SCOPE OF WORK

For

Estimated BOQ for Construction of Water Network, Elevated Tank, and Pump Station for Annex 1,2, and 5 in Al Hol Camp - NES.

1. **Excavation works:**

1.1 Site Preparation and Excavation.

Site preparation and excavation are crucial initial stages in the construction process of various projects, including buildings, roads, bridges, and other infrastructure developments. These processes involve clearing and grading the land, excavating the soil, and creating a level and stable foundation for the subsequent construction work. Here's a breakdown of these processes:

1- Site Clearing: The first step is to clear the construction site of any obstacles, debris, vegetation, or existing structures that might hinder construction. This may involve the removal of trees, shrubs, rocks, and any other obstructions.

2- Site Grading: Grading involves shaping and leveling the terrain to achieve the desired slope, elevation, and drainage for the project. Proper grading ensures that rainwater and other runoff flow away from structures and areas prone to erosion.

3- Excavation: Excavation is the process of digging and removing soil, rock, or other materials from the site to create space for foundations, utilities, and other construction elements. Excavation may be done manually or using heavy machinery such as excavators, bulldozers, and backhoes.

4- Earthwork: Earthmoving is a critical aspect of excavation, involving the transportation and redistribution of excavated materials to achieve the desired topography. Earthwork may also include compaction of the soil to ensure stability and load-bearing capacity. Each backfilled layer of soil or sub-base must be adequately watered and compacted to reach the allowable compaction rate 95%

5- Foundation Preparation: Excavation is often performed to prepare the foundation for structures. This may involve digging trenches, pits, or footings to accommodate the foundation components. Proper foundation preparation is vital for ensuring structural integrity and stability.

6- Utility Installation: During excavation, utilities such as water, sewer, electrical, and telecommunications lines may be installed. Trenches or channels are created to lay these utility lines, and after installation, they are typically covered and backfilled.

7- Rock Breaking: In cases where the construction site contains significant rock formations, break down the rock into manageable sizes for removal.

8- Soil Testing: Throughout the excavation process, soil testing and analysis are often conducted to assess the soil's properties, bearing capacity, and suitability for construction. This information helps engineers make informed decisions about foundation design and other structural considerations.

9- Erosion Control: As the site is excavated and graded, measures are taken to prevent erosion and sediment runoff, which could harm the environment and adjacent areas. Techniques like erosion control blankets, silt fences, and retention ponds are used to manage runoff.

10- Backfilling: After utility installation and foundation work, excavated areas are refilled with suitable materials to restore the terrain to its intended contours. Proper compaction of backfilled materials is essential to maintain stability.

Site preparation and excavation set the stage for the entire construction project and greatly influenced its success. These processes require careful planning, coordination, and adherence to safety regulations to ensure a solid foundation and safe working environment for subsequent construction phases.

1.2 Excavation below the concrete.

Excavation below concrete refers to the process of digging or removing soil, rocks, or other materials from beneath a concrete structure. This type of excavation may be necessary for various reasons, such as the Installation of utilities. Excavation may be required to install or repair underground utilities like plumbing, electrical conduits, or sewer lines that need to pass beneath the concrete, Basement construction: when constructing a basement, excavation is done before pouring the concrete slab to create the desired depth and space for the basement area, soil stabilization. Excavation might be done to improve the stability of the soil beneath the concrete, especially if there is a risk of settling or subsidence.

Excavation below a foundation requires careful planning, engineering expertise, and adherence to safety procedures. It is typically carried out in the following steps:

- Site Evaluation: Before starting the excavation, a thorough site evaluation is conducted to assess the foundation's condition, the type of soil, groundwater levels, and any potential risks or obstacles. This evaluation helps in devising the most suitable excavation plan.
- Marking and Layout: The area around the foundation is marked and laid out with precise measurements to ensure that the excavation is done accurately, avoiding any encroachments on adjacent structures or property lines.
- Clearing the Area: Any obstacles, debris, or vegetation are cleared from the excavation area to provide a clean and safe work environment.
- Excavation Process: Using appropriate excavation equipment such as excavators or backhoes, the soil is carefully dug out from beneath the foundation. The excavation depth will depend on the drawings and the type of foundation. and according to the instruction of the site engineer, In the case of using mechanical means, a depth of 10 cm is left to be dug by hand to ensure the cohesion of the soil below the bases.
- Inspections: Regular inspections are conducted during the excavation process to ensure that the foundation remains stable, and there are no signs of structural compromise or shifting.
- Waterproofing: In some cases, waterproofing measures may be applied to the foundation walls or footing during excavation to protect the foundation from water infiltration.

1.3 Backfilling Concrete Works.

After the necessary repairs or modifications are completed, the excavated area is filled with suitable materials. The backfill material shall be implemented on layers each layer thickness shall not exceed 25 cm and each layer shall be watered and then compacted mechanically or manually to provide support to the foundation and prevent future settlement the compaction must be sufficient to reach all the materials to a dry density equal to 95% of the density, as determined by Proctor test If the excavated soil is suitable, the contractor can use it for Re-filling, if not, the contractor must provide good materials for backfilling. After the approval of the Blumont engineer at the expense of the contractor, the contractor must take all necessary measures to get rid of the unsuitable excavated material and move it outside the site as per instructions of the supervising engineer. providing what is necessary and suitable for re-filling near the work site After the backfilling is complete, the area is restored to its original condition, and any disturbed surfaces are repaired or replaced. Throughout the entire process, regular inspections are carried out to ensure that the excavation is proceeding safely and according to the engineering design and the instruction of the site engineer.

1.4 INFRASTRUCTURES

During site investigations, existing underground systems might be found. When installing a new system in an area with already existing systems the standards highlighted in Figure 1.4 shall be followed.

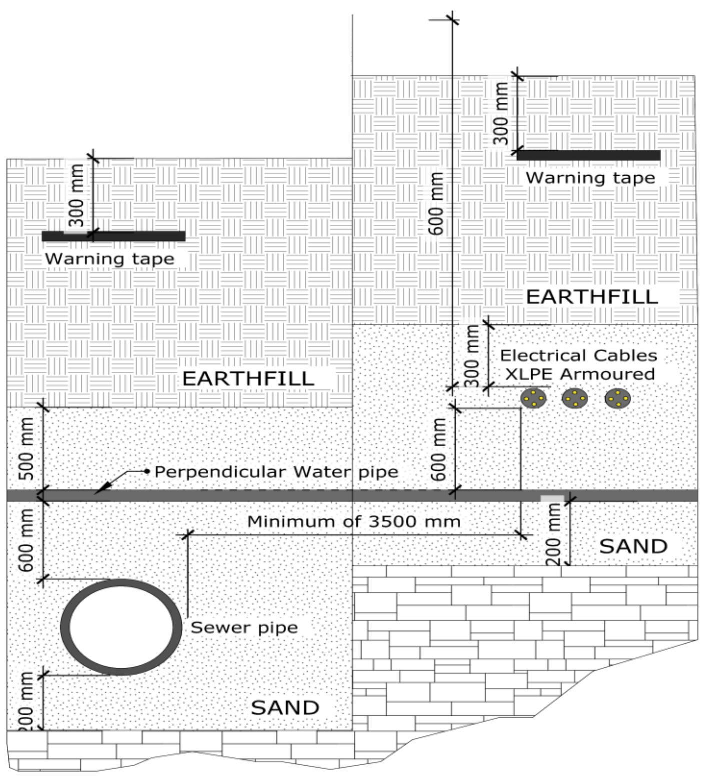


Figure 1.4 – Buried infrastructures correlation (Cross-sectional view)

Potable/non-potable water pipes shall be at least 600mm above any existing sewage line when the lines are perpendicular. And shall be at least 3000mm apart when parallel. Electrical lines shall be always 600 mm away from any other pipes when perpendicular. And 3500mm apart when parallel. Each system shall be in a separate trench.

