CHAPTER 12

CONCRETE WORKS

CONCRETE WORKS

12.1 Basic Features

Concrete is the most common building material used in today's construction industry. It can be cast in any desired shape and fashion and is therefore applicable for most building purposes. Its long life and relatively low maintenance requirements add to its popularity. Concrete does not rot, rust or decay and is resistant to wind, water, rodents and insects. It is a non-combustible material, making it fire resistant and able to withstand high temperatures. In the road sector, concrete is used for a number of purposes, including pavements, bridges, culverts, retaining walls and other structures.

Concrete is a mixture of cement, water and aggregate. The aggregate consists of a mixture of various sizes of gravel and sand. When water is added to cement, a chemical reaction takes place causing the mix to harden.

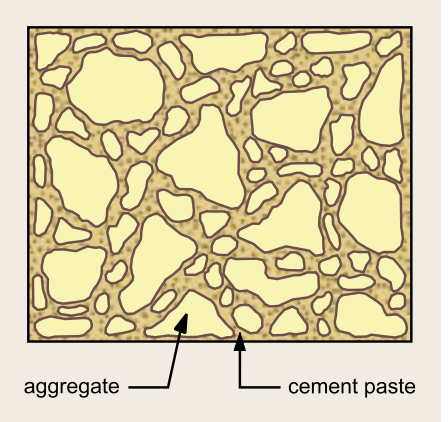
Cement is essentially made from a mixture of limestone and clay, which is ground into a very fine powder and then burnt at a high temperature in a rotating kiln, thereby fusing it into a material called clinker. The clinker is cooled down and ground into a fine powder. Gypsum and various additives are then added to the cement.

Concrete is similar in composition to mortar, which is used as a bonding material in masonry works. Mortars are however normally made using sand as the sole aggregate, whereas concrete contains a considerable amount of larger size aggregate.

Cement is the most costly of the ingredients required to produce concrete. This implies that in order to minimize the costs of the concrete, the amount of cement used depends on the purpose for which the concrete is required. Concrete for load-bearing structures normally contains one part cement, two parts fine aggregate and four parts of coarse aggregate. Concrete used for culvert beds and foundations needs less cement than structural concrete.

The density and strength of the finished concrete also depends on the distribution of the particle sizes. By mixing the right quantities of various sizes of gravel and sand it is possible to achieve a dense and strong concrete.

The gravel part of the aggregate forms the skeleton of the concrete, providing its compression strength. The smaller-sized aggregate fills the empty spaces between the large particles, while the cement paste fills the smallest spaces, coats the aggregate particles and glues them together. The very fine cement particles also fill the smallest empty



spaces, thereby giving the concrete its high density and impermeability.

By using different quantities of gravel, sand and cement, concrete of various strengths can be produced. The choice of small or large aggregate also determines the working properties of the wet concrete.

While concrete easily resists compression, it does not tolerate tension well. To improve the tensile strength, steel bars are added to the concrete in places where tensile stress is expected to occur. With reinforcement steel firmly embedded into the hardened concrete, it can be used to build load-bearing structures such as bridges, culverts and retaining walls.

Concrete can also be strengthened by pre-stressing, using stretched steel cables, thereby allowing for beams and slabs with slimmer shapes or longer spans than is normally possible with standard reinforced concrete.

When the concrete is first mixed, it is in a plastic or semi-fluid state, allowing it to be worked or moulded into different shapes. After a couple of hours the concrete enters a setting stage during which it begins to stiffen. Although the concrete is still soft, any moulding or shaping needs to be completed before reaching this stage. After the concrete has set, it still continues to harden and gain strength. The most significant increase in strength takes place during the first week, although it continues to harden as time goes by.

The compression strength of the concrete increases continually, reaching approximately 95 per cent of its strength after a period of 28 days. The increase in strength is most rapid during the first 24 hours of the hardening process.

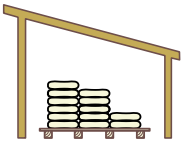
Engineers usually specify the performance of concrete as the compressive strength achieved in a sample after 28 days of curing. The most common unit of measurement is megapascals (MPa). Structural concrete has a compressive strength of at least 25 – 30 MPa. In recent years, advanced concrete technology has developed concrete with compressive strengths of more than 90 MPa, used in large and complex structures such as skyscrapers and offshore oil platforms.

A wide range of chemicals can be added to the concrete in order to change its features. Referred to as admixtures, they are used for purposes such as increasing the fluidity of the concrete mix, accelerate or retard the curing process, make it more frost resistant, increase its strength - and many more reasons.

12.2 Materials and Storage

Cement

Cement is usually supplied in bags weighing 25 or 50kg. Loading and unloading the bags should be done carefully – preferably by manual labour - to avoid any damages to the bags. If a bag is torn, moisture enters the cement and triggers the chemical action causing the cement to harden. Hardened pieces found when using the cement must be removed, because the strength of the concrete will be reduced if they remain inside the batch.



The cement should be stored in a dry place where the bags do not get damp or wet. The floor should have a good clearance from the ground or walls, to avoid moisture penetrating from below and secondly to allow for good ventilation.

Cement deteriorates with time and should therefore only be purchased just before it is to be used. The oldest cement in the store should be used first. The reduction of strength in a standard 1:2:4 mix as a result of storage is shown in the table below.

Age of Cement	Reduction in Strength
3 months	20%
6 months	30%
12 months	40%
24 months	50%

Aggregate

The aggregate is the main contributor to the strength of concrete. Using aggregate consisting of particles with varying size provides a more dense and strong concrete. Fine aggregate is normally made up of sand with particle sizes ranging from 0.3 to 5 mm, while the coarse aggregate may contain stone up to 40 mm.

Aggregate is obtained from various sources. Natural aggregate for direct use without any mechanical treatment can be extracted from riverbeds, gravel pits, lakes and dunes. This aggregate normally consists of round and polished particles.

Before using aggregates for concrete manufacture it is important to make sure that the particles are of sufficient strength and are not prone to erode or deteriorate. Aggregate should not be porous, neither brittle nor soft.

The composition of natural aggregate may need to be adjusted before it can be used for concrete manufacture. If it contains too high quantities of clay and silt these fractions need to be removed. Sieving the materials will provide the correct grading. Large pieces can be crushed manually or with the use of a crusher.

