field staff.
- Revised drawings should be marked immediately
- Sub-standard material should not be allowed to remain at the construction site.
- Notes given in drawings to should be read first.
- Action against sub-standard/defective work must be taken quickly to send a strong message to the contractor.