All systems (i.e. pipes, cables) shall be bedded with 200mm of sand from all sides, before backfilling. All systems shall be labeled with a warning tape 300 mm below ground level. After backfilling compaction shall be done on several layers after placing the backfilling materials. The compaction shall be tested under ASTM D – 1557. All site investigations must be carried out in coordination with the Blumont team and camp-related sides.

2- Concrete Works

2.1 Concrete Mix Design

Concrete mix design is the process of determining the proportions of various ingredients to create a concrete mix with specific properties and performance characteristics. Achieving the desired properties in concrete is essential for ensuring its strength, durability, workability, and other performance factors.

The key ingredients used in concrete mix design are:

Cement: It acts as the binder that holds all the other ingredients together. Common types of cement include Portland cement, which is widely used in construction The cementitious material content shall not be less than 390 kg/cubic meter.

Aggregate: Aggregates are inert granular materials that provide bulk to the concrete mix and contribute to its strength. such as sand, gravel, and crushed stone masonry sand shall be a fine-grained, pure type.

Water: is essential for the hydration of cement, leading to the hardening of concrete. The right amount of water is critical to achieving the desired workability and strength of the concrete. concrete shall have a maximum water-soluble chloride ion content for corrosion protection of 0.15 percent by mass of the Portland cement.

Fresh concrete is recommended to be provided from a certified concrete plant. Otherwise, on-site concrete mixing shall be done using portable concrete mixers under the supervision of Blumont's engineers. Pouring for quantities not exceeding 10 m3 can be cast manually, through a worker. The quantities are determined accurately through a limited-sized container dry materials are mixed first then water is added, It is not permitted to mix more than 3 m3 in each mix process if the pouring is more than 10 m3, the contractor is obliged to pour semi-automatic through mounts on the site, and the contractor shall abide by the time required to obtain a homogeneous and acceptable mixture, which is not less than 1 minute and according to the instructions of the supervising engineer, The concrete mixture shall be free of dust and any other impurities. The ratio of the fresh concrete components varies according to the concrete mix design and required compressive strength. Table 2.1 shows different types of concrete grades and their uses.

Table 2.1.1 – concrete uses for different grades.

Concrete Grade	Mix Ratio (C:S:A)	Compressive Strength (28 days)	Uses
C 10	1:3:6	10 MPa	non-structural construction elements like patio slabs and pathways.
C 15	1:2:4	15 MPa	floor blinding and curb mix.
C 20	1:1.5:3	20 MPa	domestic workshop and garage bases as well as driveways and internal floor slabs.
C 25	1:1:2	25 MPa	wide range of commercial and domestic construction sites. often used for foundations (footings).
C 30	Design Mix	30 MPa	pathways and roadways for heavy vehicles.
C 35	Design Mix	35 MPa	structural piling and creating external slabs and walls. Other uses include commercial slabs.
C 40	Design Mix	40 MPa	commercial construction sites. Used in chemically harsh environments where the additional strength can combat and contain acidic and hazardous chemicals

2.2 ACI Method of Concrete Mix Design

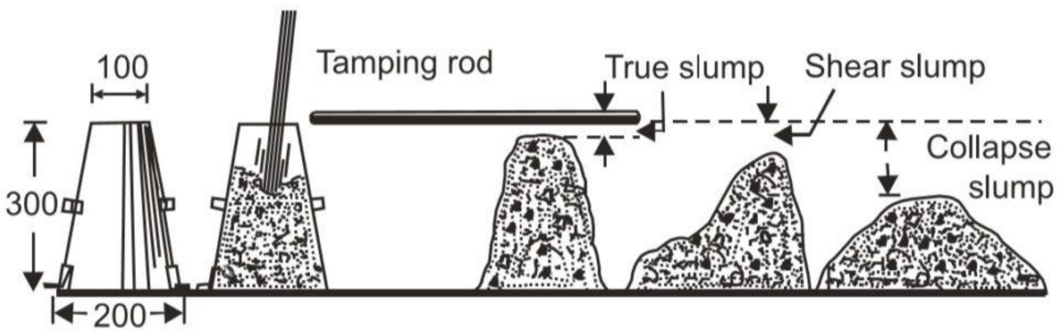
A- Choice of the slump.

If a slump is not specified, a value appropriate for the work can be selected from Table 2.2 The values provided in Table 2.2 can be used only when vibration is used to consolidate concrete.

Table 2.2.1 Recommended slumps for various types of construction

Construction type	Slump value, mm	
	Minimum	**Maximum***

Reinforced foundation walls and footings	25	75
Plain footings, caissons, and substructure walls	25	75
Beams and reinforced walls	25	100
Building columns	25	100
Pavements and slabs	25	75
Mass concrete	25	50
*May increased by 25mm for methods of consolidation other than vibration		



B- Choice of the maximum size of the aggregate

commonly, the maximum aggregate size should be the largest that is economically available and consistent with the dimensions of the structural element. ACI 211.1-91 specifies that the maximum aggregate size shall not surpass:

- one-fifth of the narrowest dimension between sides of forms.
- one-third the depth of slabs
- 3/4-ths of the minimum clear spacing between individual reinforcing bars, bundles of bars, or pre-tensioning strands.

These limitations may be ignored if workability and methods of consolidation are such that the concrete can be placed without honeycomb or void.

C- Estimation of mixing water and air content

The quantity of water per unit volume of concrete required to produce a given slump is dependent on:

- nominal maximum size
- particle shape
- grading of the aggregates
- concrete temperature
- amount of entrained air
- use of chemical admixtures.

Table 2.2.2 and Table 2.2.3 provide estimates of the required mixing water for concrete made with various maximum sizes of aggregate, for non-air and air-entrainment concrete, respectively.

Table 2.2.2 Approximate mixing water (Kg/m^3) and air content for different slumps and nominal maximum sizes of aggregates for non-air content concrete

Slump, mm	Water, Kg/m³ of concrete for indicated nominal maximum sizes of aggregate							
	9.5 mm	12.5 mm	19 mm	25 mm	37.5 mm	50 mm	75 mm	150 mm
25-50	207 kg	199 kg	190 kg	179 kg	166 kg	154 kg	130 kg	113 kg
75-100	228 kg	216 kg	205 kg	193 kg	181 kg	169 kg	145 kg	124 kg
150-175	243 kg	228 kg	216 kg	202 kg	190 kg	178 kg	160kg	----
Approximate Air content quantity, %	3	2.5	2	1.5	1	0.5	0.3	0.2

Table 2.2.3 Approximate mixing water (Kg/m^3) and air content for different slumps and nominal maximum sizes of aggregates for "Air-entrained” concrete.