For large works it is common practice to produce aggregate by crushing hard rock, such as basalt, quartzite, granite, limestone and porphyry. Aggregate particles produced in this manner are usually sharp edged and angular. These mixes may be less workable, however this aggregate provides a mix that interlocks well.

If the aggregate contains a large percentage of flat or flaky particles it should be

rejected as far more cement and water is required to obtain acceptable results.

It is necessary to wash the aggregate if it contains impurities, as these negatively influence the strength of the finished concrete. Clay impurities, especially, cause a high level of shrinkage, and prevent the concrete-steel adhesion in reinforced concrete. Dust and fine crushing residues reduce the mechanical strength and chemical resistance. To keep the aggregate clean, it should be stored on clean hard ground (preferably a concrete floor) away from trees.

Aggregates of different sizes should be stored separately. Too often, heaps of different-sized gravels are dumped next to each other with no separation in between. The heaps overflowing into each other cause the different sizes to get mixed. As a result it will be difficult to obtain a mixture containing the right quantities of different size aggregate.

Reinforcement Steel

Reinforcement steel is normally provided as individual steel bars or as steel bars welded together into a mesh. The bars are used for beams and columns, while the mesh is prepared for large surfaces such as slabs and walls.

The reinforcement steel should be stored in a clean location, lifted off the ground and away from mud and oil. It should be placed on a flat surface with sufficient support so that the bars do not buckle, bend or sag. Different dimensions should be stored separately so they are easily identified when required.

The good performance of the steel bars depends on a proper bond between the steel and the concrete. This requires the steel to be clean and in good condition.

Minor rust coatings have no effect on its performance. Any loose rust should of course be removed, however, there is no need to brush the bars free from all rust. Bars stored outside for a longer period may however have rusted so much that the diameter has been reduced. Any reinforcement steel with considerable amounts of pit rust should not be used. It is not necessary to remove mortar or cement droppings that are firmly adhering to the bars.

Water

Good quality water is required for the mixing of concrete. Drinking water is the best, however, water from rivers and lakes is normally of adequate quality. Salt water should not be used for mixing concrete.

Water is used for both the mixing process as well as during curing. Before the first of these activities commence, it is important to make sure that the site has adequate supply of water for both the mixing as well as the curing. This may involve arrangements such as stockpiling water to ensure there is sufficient water for the entire period from mixing until the end of the curing process.

Safety

When handling cement or fresh concrete, it should not come in contact with the skin or eyes. Wearing gloves, a long-sleeved shirt, full-length trousers and boots reduces the exposure. Wet concrete, mortar or cement should be washed from the skin immediately. Eyes need to be flushed with lots of water for at least 15 minutes immediately after contact.

The final strength of the finished concrete depends on:

12.3 Proportion of the Components

(i) the proportions of the components, i.e. the quantities of gravel, sand, cement and water;
(ii) the quality of the components;
(iii) the distribution of the grain sizes of the gravel and sand;
(iv) how the components are mixed;
(v) how the mixture is transported, placed, compacted and cured.

When the mixture is prepared it is important to make sure that the proportions of the aggregates used in the mixture are correct and that the right quantities of cement and water are added. The ideal mixture is one that solidifies with the minimum amount of air space, with mortar and small particles filling all voids.

Sand and gravel contain particles of different sizes with empty spaces in between. Generally, it can be assumed that sand and gravel, in a dry condition, consist of 60 percent solid matter and 40 percent empty spaces. To obtain a dense concrete these empty spaces need to be filled. The empty spaces between the sand grains are filled with cement, while the sand-cement-water paste (mortar) fills the empty spaces between the gravel particles. An extra 10 percent of mortar is necessary to "coat" the particles completely.

This means that for a certain quantity of gravel it is necessary to add 50 percent wet mortar in order to fill the empty spaces and to coat the particles. In theory, therefore, a mixture of 1:2:4 (cement : sand : gravel) will produce a dense concrete. In practice, when a dense but plastic concrete is required, a mixture of 1:2:3 is often applied mainly because of the variation in the percentage of empty spaces. However, different mixes are applied depending on the purpose for which the concrete is used. The table below shows various mix proportions used to produce various qualities of concrete.

The volumes of cement and sand vary considerably depending on the degree to which they are compacted. The volume of sand also varies with its moisture content. The volume of sand can increase by up to 50 percent if the water content is increased. For these reasons, volumetric proportioning is not used when big quantities of high quality

Type of concrete	Class of Concrete	Mixture (cement : sand : gravel)	Purpose
Lean Concrete	C10	1 : 4 : 8	Culvert beds, fills
Mass Concrete	C15	1 : 3 : 6	Non-reinforced structures
Structural Concrete	C25	1 : 2 : 4	Culvert pipes,lightly reinforced structures
	C30	1 : 1.5 : 3	Heavily reinforced structures

concrete are produced. In such cases, the materials are weighed and the moisture content is measured to determine the exact quantities of gravel, sand, cement and water. For most concrete works carried out on rural roads, however, the above rules of thumb can be applied.

12.4 Water to Cement Ratio

When water and cement is mixed, it forms a paste that coats and binds the aggregate particles together. Through a chemical process called hydration, the paste hardens and gains strength. The strength of the paste is determined by the applied ratio of water to cement.

The strength of concrete increases when less water is used during the preparation of the mix. Although the hydration process consumes a certain amount of water, wet concrete actually contains more water than required for the hydration reactions. The excess water is added to provide the wet mix with sufficient workability. Concrete needs to be workable so that it can be moulded into the desired shapes and consolidated to the required density.

The quantity of water divided by the amount of cement gives the water to cement ratio. A low water to cement ratio leads to high strength but low workability while a high water to cement ratio produces a low strength concrete but good workability. A careful balance of cement to water is therefore required when preparing the mix. Water/cement ratios in the range between 0.4 and 0.6 provide a good workability without compromising the quality of the concrete. Hand-mixed and hand-placed concrete requires more water to secure sufficient workability (water/cement ratio between 0.5 and 0.65).