Slump, mm	Water, Kg/m3 of concrete for indicated nominal maximum sizes of aggregate

	9.5 mm	12.5 mm	19 mm	25 mm	37.5 mm	50 mm	75 mm	150 mm
25-50	181 Kg	175 Kg	168 Kg	160 Kg	150 Kg	142 Kg	122 Kg	107 Kg
75-100	202 Kg	193 Kg	184 Kg	175 Kg	165 Kg	157 Kg	133 Kg	119 Kg
150-175	216 Kg	205 Kg	197 Kg	184 Kg	174 Kg	166 Kg	154 Kg	----

What is Air-Entrained Concrete?

Air-entrained concrete contains billions of microscopic air cells per cubic Meter. These air pockets relieve internal pressure on the concrete by providing tiny chambers for water to expand into when it freezes. Air-entrained concrete is produced using air-entraining Portland cement, or by the introduction of air-entraining agents, under careful engineering supervision, as the concrete is mixed on the job. The amount of entrained air is usually between four and seven percent of the volume of the concrete but may be varied as required by special conditions. The primary use of air-entrained concrete is for freeze-thaw resistance. The air voids provide pressure relief sites during a freeze event, allowing the water inside the concrete to freeze without inducing large internal stresses.

D- Selection of water-cement or water-cementitious material ratio.

Strength, durability, and determining water-to-cement ratio: a conservative estimate can be made for the accepted 28-day compressive strength from Table 2.2.4 Additionally, if there are severe exposure conditions, such as freezing and thawing, or sulfates, the w/c ratio can be obtained from Table 2.2.4 Table 2.2.5 Relationship between water-cement or water-cementitious materials ratio and compressive strength of concrete.

Table 2.2.4 Relationship between water-cement or water-cementitious materials ratio and compressive strength of concrete

28-days compressive strength in MPa (psi)	**Water cement ratio by weight**	
	Non-air entrained	**Air entrained**
41.4 (6000)	0.41	---
34.5 (5000)	0.48	0.40

27.6 (4000)	0.57	0.48
20.7 (3000)	0.68	0.59
13.8 (2000)	0.82	0.74

Table 2.2.5 Maximum permissible water/cement ratios for concrete in severe exposure

Types of structure	**Structure wet continuously of frequently exposed to freezing and thawing**	**Structure exposed to seawater**
Thin sections (railings, curbs, sills, ledges, ornamental work) and sections with less than 25mm cover over steel	0.45	0.40
All other structures	0.50	0.45

E- Calculation of cement content

The amount of cement is fixed by the determinations made in Steps C and D above, and by the contract terms, which directly indicate the concrete ratio.

F- Estimation of coarse aggregate content

The most economical concrete will have as much as possible space occupied by coarse aggregate since it will require no cement in the space filled by coarse aggregate. The percent of coarse aggregate to concrete for a given maximum size and fineness modulus is given in Table 2.2.6 Coarse aggregate volumes are based on oven-dry rodded weights obtained by ASTM C 29. Aggregates shall not be rounded; they shall be crushed with sharp edges.

Table 2.2.6 The volume of coarse aggregate per unit of volume of concrete

Maximum aggregate size, mm	fineness moduli of fine aggregate			
	2.40	2.60	2.80	3

9.5	0.50	0.48	0.46	0.44
12.5	0.59	0.57	0.55	0.53
19	0.66	0.64	0.62	0.60
25	0.71	0.69	0.67	0.65
37.5	0.75	0.73	0.71	0.69
50	0.78	0.76	0.74	0.72

G- Estimation of fine aggregate content

After Step F, all ingredients of the concrete have been estimated except the fine aggregate. There are two standard methods to establish the fine aggregate content, the mass method, and the volume method. the "volume" method will be used because it is a somewhat more exact procedure. The volume of fine aggregates is found by subtracting the volume of cement, water, air, and coarse aggregate from the total concrete volume. Then once the volumes are known the weights of each ingredient can be calculated from the specific gravities. The volume occupied in concrete by any ingredient is equal to its weight divided by the density of that material (the latter being the product of the unit weight of water and the specific gravity of the material)

Figure (2.2) Coarse aggregate

Figure (2.3) Fine Aggregate.

2.3 Admixtures:

These are optional ingredients that are added to the concrete mix to modify certain properties. Admixtures can improve workability, reduce water content, enhance durability, and control the setting time. As per ACI 212 Concrete admixture is a material other than water, aggregates, hydraulic cement, and fiber reinforcement used as an ingredient of concrete or mortar and added to the batch immediately before or during its mixing. Concrete admixtures are used to improve concrete or mortar properties in plastic and hardened state. otherwise, us types of concrete admixtures such as water-reducing admixtures, retarding admixtures, accelerating admixtures, water-reducing and retarding admixtures, water-reducing and accelerating admixtures, water-reducing high range admixtures, and

water-reducing, high range and retarding shall conform to the specification of the applicable codes otherwise the expected results would not be obtained. The admixtures must be used according to the specifications and under the supervision of the Blumont Site engineer.

2.4 Concrete Placing

Fresh concrete delivered by mixers is recommended to be cast by concrete pumps. Otherwise, the manual cast works shall be done cautiously. All horizontal bodies of concrete shall be cast at once, no cold joints are allowed. All concrete placing works shall be supervised and according to the following best practices instructions:

2.4.1 Best practices - Concrete placing.

- Have all placing equipment and manpower ready before the first mixer delivery
- Use a vapor barrier (plastic sheeting) inside the forms before casting
- Conduct Slump tests to ensure a consistent low-slump concrete
- use concrete with a lower water content at the top of deep members and progressively increase toward the bottom to equalize water content when bleeding occurs.
- use concrete with a lower water content at the top of deep members and progressively increase toward the bottom to equalize water content when bleeding occurs.
- Place concrete in layers that are no more than 60 cm.
- Concrete free fall shall not exceed 1.5 meter
- When placing concrete through a network of reinforcement or in deep forms, use a flexible drop chute (Flexible pipe as a pathway of concrete)
- Don't place concrete on extremely cold or hot reinforcement. Use water or any heat improvement method before casting.
- When bonding is desired, scrub a grout or mortar coat into hardened concrete to roughen the surface before casting a new layer.