The characteristics of the aggregate may also have an indirect impact on the quality of the concrete. If the size and shape of the aggregate makes the concrete unworkable, the contractor is likely to add more water, resulting in a higher water to cement ratio and a weaker end product.

The aggregate may already contain a certain amount of water, which needs to be taken into consideration when preparing the mix. Particularly when using moist sand, it may be necessary to reduce the amount of water being added to the concrete.

Additional water should never be added when a mix is drying up. If it is necessary to improve the workability of the concrete, a mixture of cement and water should be used instead.

12.5 Mixing Concrete

Thorough mixing is essential in order to obtain a homogeneous mixture of all the ingredients and achieving a suitable workability. The equipment and applied work methods need to be able to effectively mix concrete containing the specified size aggregate, obtaining a uniform mixture with the required workability within an acceptable water cement ratio.

The term workability is used to describe the ease at which the concrete can be placed and consolidated without segregation or separation. It takes a greater effort to achieve a uniform and dense mass of concrete in structures containing a considerable amount of reinforcement bars as compared to mass concrete used in a foundation. The amount of large aggregate as well as the water content will greatly influence the workability of the concrete, however, these are also factors determining the final strength of the concrete. Another alternative to improve the workability of concrete is by using additives.

Hand Mixing

When mixing is carried out by hand it requires a suitable surface (metal sheets, boards or lean concrete slab) to ensure that the mix is not contaminated with soil. The surface should be level to prevent water or fluid material from running off the mixing area. The space needs to be sufficiently large to allow for the required size of batches to be mixed without spilling into surrounding areas.

The following steps describe a good way to mix by hand:

- Limit the size of the batch to approximately a third of a cubic metre.
- First place a layer of sand on the mixing platform on which the cement is spread. Mix thoroughly by turning the heap over several times. This is best done by two persons facing each other, working the mix from opposite sides. Mix until the cement is evenly distributed in the sand, i.e. until the mix has a uniform colour.
- Add coarse aggregate and turn the mix until the batch is once again properly mixed.
- Sprinkle the predetermined quantity of water gradually on top of the mix while turning it over another three times, or until the water is evenly distributed.
- Use the wet concrete immediately after it has been mixed. Make sure it is placed and compacted straight away, avoiding that it starts setting before it is used.

Mechanical Mixing

There exist a large number of different types and sizes of concrete mixers. The most commonly found type on construction sites is the tilting drum mixer. Depending on their size, these mixers can be manually driven or powered by electrical or diesel/petrol engines. The drum on the mixers can be positioned at different angles for charging, mixing and discharging. The drum rotates on an inclined axis when

mixing to avoid the mix falling out of the drum. When the mix is ready the drum can be tilted in order to discharge the concrete.

Mechanical mixing produces a more homogeneous and better mix. The concrete mixer should never be filled completely.

Loading the Concrete Mixer

The following procedure is recommended for loading concrete mixers:

(i) place a part of the water into the mixer to clean the drum walls of any concrete left from the previous mix;
(ii) charge half the volume of coarse gravel. The gravel will also assist in cleaning the inner surfaces of the drum;
(iii) add the prescribed amount of sand and finer gravel;
(iv) add the cement;
(v) add the remainder of the coarse gravel;
(vi) mix dry for one minute;
(vii) when the aggregate and the cement have been thoroughly mixed, add the remaining quantity of water and mix wet for another two minutes.

The mixing time varies with the proportions and the total quality of the components, the capacity and rotation speed of the drum and the desired plasticity. Usually 1.5 to 3 minutes is sufficient to obtain a good mixture. Mixing more than 3 minutes will not improve the quality of the mixture.

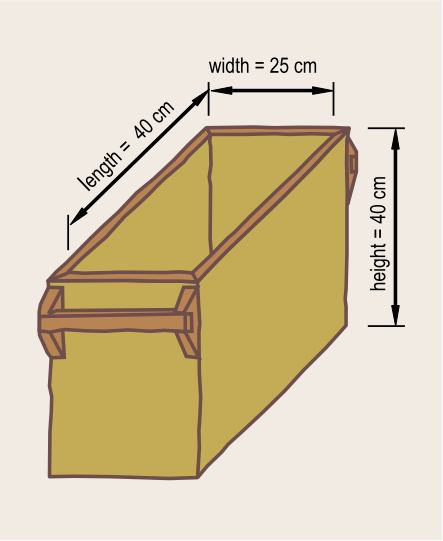
Ensure that all the tools, platforms and mixers are thoroughly cleaned after the mixing is complete. Leftover hardened concrete may damage the equipment.

It is important to remember that much more than 1 m³ of components is required to produce 1 m³ of concrete. The reason for this is that the cement and fine aggregate fills the empty spaces between the larger particles. The following table shows the materials necessary to produce one cubic metre of concrete.

It is always important to use a gauge box to measure and keep control of the volumes

Concrete		Material required to produce 1 m³ concrete		
Mix	Class	Cement (kg)	Sand (m^3)	Gravel (m^3)
1:4:8	C10	3 bags (150 kg)	0.48	0.96
1:3:6	C15	4 bags (200kg)	0.48	0.96
1:2:4	C20	5.5 bags (275kg)	0.44	0.88
1:2:3	C25	6.5 bags (325 kg)	0.52	0.78

of the ingredients when mixing concrete. A useful sized gauge box is one having a volume corresponding to the volume of 50kg bag of cement (with a density of 1.25kg/m³, a standard bag of cement will have a volume of 0.04m³ or 40 litres). A shovel should never be relied on as a unit to measure the quantities of the ingredients. A shovel full of sand does not have the same volume as a shovel full of cement or coarse aggregate.



The table below shows how much aggregate and gravel is required for each 50 kg bag of cement and the resulting output of concrete using the same mix recipes.

Concrete		Material required for each bag of cement			Approximate yield per batch (m^3)
Mix	Class	Cement (kg)	Sand (m^3)	Gravel (m^3)	
1:4:8	C10	50	0.16	0.32	0.34
1:3:6	C15	50	0.12	0.24	0.27
1:2:4	C20	50	0.08	0.16	0.19
1:2:3	C25	50	0.08	0.12	0.16

12.6 Formwork

Concrete is cast into moulds referred to as forms or shuttering. Usually, the forms used for walls, columns, beams and slabs are built by joining wooden boards edge on edge. The advantage of using wood is that it can easily be used to create any required shape. Plywood, laminated boards and metal are also commonly used for formwork.

These materials have the advantage that they are more durable and can be reused many times. Formwork is also available in panels with hinges making it easy to assemble and to facilitate re-use. Joints and hinges on formwork need to be thoroughly cleaned when it is removed.

Formwork should be built solid enough to contain the concrete when poured as well as the weight of the reinforcement steel. The wet concrete has some considerable weight and requires extensive support arrangements. Before commencing a pour,

it is important to make a final assessment of the integrity of the formwork. Any shuttering removed during the placing of the reinforcement steel has to be replaced before starting the pour.

Before commencing the pour, make sure that the forms are clean and contain no debris. Steel formwork should be oiled to allow easy removal of the forms when the concrete has set. Wooden forms should be moistened before the pouring commences. Similarly, dry ground should be dampened before placing concrete on top of it.

Removing Formwork

Forms should be left in place until the concrete has hardened sufficiently to hold its own weight. The surface should be hard enough to withstand any damage caused by the stripping of forms. Care should be taken not to damage edges and corners.

Keeping the formwork in place for the first week contributes to the curing process as the forms stop water in the concrete from evaporating.

Side forms for beams, slabs and columns can be safely removed after a couple of days. When the concrete needs to bear its own weight, it is necessary to leave it to cure before removing the formwork

underneath the structure. The table below provides some guidance on when it is appropriate to remove formwork for structural concrete.

Curing Periods	
Clear span less than 3m	8 to 14 days
Clear span between 3m and 6m	14 days
Clear span longer than 6m	24 to 35 days

Honeycombing

Honeycombing refers to excessive amounts of air voids created in set concrete as a result of insufficient filling of space between the coarse aggregate. It is caused either by inadequate compaction or by holes or gaps in the formwork allowing some of the mortar to drain out. Unfortunately, this type of sub-standard results are only discovered after the concrete has set, in most cases when the formwork is removed.

To avoid honeycombing, the following measures are recommended:

- ensure that the mix contains sufficient fine aggregate. Using concrete with a large proportion of large aggregate increases the risk of honeycombing;
- make sure that the fresh mix has the correct workability;
- provide sufficient compaction. Compaction with the use of vibrators reduces the risk of honeycombing;
- particular attention should be given to pouring concrete into tight spaces, such as between reinforcement bars and formwork;
- check that the formwork has no leakages, allowing mortar to exit.

If the honeycombed area is small and does not compromise the structure, it can be repaired by patching with mortar. Before applying the mortar, any loose or lightly attached stones should be chiselled out in order to establish the full extent of the air voids. The essential task is to make sure that the reinforcement is properly covered and is not exposed to air and humidity, thus avoiding any future corrosion.

If the damage is extensive and appears to compromise the integrity and strength of the structure, the section needs to be fully removed and replaced with new concrete. In such cases, it is necessary to obtain advice and directions from a qualified engineer.

12.7 Transport of Concrete

Concrete can either be produced on site or at commercial mixing plants. When large quantities of concrete are required, it is common practice to organise the supply from a local mixing plant (if available), from which the fresh concrete is transported by truck to the work site. On site, concrete is transported using wheelbarrows and buckets to reach the final locations where it is placed. The transport time of any concrete should be as short as possible. Ideally, the concrete should be poured within 15 minutes after the mixing has been completed. When rotating drum trucks are used, a maximum of two hours is normally permitted for transport.

Whether mixing is done on site or at a plant, it is important to organise the site in a manner that provides ready access to the forms where the concrete will be poured. Materials and rubbish should be cleared away thereby allowing

cement trucks close access to the formwork. If concrete is mixed on site, the mixer is placed as close as possible to the forms.

When wheelbarrows are used for transport, the concrete pouring should be organised so that long wheelbarrow runs are avoided. The wheelbarrow runs must have good surfaces and organised in a circle so the wheelbarrows do not meet. Long wheelbarrow runs not only slow down the pouring of concrete but the vibration caused by an uneven rolling surface may cause the segregation of the coarse particles from the fine.

The concrete should not drop freely from heights greater than a metre. This causes segregation as the coarse particles drop more rapidly than the finer ones. For the same reason, the mixture should not be thrown far with shovels, but should instead be unloaded as near as possible to where it is placed.

To avoid any delays during the supply and placing of concrete, it is important that this work activity is properly planned. All ingredients and sufficient tools and workers need to be ready and available on site. Equally, a last check of the formwork and steel bars should be carried out to ensure that this work is complete and to the required standards. A contractor will often need to have the formwork and reinforcement steel inspected by the supervising engineer before being allowed to start pouring concrete.

12.8 Pouring Concrete

Having secured the necessary supply, the concrete needs to be placed and compacted. These two activities are carried out simultaneously. Placing and compaction of concrete should be done without causing any segregation of its ingredients. When placing the concrete, care need to be taken not to damage the formwork or dislodge the reinforcement.

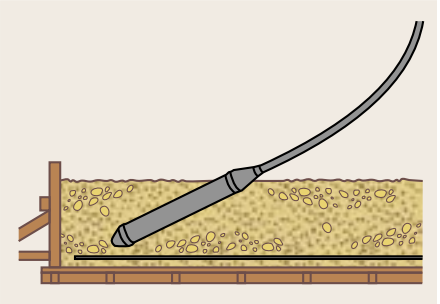
Placing the concrete starts from the corners of the formwork with compaction of the concrete starting immediately after it has been placed. In the case of a sloping site, pouring should start at the lowest level. The concrete should be placed in layers not higher than 30 cm when compacted by hand and in layers not higher than 60 cm when compacted by vibration.

Slabs and floors should be poured in one continuous operation to avoid any vertical or horizontal joints, which would create planes of weaknesses within the structure.

If the concrete is not properly compacted, air will remain inside the pour. When it hardens, the concrete then appears with honeycomb spots or rashes. As these spots contain a considerable amount of air, they compromise the strength and impermeability of the concrete.