2.5 Vibration

Tips for Proper Concrete Vibration

- An internal vibrator must be withdrawn very slowly. If bubbles emerge at the concrete surface when the vibrator is withdrawn, it means more vibration is necessary.
- Quick vibration of concrete can result in structural failure once the concrete cures. If the concrete vibrator is used for a longer period, the aggregates and water can separate,

- Always hold the vibrator in a vertical or nearly vertical position to maximize the effect of vibration.
- The concrete won't wait to sort out the equipment problems. So, always keep another vibrator as a backup if the first one fails.
- Excessive bending of the vibrator must be avoided as it would result in ruining the equipment.
- Do not use the concrete vibrator as a concrete placement tool. This mistake can result in an inconsistent surface along with other problems.
- Always make sure the concrete has not been vibrated previously by any co-workers before proceeding with the vibration.
- The vibrator needle is fully inserted into the concrete and vibrated for at least 10 seconds. Make sure that the tip of the vibrator is fully submerged during vibration.
- Stop the vibration when it does not result in the formation of any air bubbles on the surface or when a sheen surface is obtained.
- The vibrator must not be forced into the concrete as it may result in a collision with the reinforcement.
- Always penetrate the previous lifts or layers of concrete to prevent cold joints. A minimum of 15 cm penetration is recommended.

2.6 Concrete Curing

2.6.1 What Is Concrete Curing?

Concrete curing is the process of maintaining adequate moisture in concrete within a proper temperature range to aid cement hydration at early ages. Hydration is the chemical reaction between cement and water that results in the formation of various chemicals contributing to setting and hardening. Some of the factors that affect the hydration process are the initial concrete temperature, the ambient air temperature, the dimensions of the concrete, and the mix design. Therefore, for the success of this process, in-situ concrete must have sufficient moisture and a temperature that favors this chemical reaction at a rapid and continuous rate. the curing should start after a minimum of six hours (Final setting time of cement) and not less than 24 hours after concrete placing. Thus, the concrete curing t is varied and depends on when the surface of the concrete begins to dry. Concrete curing should be started before the concrete surface loses its water and undergoes shrinkage.

2.6.2 Methods of curing:

As mentioned previously Curing shall start between 6 to 24 hours after concrete placing. There are many effective curing methods. Table 2.6.2 provides a summary of the most widely used methods and procedures. Complete concrete curing takes 28 days. Curing methods shall be carried out for 3 to 7 days depending on the temperature and humidity of the atmosphere.

Table 2.6.2 below shows different methods of concrete curing:

Method	Description	Photograph
Water Curing	The application of the water is done to avoid the drying of the concrete surface. Usually, this method applies when the concrete is thinner. For example, in building construction, the curing of the floor slab can be done with this method. There are two methods to apply water to concrete: Ponding the Concrete or constantly spraying water on the concrete.	
Wet covering	Wet curing is a method of maintaining the surface moisture level by placing materials like hessian. These coverings shall be placed on the concrete surface when it hardens enough to work to please covers. Further, the drying of the concrete surface shall not be allowed due to any reason.	
Formwork Curing	Formwork is the most effective curing agent in construction. Especially in thick concretes where the hydration temperature is high, this method is used. Further, no cost is involved as the cost is already covered under the formwork. The only concern is keeping the formwork a bit longer than usual.	

Membrane Curing	A membrane is formed on the concrete surface to avoid the evaporation of moisture in the concrete. Liquid form material is sprayed over the concrete surface, and it solidifies and forms a membrane. These materials can be applied with brushes or rollers. There are two types of membranes. Water-based Oil-based	

2.7 Concrete Cover

What is a concrete cover?

The concrete cover is the distance measured between the exposed concrete face and the nearest steel reinforcement.

The ACI code specifies requirements for the minimum thickness of concrete cover over reinforcement in various types of structures to ensure durability and protection against corrosion. The specific requirements for concrete cover can vary depending on factors such as the type of structure, the exposure conditions (e.g., environmental exposure, aggressive substances, etc.), and the type of reinforcement used (e.g., epoxy-coated, galvanized, etc.). In certain conditions, this minimum cover thickness would not be adequate and hence it needs to be increased. These conditions include a corrosive environment, fire protection, and future extension. For example, for reinforced concrete members subjected to salts, the ACI code specifies that the thickness of the concrete cover should be at least 50mm. It is desired to set the minimum thickness of the concrete cover as 65mm to account for possible construction errors and hence make sure that 50mm cover thickness is achieved, the thicknesses of the cover mentioned in the below table shall depend on the implementation of the concrete and according to the instruction of the site engineer.

Table 2.7 Min Concrete Cover Thickness

No.	Structural Member	Min Cover mm
1	Footing	50
2	Raft foundation Top	50
3	Raft foundation bottom/sides	50
4	Water retaining structures	20
5	Strap beam	50
6	Grade Slab	20
7	Column	40
8	Shear wall	25

9	Beam	25
10	Slabs 15	25
11	Flat slab	20
12	RET. Wall	20
13	Water retaining structure	20
14	Staircase	15

The above-mentioned limits for the covers are the minimum limits and can be changed according to the drawing, site condition, and instruction of the site engineer.

2.8 Concrete test

Why does concrete need to be tested?

Concrete testing is critical to ensure the safety and longevity of buildings and structures., and testing procedures can save time and money. quality tests on concrete are performed as a part of the quality control of concrete structures. Different quality tests on concrete such as compressive strength tests, slump tests, etc. are used to assure the quality of the concrete that is supplied for a given specification. These quality tests on concrete give an idea about the properties of concrete such as strength, durability, air content, permeability, etc. Concrete testing ensures that concrete has been poured, set, and constructed correctly. Testing concrete helps avoid and identify concrete deficiencies that could be detrimental to the structure of the building or structure. The compressive strength of concrete depends on many factors such as water-cement ratio, cement strength, quality of concrete material, quality control during the production of concrete, etc.

2.8.1 Compressive Strength Test

Compressive strength is the ability of a material or structure to carry the loads on its surface without any crack or deflection.

Mix the concrete either by hand or in a laboratory batch mixer.

i- Hand Mixing

- Mix the cement and fine aggregate on a watertight non-absorbent platform until the mixture is thoroughly blended and is of uniform color.
- Add the coarse aggregate and mix with cement and fine aggregate until the coarse aggregate is uniformly distributed throughout the batch.
- Add water and mix it until the concrete appears to be homogeneous and of the desired consistency.

ii- A sampling of Cubes for the Test, Specimen 6 cubes of 15x15 cm size,

- Clean the mounds and apply oil.

- Fill the concrete in the molds in layers approximately 5 cm thick.
- Compact each layer with not less than 35 strokes per layer using a tamping rod (steel bar 16mm diameter and 60cm long, bullet-pointed at the lower end).
- Level the top surface and smoothen it with a trowel.

iii- Curing of Cubes

The test specimens are stored in moist air for 24 hours and after this period the specimens are marked and removed from the molds and kept submerged in clear freshwater until taken out before the test.

iv- Precautions for Tests

The water for curing should be tested every 7 days and the temperature of the water must be at 27+-2C.

2.8.1.1 Procedure for Concrete Cube Test

- Remove the specimen from the water after the specified curing time and wipe out excess water from the surface.
- Take the dimension of the specimen to the nearest 0.2m
- Clean the bearing surface of the testing machine.
- Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
  - Align the specimen centrally on the base plate of the machine.
- Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
- Apply the load gradually without shock and continuously at the rate of 140 kg/cm2/minute till the specimen fails.
- Record the maximum load and note any unusual features in the type of failure.