The poured concrete therefore needs to be consolidated to secure the necessary density, imperviousness and strength as well as to improve its adhesion to the reinforcement bars. This consolidation can be done by hand with hand-tampers or iron rods. A more effective method is to use a poker vibrator. This is a steel tube, housing a rotating eccentric mass driven by compressed air or an engine.

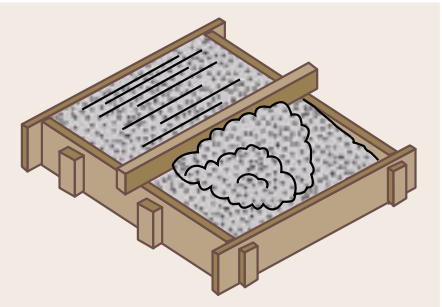
The vibrator is immersed into the concrete at regular intervals of half



a metre a part. When the concrete is vibrated, the internal friction between the aggregate particles is reduced and the concrete becomes more fluid. As a result, it then settles better into the forms and releases some of the air voids dispersed in the mix. When water wells up to the surface it is slowly taken out. Vibration should not be longer than 10 seconds in one place and the vibrator should be kept away from the formwork and reinforcement bars. Excessive vibration causes the aggregate to segregate.

After the concrete has been properly compacted, the top of the placed concrete is levelled to a smooth surface with a masons trowel or a float. For large surfaces, a straight-edged 2x4 plank or an aluminium profile can be used as a screed for levelling the concrete. The 2x4 is worked back and forth in a sawing fashion to level the entire surface of the concrete.

In order to provide skid resistance on a slab, or good adhesion for a surface treatment, the final surface can be roughened by drawing a broom across the surface of the wet concrete.



12.9 Curing

When the ingredients in concrete are brought together, the cement and water react with each other starting a chemical process, causing the concrete to form a hard mass, which adheres to and binds together the aggregate. Concrete starts setting roughly two hours after is has been mixed. This implies that the pouring and compaction need to be complete within this period of time. Any shaping or reworking of the concrete once the concrete starts setting will cause serious damage to the concrete.

Adequate curing of the concrete during its initial days after placing is essential in order to achieve its strength and other qualities such as surface durability, volume stability, water-tightness and abrasion resistance. Proper curing also prevents the surface from cracking, caused by insufficient binding due to the non-availability of water.

Curing the concrete basically consists of preventing the concrete from drying out during the setting and hardening stage. Water is a necessary ingredient in the curing process, since hydration is a chemical process, taking place between the water and the cement. Freshly mixed concrete contains sufficient water to secure that proper curing can take place, however, any loss of water caused by evaporation will compromise the curing process. The curing process is most critical during the initial days after pouring. The exposed surface of the concrete is therefore kept moist during a period of four to six days.

Effects of Curing

Providing sufficient water to facilitate a proper curing process has a significant impact on the quality of the concrete. Concrete which is allowed to dry out immediately after being poured will only achieve 40 percent of the strength it could reach if properly cured. By providing proper water curing for three days will increase the strength to more than 60 percent of its full potential. This process continues over time reaching 95 percent after 28 days.

Proper curing essentially consists of keeping the concrete moist during the period during which it is gaining strength. This is secured either by containing the water already added to the concrete when it was poured or by replenishing its surfaces with additional water to compensate for any water lost through evaporation. The most common method of keeping concrete moist is by frequently sprinkling or flooding the surface, or by covering the surface with wet jute, paper bags, sand or sawdust.

Equally, covering surfaces with plastic sheets, banana or palm leaves or other materials may reduce the evaporation from bright sun and winds. Keeping the casting forms on as long as possible reduces moisture loss from vertical surfaces.

Exposed slab surfaces are especially sensitive to curing and need special attention during the initial days of curing. All the arrangements necessary for the curing process should be in place before commencing the pour.

Creating ponds is an effective and inexpensive method to cure large horizontal surfaces, such as floors and slabs. It also has the advantage of maintaining a uniform surface temperature, thereby reducing the likelihood of thermal cracking. The pond can be created by building a dam along the edges of the surface using clayey soils or any other material that retains the water.

Special membrane-forming compounds can also be used to facilitate the curing of concrete. These compounds are applied directly to the concrete surface, providing an impermeable membrane, thereby reducing the moisture loss. Curing compounds are produced from wax emulsions, rubber, synthetic and natural resins and applied using a hand spray, brush or rollers. The surface of the concrete should be thoroughly moistened before the compound is applied to avoid it from being absorbed into the concrete. The disadvantage of these compounds is that they are costly in comparison to the use of water. Secondly, they will compromise the bond between the concrete and any subsequent surface treatments.

The curing process in concrete takes place during its entire life, however, the increase in strength is more profound during the first month after it has been poured.

Concrete Works in Hot Weather

The ideal climatic conditions for setting and hardening are a constant temperature of 20°C and a relative humidity of 80 - 90 percent. High temperatures, combined with strong wind and low humidity enhance the rate of evaporation of the water required for the curing of the concrete. Hot weather will also reduce the setting time of the fresh mix, leaving less time for transport, placing and compaction. Finally, the lack of water as a result of hot weather makes the concrete prone to excessive contraction and may lead to cracks developing soon after placing.

The loss of water as a result of hot weather also affects the workability of the concrete during the period required for pouring and compaction. To secure the necessary consistency, additional water is required during pouring and placing which may compromise the final quality of the concrete.

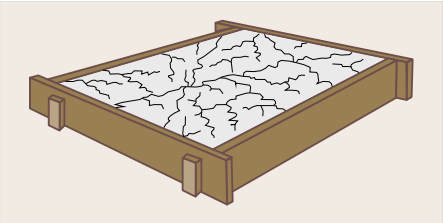
When carrying out building works in hot climates, it is preferable to schedule the pouring of concrete to the cooler parts of the day, either early in the morning or in the evening. The

ingredients used for the concrete should be stored in locations under shadow and sprinkled with water before use.

Shrinkage Cracking

Shrinkage cracks are commonly observed on newly cast slabs. Once the concrete has set and starts hardening it is a relatively brittle material that shrinks over time. Cracking occurs as a result of the concrete being restrained from contracting. The early loss of moisture from fresh concrete will accelerate the shrinkage causing the cracks. Although these cracks appear small and shallow, they may increase in size when loads are exerted on the structure and then cause more serious damage. Surfaces left to dry out during the first few hours of curing are more prone to cracking.