2.8.1.2 Test Result

A minimum of three specimens should be tested at each selected age (7 days & 28 days). If the strength of any specimen varies by more than 15 percent of the average strength, the results of such specimens should be rejected. The average of three specimens gives the crushing strength of concrete.

2.8.1.3 Compressive Strength of Concrete at Various Ages

The strength of concrete increases with age. Table 2.8.1.3 shows the strength of concrete at different ages in comparison with the strength at 28 days after casting.

Table 2.8.1.3 The strength of concrete at different ages

Age	Strength percent
1 day	16%
3 days	40%
7 days	65%
14 days	90%
28 days	99%

Table 2.8.1.4 Compressive Strength of Different Grades of Concrete at 7 and 28 Days

Grade of Concrete	Minimum compressive strength N/mm2 at 7 days	Specified characteristic compressive strength (N/mm2) at 28 days
C15	10	15
C20	13.5	20
C25	17	25
C30	20	30
C35	23.5	35
C40	27	40
C45	30	45

2.8.2 Slump test

The concrete slump test is done according to ASTM C143 - Slump Test of Hydraulic Cement Concrete and measures the consistency of fresh concrete before it sets. It is performed to check the workability of freshly made concrete, and therefore the ease with which concrete flows. It can also be used as an indicator of an improperly mixed batch. The slump test is used to ensure uniformity for different loads of concrete under field conditions.

2.8.2.1 Preparing for the Slump Test

Equipment & Dimensions

- Cone dimensions: 4" (top) x 8" (base) x 12" (height), with a tolerance of +/- 1/8"-inch for any of those dimensions.
- Tamping rod: 5/8" in diameter (+/- 1/16-inch) that's at least 4 inches greater than the depth of mold in use, but not greater than 24 inches – with one or both sides having a hemispherical tip. (A rod size of 16 - 24 inches is suitable for use on all the ACI tests.)
- A measuring device at least 12" long with increments of at least 1/4" must be used to measure slump.
- The slump cone mold must be checked annually for irregularities.
- The slump cone can either be metal or plastic. If plastic, it should maintain an average minimum wall thickness of no less than .100 inches. The metal cone is no less than .060 inches.

2.8.2.2 Steps Performed in the Slump Test

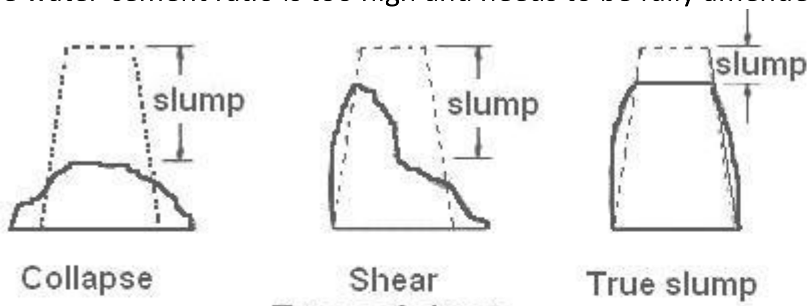
- Place the cone on a flat, smooth, horizontal surface and stand on the footholds on either side to ensure the cone is planted firmly on the ground!
- Fill the cone in three layers, using the steel tamping rod to compact — or tamp — the concrete after each layer in an even, uniform manner (this should be done 25 times per layer).
- Once the cone is filled, remove any overflowing concrete from the top, making sure the concrete fills the cone exactly to the top level. Remove any spilled concrete from the base of the cone, too.
- Lift the cone vertically, using a slow and steady motion until the cone is clear of the concrete. Place the cone upside down on the surface next to the concrete.
- The concrete will subside — or slump. To measure the slump, place the steel rod across the top of the upturned cone so it overhangs the concrete.
- Now, measure from the rod down to the top of the slump. The level of slump is measured to the nearest 5mm.

2.8.2.3 RESULTS OF THE SLUMP TEST

- Depending on the water-cement ratio of the mix, the concrete slump will fall under one of three categories:
- True slump — the concrete largely retains its cone shape, demonstrating that the mix is cohesive, and its workability isn't too high.

- Shear slump — the top half of the concrete subsides dramatically, leaning to one side, meaning the mix has workability but low cohesion. The mix may have too much water content and can be retested after being amended.

- Collapse — the mix doesn't retain its shape at all and completely collapses. This means the water-cement ratio is too high and needs to be fully amended.



Types of slump

Table 2.8.2.3 Recommended value of slump for various types of constructions as per ACI 211.1-91

Types of Constructions	Range of Slump (mm)
Reinforced foundation walls and footing	20-80
Plain footing substructure walls	20-80
Beams & Reinforced Walls	20-100
Building columns	20-100
Pavement & slabs	20-80
Mass Concrete	20-80

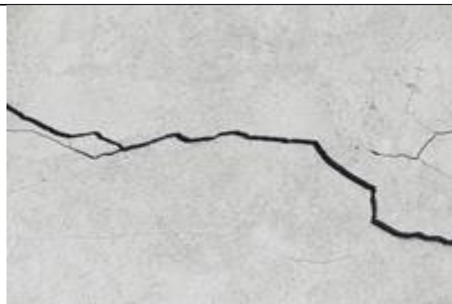
2.9 CONCRETE ASSESSMENT

The assessment of concrete with a successful mixture shall begin immediately after removing the formwork. The first step of the concrete assessment process is the visual inspection.

2.9.1 Visual inspections:

Imperfections and distresses have been categorized and illustrated by photographs. The purpose of tare photographs is to detect and report defects. Those performing the survey should be thoroughly familiar with the terminology of various types of imperfections and distresses. All these conditions are highlighted in Table 2.9.1 Refer to the "ACI Concrete inspection guide" for the complete concrete inspection guidelines.

Table 2.9.1.1 Most common concrete defects and photographs.

Defect	Photo	Defect	Photo
A crack		Peeling	
Delamination		Scaling	
Disintegration from chemical attack		Exposed steel	
Dusting		Cold-joint line.	

Pitting		Honey combing	
Discoloration			

2.9.2 Schmidt hammer test

The rebound hammer test, also known as the Schmidt Hammer Test or sclerometer test, is the simplest and non-destructive test for concrete applications. The device uses a spring with known energy and measures the hardness of the concrete surface using the rebound principle. The Schmidt Hammer Test is standardized according to ASTM C805.

Tests may be performed horizontally, vertically both upwards and downwards, and in any angular position intermediate to the surface. At least 8-10 measurements are required to have reliable mean data respecting the distance between one test area and the other established by the above standards. The tip has a diameter of about 1 cm and on the analyzed surface, depending on the material of which it is made, it creates a small circular depression and is more or less visible. The surface should be planar and smooth if possible, this is why the instrument is equipped with a stone to smooth the test surface.

2.9.2.1 Summary of Test Method

steel hammer impacts, with a predetermined amount of energy, a metal plunger in contact with a concrete surface Either the distance that the hammer rebounds is measured, or the hammer speeds before and after impact are measured. The test result is reported as a dimensionless rebound number. This test method is applicable to assess the in-place uniformity of concrete, delineate variations in concrete quality throughout a structure, and estimate in-place strength.