The most effective remedy against this phenomenon is therefore to keep the concrete moist throughout the curing process and in particular during the early stages while the concrete is still weak and more prone to damages. Protecting the concrete surface during the first few hours significantly reduces the chances of cracking. A good compaction of the mix reduces the amount of air voids and also makes it less prone to cracking. Providing joints as soon as possible on large surfaces can limit the strains caused by shrinkage and prevent the cracking.

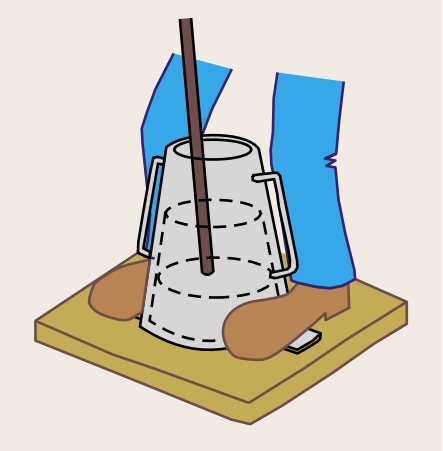


12.10 Quality Testing

Standard work specifications describe the detailed testing procedures available for securing the necessary quality of each of the ingredients to the concrete. Besides testing each of the individual ingredients, quality testing of concrete itself is mainly related to (i) testing the workability of the delivered or produced concrete, and (ii) taking samples for later compressive strength testing.

Slump Test

The workability – or consistency - of concrete is an important feature when pouring concrete. A more fluid mix is easier to distribute in a dense manner into all corners and also into any tight spaces in between the formwork and the reinforcement bars. The workability of the concrete essentially depends on its water content and any use of admixtures for this purpose. A high content of large aggregate will also result in a difficult mix with a very low "slump". These aspects need to be carefully weighed against the fact that the use of excessive amounts of water compromises the strength of the concrete.

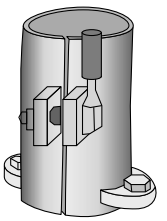


The workability and the amount of water in a fresh concrete mix can be assessed using the slump test, in which a sample of the mix is shaped in a standard form. The form is then removed from the fresh mix and the extent to which the material settles (the sag or slump) is measured.

The slump test cone is set up on a flat clean surface and filled with the fresh concrete, in layers of equal thickness. Each layer is hand tamped before the next is added. The cone is then lifted straight off and placed back on the ground next to the test material. When the cone is carefully lifted off, the material will slump a certain amount depending on its viscosity. A dry mix will settle very little, while wet concrete will immediately loose its conical shape and have very limited cohesion. A spirit level and tape are used to measure how much the concrete subsides.

When the slump is within a range of 50 to 125 mm the concrete is regarded as having an acceptable consistency and water content when used for structural works. If the slump is less than 50 mm, the concrete may be too stiff and not sufficiently workable. Equally, a higher slump normally indicates that the water content in the mix is too high.

Concrete Cubes

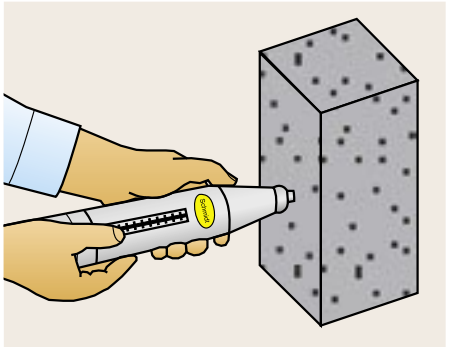


The most common method of testing the final strength of the concrete is by taking samples of the wet mix, and moulding sample cubes (or cylinders), which is subjected to compressive strength tests once they have been cured.

Technical specifications provide detailed procedures on how and when test cubes should be made, how they should be cured and finally how the strength tests are carried out. These specifications are often based on international standards.

Rebound Hammer

Commonly referred to as the Schmidt hammer, this instrument is one of the best-known methods of assessing the quality of hardened concrete. The hammer measures the rebound of a spring-loaded impact against the surface of a sample. What it actually measures is the surface hardness. The surface therefore needs to be clean and smooth in order to obtain reliable test results. Dirt or loose materials should be removed before carrying out the test. As the instrument is easy to use, it is possible to take numerous measurements.



CHAPTER 13

SETTING UP AND ADMINISTERING A SITE

SETTING UP AND ADMINISTERING A SITE

13.1 Introduction

Establishing and operating a site camp forms part of the activities in a civil works project. A work site includes the camp, stores and other facilities provided on a temporary basis for the purpose of the project. The operation of the site camp is part of the services provided by the contractor. As part of the contract, the client may request the contractor to provide facilities such as an office, accommodation and catering for the supervising engineer and other representatives of the client.

In order to function properly, the site must be well organised from the very beginning. When commencing a new works project, the first task of the contractor is to establish an adequate and efficient site camp. The planning and mobilization of the camp is the responsibility of the site engineer. Eventually, a supervisor can be given the responsibility for the daily organisation and running of the camp.

The site camp provides essential backup and support to the construction activities. There are four important elements that make a construction site work well:

- availability of sufficient quantities of stores (tools and materials),
- timely engagement and organisation of skilled and unskilled workers,
- proper management of equipment, including repair and service facilities, and
- good administration of camp activities.

13.2 Setting Up Camp

Before construction works commence, a camp is set up to accommodate the supervisory staff, materials, tools and equipment. The site camp needs careful planning to provide site staff with basic comfort, adequate storage and security for equipment and materials.

Location

The selection of a suitable location is normally made by senior staff from the construction firm, based on either instructions provided by the client or through negotiations with local landowners or villagers. The following issues need careful consideration:

- proximity to the construction site - preferably it should be within walking distance,

- good access to drinking water,
- it should be located on high, well-drained land,
- it should have sufficient space for material storage and parking equipment after working hours, and
- it should be easily accessible for project vehicles supplying equipment and materials.