2.9.2.2 Significance and Use.

- This test method is applicable to assess the in-place uniformity of concrete, delineate variations in concrete quality throughout a structure, and estimate in-place strength.
- For a given concrete mixture, the rebound number is affected by factors such as the moisture content of the test surface, the type of form material or type of finishing used in the construction of the surface to be tested, the vertical distance from the bottom of a concrete placement, and the depth of carbonation. These factors need to be considered in interpreting rebound numbers.
- Different instruments of the same nominal design may give rebound numbers differing from 1 to 3 units. Therefore, tests should be made with the same instrument to compare results. If more than one instrument is to be used, perform comparative tests on a range of typical concrete surfaces to determine the magnitude of the differences to be expected in the readings of different instruments.
- Relationships between rebound number and concrete strength that are provided by instrument manufacturers shall be used only to provide indications of relative concrete strength at different locations in a structure. To use this test method to estimate strength, it is necessary to establish a relationship between strength and rebound number for a given concrete and given apparatus, Establish the relationship by correlating rebound numbers measured on the structure with the measured strengths of cores taken from corresponding locations. At least two replicate cores shall be taken from at least six locations with different rebound numbers. Select test locations so that a wide range of rebound numbers in the structure is obtained. Obtain, prepare, and test scores by Test Method C42/C42M. If the rebound number is affected by the orientation of the instrument during testing, the strength relationship is applicable for the same orientation as used to obtain the correlation date. Locations, where strengths are to be estimated using the developed correlation, shall have similar surface texture and shall have been exposed to similar conditions as the locations.
- This test method is not suitable as the basis for the acceptance or rejection of concrete.

2.9.3 Core test

2.9.3.1 what is the core test?

A concrete core test is a very famous and well-established testing method for the compressive strength of hardened concrete. Concrete core testing enables visual inspection of the interior region of tee concrete member, which is also related to strength estimation, concrete coring also enables to evaluation ofthe properties of reinforced concrete framed structures by concrete core test,

In any case, the necessity of conducting concrete core tests generally arises out of the failure of the concrete cube to get a more realistic idea of concrete strength as existing in the concrete elements.

2.9.3.2 Testing of Concrete Cores for Strength:

The testing of concrete cores is carried out according to the ASTM Standard C 42. The diameter of core specimens for the determination of concrete compressive strength should preferably be at least three times the nominal maximum size of the coarse aggregate used in the concrete and must be at least twice the maximum size of the coarse aggregate in the core sample. The length of the specimen, when capped, should be nearly as practicable twice its diameter. A core having a maximum height of less than 95% of its diameter before capping or a height less than its diameter after capping must be rejected. It is preferable to test the cores in moist conditions.

The ASTM standard prescribes the following procedure: “Submerge the test specimens in lime-saturated water at 23.0 +/- 1.7° C for at least 40 h immediately before making the compression test. Test the specimens promptly after removal from water storage. During the period between removal from water storage and testing, keep the specimens moist by covering them with a wet blanket of burlap or other suitable absorbent fabric.” If the ratio of the length to the diameter of the specimen is less than 1.94 apply the correction factors shown in Table 2.9.3.2 Correction Factor for Ratio of Length of Cone to its Diameter.

Table 2.9.3.2 Correction Factor for Ratio of Length of Cone to its Diameter.

The ratio of the length of the cylinder to diameter (L/D)	Strength correction factor
1.75	0.98
1.50	0.96
1.25	0.93
1.00	0.87

The following guidelines are of particular importance in core sampling:

- The number, size, and location of core samples should be carefully selected to permit all necessary laboratory tests. If possible, use virgin samples for all tests so that there will be no influence from prior tests.
- For determination of strength the core must have a minimum diameter greater than three times the maximum nominal size of the coarse aggregate, or 50 mm.
- For strength tests, the cores must have a length of at least twice their diameter.
- Reinforcing steel should not be included in a core to be tested for strength.
- During the drilling of cores, the electrical conduits or prestressing steel must not be disturbed.
- It is better to drill the core through the full depth of the member to avoid the need for its breaking for extraction. An extra 50 mm is usually drilled to allow for possible damage at the base of the core.
- At least three cores must be removed at each location in the structure for strength determination.

3- STEEL Reinforcement

Steel is one of the most important building materials used in construction, Steel is the backbone of a structure. The strength and durability of a structure significantly depend upon the steel used. With technological advancement, various types of steel have been introduced like mild steel, TMT, steel, alloy steel, etc.

3.1 Types of Steel Used in Construction

3.1.1 Rebar Steel

Steel rebar, often known as reinforcing or fortifying steel, is used as a strain device in reinforced concrete or masonry structures. It is made of carbon steel and has edges for mechanically fastening it down in a superior path in the solid. These bars generally have a deformed surface to improve cohesion with concrete. Reinforcement bars vary in diameter, usually starting from 6mm up to 50 mm. as shown in Table 3.1.1.

Reinforcing steel of deformed bars shall conform to ASTM A615/A615M grades and sizes shall be indicated in the design. Fabrication and placement details of steel and accessories specified or shown in design details must follow ACI SP-66 and ACI 318. Contractors shall submit certified copies of manufacturer reports attesting that the reinforcing steel furnished meets the specified requirements before the installation of reinforcing steel. overlapped bars shall have a minimum length of 50 times the bar diameter. reinforcing steel bars are available in various grades with different yield strengths. The minimum yield stress shall be 423 kg/cm².
Rebar steel offers durability and aesthetic appeal, as well as local resistance and stiffness that extend across a large area. It has a large extension potential; Rebar is valuable due to its ability to be recycled. And it comes in a variety of grades and specifications, including but not limited to:

- Plain steel wire for concrete reinforcement,
- Epoxy-coated steel bars for welded deformed steel,
- Plain bars and rail steel deformed bars,
- TMT steel bars,
- Stainless steel,
- Low-alloy steel,
- Axel Steel, and
- Low carbon steel bars.

Table 3.1.1 – Reinforcement bars sizes and theoretical weights.

BAR DIAMETER (Mm)	THEORETICAL WEIGHT (KG/M)	CROSS-SECTION AREA (MM_2)	MINIMUM OVERLAP LENGTH (MM)
6	0.222	28.2	300
8	0.395	50.2	400
10	0.62	78.5	500

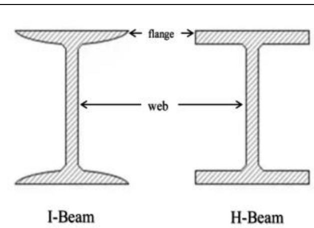
12	0.89	113.0	600
14	1.21	153.8	700
16	1.58	200.9	800
18	2	254.3	900
20	2.47	314	1000
22	2.98	379.9	1100
25	3.85	490.6	1250
28	4.83	615.4	1400
32	6.31	803.8	1600
40	9.87	1256	2000
45	12.5	1589.6	2250
50	15.42	1962.5	2500

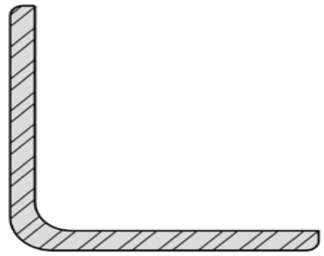
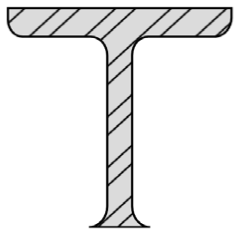
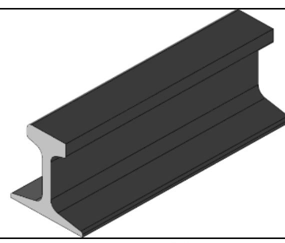
3.1.2 -Structural Steel

This type of steel is used to make structural steel shapes because it is made from a detailed cross-section while adhering to strict mechanical and chemical composition norms.

Varying countries have different requirements for standard structural steel. Structural steel is ductile, sturdy, and durable, and it can be molded into almost any shape depending on the construction; it may be built almost immediately after arriving at the construction site. Structural steel is fire-resistant in and of itself, but fire protection should be supplied if it becomes overheated to the degree that it begins to lose strength. Corrosion must be avoided when employing structural steel by painting with one layer of anti-rust paint and three layers of oil paint, all works should be done according to the instruction of Blumont site engineer although towering buildings can withstand various disasters when constructed with structural steel. . Table 3.1.2 shows Some of the structural steel sections:

Table 3.1.2 structural steel sections:

<table>
<tr><td>I-beam, H beam</td><td>
</td></tr>
<tr><td>Z-beam,</td><td></td></tr>
</table>

Tube sections (HSS- SHS)	
L-beam (angle),	
T-beam,	
Rail profile,	
UPN (C-beam, cross-section),	

3.2 Steel Test

It is important to check the quality of reinforcement bars to ensure that the required characteristics are instilled into a structure. The quality check of the reinforcement bars brought to the site can be performed by the following inspections and tests:

3.2.1 Inspections of Steel at the Site

- Check the manufacturer's test certificate which shows the actual properties issued for a particular lot.
- Check the steel grade in the manufacturer certificate and look at whether it is as per the order.

- Check for rust and unwanted debris on the surface of steel bars. An undesirable amount of foreign material is not acceptable. Do check for any critical deformation or splits.
- Check the brand, the grade, and the diameter of the bar.

3.2.2 Inspections of Steel at the Lab

Proper mechanical testing is necessary for determining if the rebar meets its published specifications and ensuring the quality of the product. Mechanical testing requirements for rebar can vary but typically fall into the following basic test categories: Tensile, Bend, Compression, and Fatigue.

3.2.2.1 Tensile Test:

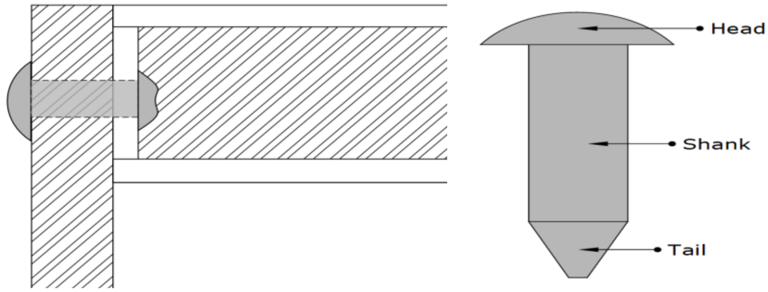
The tensile test process is one of the crucial tests of steel bars. A tension test of steel materials is a damaging procedure that gives data about the elasticity, tensile strength, and yield strength of the sample. This tensile test is done to decide how the material responds when you apply a force to it. Generally, by pulling the metal, one must recognize the material's rigidity and yield quality, The tension test is the essential criterion where one presents a steel bar test to tension, which is under control until the failure stage. according to ASTM Grade, 60 Rebar offers a minimum yield strength of 60,000 pounds per square inch or 420 megapascals on the metric grading. which must be achieved in the tensile test to be accepted in the site construction work.

3.3 STEEL CONNECTION

Steel members are linked together by connections, and there are different types of steel connections including:

3.3.1 Riveted connections

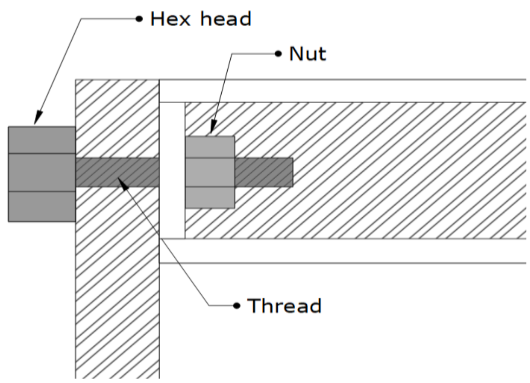
A rivet is made up of a round ductile steel bar which is called a ‘shank’ and with a head at one end. It is made of mild steel or high-tensile steel. Riveting is a particular method of connecting pieces of metal. This process is conducted by inserting the ductile metal pins called rivets into the holes of pieces to be joined and forming a head at the end of the rivet to prevent each metal piece from coming out. The shank of the rivet is made up of the length to the extent through the different parts which are to be connected and with sufficient extra length for a second head to be made at the other end. Shall confirm to ASTM D5652.



Rivet Details.

3.3.2 Bolted connections

Most used connections include bolted connections. This connection has the advantage of flexibility in assembling parts of the structure as well as dissembling it which is necessary if there is an inspection or some routine maintenance. This type of connection is applicable for members subjected to tension or shear or both tension and shear. The mechanical properties of externally and internally threaded fasteners, washers, direct tension indicators, and rivets shall be tested according to ASTM F606 / F606M – 21.

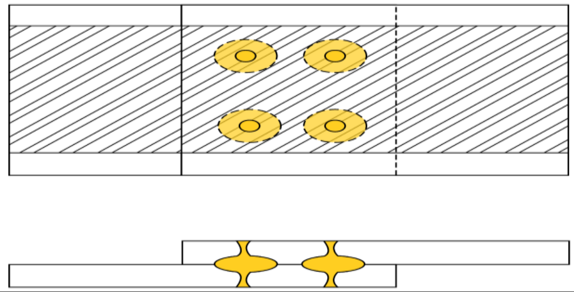
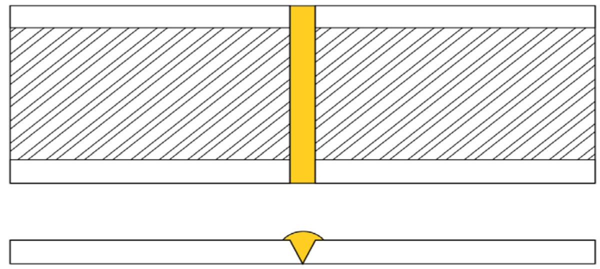
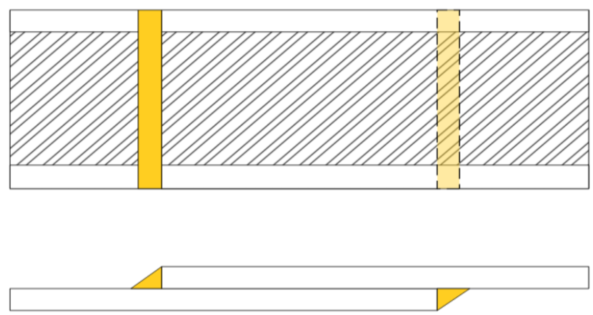
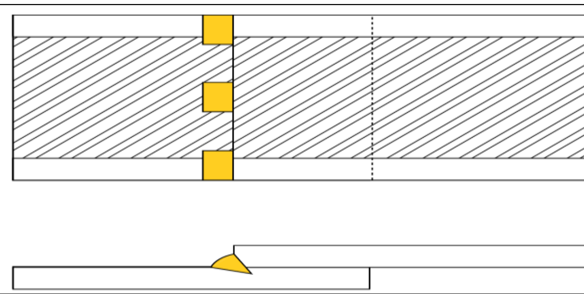