For a road construction project covering more than 7 to 8 kilometres, the camp may have to be moved once or twice in order to remain close enough to the work site. Alternatively, the contractor may choose to keep the original camp and instead establish smaller satellite camps further down the road alignment. The camps and any relocations have to be planned well in advance to secure necessary transport, and to avoid any disruption of the construction works.

Standard Requirements for a Site Camp

- site office,
- site store,
- soil and concrete testing facilities,
- accommodation for the supervisors and equipment operators,
- parking area for equipment and vehicles,
- loading area for construction materials,
- assembly area for culvert manufacture, reinforcement steel, etc.
- mechanical workshop,
- supply of electricity and water,
- appropriate cooking or catering facilities,
- toilet and bathroom facilities, and
- separate storage facilities for fuel, oil and lubricants.

The size of the camp depends on the size and type of works carried out and its remoteness (i.e. the distance to headquarters or the nearest town). In most cases, the site camp can be set up in one of the nearby villages. Suitable accommodation and stores can then be rented from the villagers. In more remote locations, the entire site and all its facilities may need to be established by the project.

On large projects, the camp requires a sizeable amount of space – particularly when the project is located in a remote place where supplies need to be brought in from far away. To establish such camps often requires a significant amount of clearing and preparation work before the site facilities can be installed. Access to sufficient land for this purpose is sometimes facilitated by the government agency in charge of the works. In other cases, the contractor may have to find an appropriate site by contacting local landowners at suitable camp locations.

The site camp is a temporary facility and is only in place during the period of the construction works. Once the work is completed, the entire camp is removed. This includes dismantling all buildings, removing access roads, loading and work areas, drainage systems, utilities and basically restoring the site to its original condition in a neat and tidy manner.

The operation of the camp should be organised so as to avoid any negative impact on the surrounding environment. This implies that proper measures

are installed for garbage and sewage management. Equally, the camp itself and its access roads need to be designed in a manner which is environmentally sound, ensuring that it has no detrimental effect on the surrounding areas. Wastewater from the camp needs to be carefully managed and if required subjected to prescribed treatment.

Sanitary and Health Arrangements

Proper arrangements for the supply and storage of drinking water are necessary for the staff living at the site camp. Storage tanks should be properly covered in order to prevent mosquitoes from breeding. For the same reason, any stagnant water should be drained away from the camp.

The site office and living quarters require proper sanitary facilities. Latrines or similar facilities need to be installed at the camp. The location of these facilities needs careful consideration and should always be downstream of the camp and as far away as possible from the water source.

Water Supply

Clean water is required for a number of purposes. Staff living on site use water for cooking and washing purposes. If culvert pipes or other concrete structures are manufactured on site, this activity also needs a good supply of clean water.

Workers carrying out hard physical work need to drink sufficient water to prevent dehydration. Water available at the work site is important for their well-being and also helps to ensure their good performance. If there is no potable water within the vicinity of the work site, arrangements need to be made for the supply and distribution of drinking water. This can be organised by engaging a couple of workers to transport clean water to the workforce. The required amount of drinking water depends on the weather conditions, but a minimum of 3 litres per person per day should be provided.

Migrant Labour

A common feature of the construction industry is that staff and workers have to move to the areas where the works take place. Unless the contractor originates from the same area as where works are located, the permanently employed staff needs accommodation during the period of the project. This can be solved by erecting temporary living quarters at the site or by renting accommodation in the nearby villages.

Unskilled workers are normally recruited from the villages in the vicinity of the road alignment. In some cases, however, the works are located in remote areas where there is a limited supply of labour. If the distance to the work site is too long, the workers need to be housed on site. Unless local housing is available in the nearby villages, the camp also needs to include dwellings and proper sanitation facilities for the entire workforce. In addition, appropriate transport arrangements are necessary so that the workers have regular access to markets. Obviously, this is a more expensive solution to labour recruitment and should be avoided if possible.

13.3 Quarries and Borrow Pits

On certain sections of the road alignment, there may be insufficient suitable material within the road reserve to complete the earthworks. The project then has to open a borrow pit as close as possible to where additional materials are required. Borrow pits should be operated in such a way as to cause the minimum environmental damage and nuisance to the public. If the borrow pit is located on farmlands, the excavation of materials should be done in a manner which allows the land to be reinstated after the required soil has been extracted.

This implies that the excavation faces are trimmed to stable and safe slopes and stockpiled topsoil is redistributed, thereby allowing farming activities to resume after the borrow pit is no longer in use.

The use of borrow pits may involve the use of private property which is often utilised for other commercial purposes. The construction work may therefore pose some inconvenience to the landowners resulting in compensation claims. Dealing with compensation issues is normally the responsibility of the owner of the project, and it is important to resolve these issues before the project starts. If access to borrow pits is left unresolved, building materials may have to be obtained from further away from the site at increased construction costs.

Often, this type of land issues can be resolved on a voluntary basis if the soil excavation is carried out during the agricultural slack season. If the land is reinstated before the start of the next farming season, the landowners along the roadside may be prepared to accept the soil excavation without demanding any compensation.

Gravel and Stone Quarries

Gravel and stone quarries are often operated by private enterprises. This arrangement relieves the project from land compensation issues as the quarry owner has already dealt with that issue when obtaining the concession for the operation of the quarry.

If a new quarry is opened by the project, then the above mentioned concerns need to be addressed once again. It is

common practice for the client to identify appropriate material sources as part of the initial design work, and include directions in the contract as to where materials are to be sourced. By the time a contractor is engaged, the issues of land compensation for access to the quarries should have been resolved.

Nevertheless, the project needs to take appropriate action during the planning stage as well as during implementation to ensure that the quarry work is organised in an environmentally sound manner. When the use of a quarry is terminated, the contractor is responsible for reinstating the borrow area. This involves activities such as:

- trimming excavation faces to stable and safe slopes,
- demolishing and removing temporary fences and structures, leaving the site neat and tidy,
- replacing stockpiled overburden and topsoil over the stripped areas,
- ensuring free drainage and filling ponded areas, and
- removing temporary access roads.

The project needs to make adequate provisions for the related costs of such work activities. These costs are normally included in the budget items relating to the work activities for which additional materials are required. The project also needs to take into account any royalty costs related to the use of the quarries.

The client will often withhold the final payment pending the reinstatement of the borrow areas.