Bolt Details

3.3.3 welded connections

Welding is a permanent joining process in which two pieces of metal together to form one piece by heating the metals to their melting points. Additional metal also called filler metal is added during the heating process to help bond the two pieces together. Different types of welds are shown in Table 5.3.3.

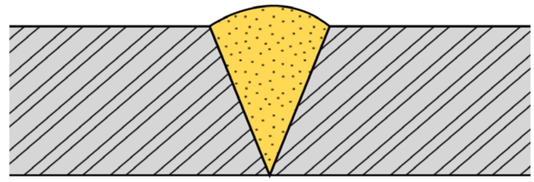
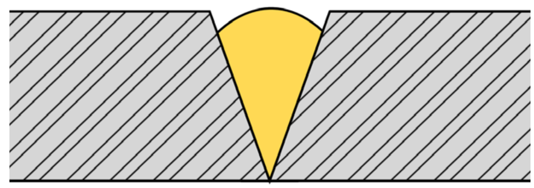
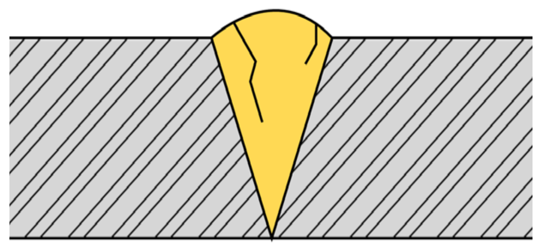
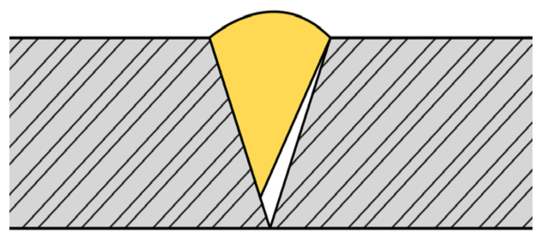
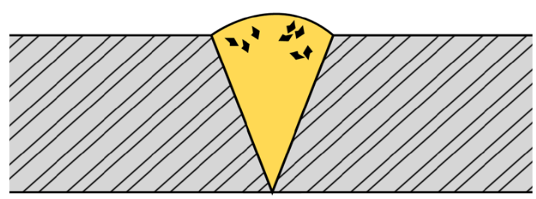
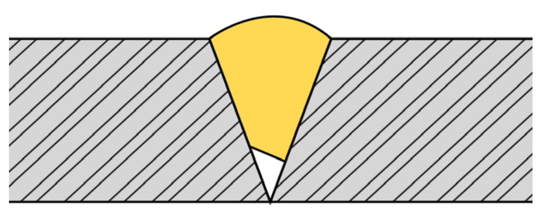
Table 3.3.3.1 – Different welding types

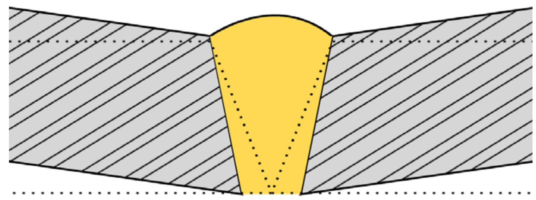
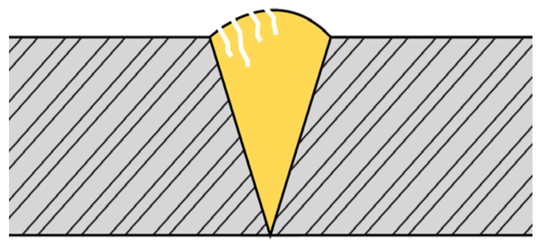
Spot (slug, plot) weld	
Groove weld	
Fillet weld	
Stich (Skip) weld	

An ideal weld or good weld must exist with good penetration with sufficient fusion between the filler metal and the edge preparation. Welding defects are formed in welding work due to the weak or poor technique used by inexperienced or untrained welders or due to structural problems in the welding operation. Visual inspection must be conducted according to Table 1.6. When testing is required, weld testing shall be carried out according to ASTM C1147.

Conform workmanship and techniques for welded construction to the requirements of AWS D1.1/D1.1M and AISC 360. When AWS D1.1/D1.1M and the AISC 360 specification conflict, the requirements of AWS D1.1/D1.1M govern.

Table 3.3.3.2 Type of Welding Defects

Defect	Description	Description
Porosity and Blowhole	Porosity is a group of small bubbles and blowholes are relatively large hidden holes or pores. They are mainly caused by trapped gases. Porosity is a result of weld metal contamination.	
Undercut	Undercut in welding makes imperfection, it is the formation of grooves in the weld toe, which decreases the cross-sectional thickness of the base metal. As a result of this weld and workpiece get weakened.	
Weld Crack	These are the most dangerous types of welding defects. It is almost not allowed by all standards in production. It can appear on the surface, in the welded metal, or in an area affected by strong heat.	
Incomplete Fusion	Occur when there is a shortage of suitable fusion between the metal and weld. It may also be visible between adjacent weld beads. This produces a gap inside the joint that is not filled with molten metal.	
Slag Inclusion	The slag is a dangerous substance that appears as a product of stick welding, flux-core arc welding, and submerged arc welding. Slag inclusion is an indication of a weak weld.	
Incomplete Penetration	Incomplete penetration happens when the metal groove is not entirely filled, which means that the weld metal does not fully spread through the joint thickness.	

Distortion	Distortion is the difference in size and location between the positions of the two metal plates before and after welding due to the temperature grade present at several points along the weld joints.	
Hot Tear	The deposited metal starts to develop cracks from the nearby edge so that it will solidify the crack increase. Due to the tearing of grain boundaries of the weld metal before it freezes and the metal is still in plastic condition. Therefore, it is also known as solidification cracking.	
Spatters	Spatters are tiny metal particles that are ejected from the arc during welding and accumulate on the base metal throughout the weld bead along its length. This is particularly common happens in gas-metal arc welding.