13.4 Administrative and Financial Routines

Administrative procedures are established on every work site to secure the proper handling of tools, equipment, materials and human resources. These procedures include a management structure, clearly defining the roles and responsibilities of the various staff members assigned to the work site. Clear and transparent administrative routines form part of the foundation on which efficient management and organisation of works can be achieved.

Administrative routines include a wide variety of activities ranging from finance, accounting, stores, equipment management, staff regulations, procurement procedures, reporting and monitoring and many others. The staff in charge of these activities plays an essential role in the effective management of the project.

In order to simplify the work, administrative procedures include a number of forms, used on a daily, weekly and monthly basis to report on the use of various resources such as tools, materials, equipment and labour. With clear procedures on how and by whom these forms are filled out, the time spent on administrative matters can be minimised and the supervisory staff can concentrate on managing the actual construction work.

Although these procedures may seem tedious and repetitive, it is important to acknowledge their importance. The use of resources is directly linked to incurring costs. All expenditures need proper reporting for accounting purposes. The reporting on the use of

materials, equipment and labour provides management with the basic information necessary in order to monitor progress and efficiency on the work site.

Office Administration

Every civil works project needs to establish an office for administrative and logistical purposes. Larger projects need an office on site to provide support services to the construction activities. Its main purpose is to assist in the logistics of securing the various resources required to carry out the civil works. The site office is also in charge of all financial transactions, which cannot be handled by the main office. This includes payment of local purchases of goods and services, labour wages, fuel and other miscellaneous items.

An important role of the site office is to keep records of all expenditure and use of resources. It is the duty of the project manager to organise this section and to ensure that its work is carried out efficiently. Clearly defined procedures, duties and responsibilities must therefore be established so that every staff member fully understands how their assigned tasks should be carried out.

Equally, a contracting firm needs to keep records of all payments for completed works. The administrative staff provides essential support to the technical personnel in terms of preparing and processing payment claims and ensuring that the client releases the payments according to agreed schedules.

The site office is in charge of preparing and hosting regular site meetings between the contractor and the client. This includes taking minutes of meetings and filing previous records of meetings, decisions and agreements made between the contractor and the client.

The site office also plays an essential role in relation to logistical support. As in any organisation, the site office needs a well functioning registry. The registry deals with receiving and recording incoming mail and archiving all important reports and documents in the correct files so that they are readily available whenever they are needed.

Communications is an essential responsibility of the site office. It is useful to have a properly trained person who can manage incoming calls and keep records of calls made and received. The phone operator should be informed about the whereabouts of all staff members and thereby pass on incoming calls or take messages accurately.

Mail leaving the office should be recorded, noting to whom and when the letter was sent and what the letter was about. Standard procedures for communications, mail and filing should be written down for office staff to refer to.

For large projects, the running of an efficient office is even more important. The engineers and technicians will depend on the office staff for a number of activities. A poorly run office will waste valuable time and could be the cause of not meeting deadlines for submitting claims, reports, plans, budget revisions, etc.

Financial Routines

The use of materials, equipment and labour will incur costs to the project. These expenditures need to be dealt with in a professional manner to ensure that the inputs are secured at the right time. Goods and services need to be paid on time to avoid any disruptions in the supply chains. Workers and sub-contractors need to be paid on time and equipment needs a steady supply of fuel and spare parts.

Although the main office carries out larger purchases, there will always be some financial transactions taking place at the site. The local project office pays local wages and there is always some procurement, taking place locally. The project therefore needs access to accounting services, which takes care of all payments of goods and services.

Each project needs to adopt a system in which the costs of all construction activities can be monitored. Expenditures relating to labour, equipment and materials need to be closely monitored. Each activity in the project budget will have a cost ceiling within which the project needs to operate.

All expenditure, including both direct and overhead costs, need to be accounted for and charged to the correct budget lines in the project accounting system. The accounts need to be kept up-to-date in order for the project management to monitor and control costs.

Finally, the project needs to prepare claims for completed works on a regular basis. In order to maintain good cash flow

in a project, the contractor tries to invoice the client on a regular basis and as soon as he/she is entitled to the next payment.

Filing

Communications with the client, the main office and with suppliers need to be stored in an efficient manner in order for project management to refer back to decisions, orders and various agreements made with the project stakeholders.

An essential part of the filing system is the storage of drawings on site. During the course of the project, drawings and design details are revised and updated to address the real conditions on site. The project management needs to keep track of all drawings and amendments and make sure that they have the formal approval from the client. A set of drawings and all revisions is kept on site so technical staff have easy access to these documents. The drawings are filed in chronological order, thus ensuring that the latest versions of the drawings are used.

The necessary file categories are established by the project management. Common files kept on site cover financial issues, purchase orders, equipment hire, personnel records, contracts and their amendments and variations, minutes of site meetings, wage records and expenditure records. In addition, the project keeps all reporting forms in dedicated files, thereby maintaining a full history of work progress, use of labour, equipment and materials on site, results of quality tests and the invoicing for completed works.

13.5 Site Stores

The site store contains tools, construction materials, fuel and spare parts. The size of the store depends on the amount of goods to be stored. When the work site is very isolated, the store has to be well stocked and therefore tends to be larger in size. Equally, the size and type of works will also determine what needs to be stored on site.

Tools and materials should be stored in a dry and secure place. Secure locks should be provided for the storeroom. The stores should be protected from water, insects and other potential causes of damage. For more permanent store buildings a solid floor should be constructed. The items should be stocked neatly so that they can be easily counted. Different items and items of different sizes should be stocked separately. Flammable materials need to be stored in a separate location away from other stores and camp facilities.

A designated storekeeper administers the site store. The storekeeper is in charge of all its contents. As part of this, the storekeeper is responsible for recording all goods entered into the store and all goods taken out, for use on site.

The camp would normally employ a person to take care of the maintenance and service of equipment as well as repair of hand tools. On smaller sites, the role of the storekeeper is sometimes combined with the tasks of the site repairman or mechanic.

When necessary, a watchman is employed to guard the stores when the storekeeper is off duty.

Supply of Tools

The amount and type of hand tools depends on the number of workers employed and the work methods used. A standard list of tools for the work sites is usually drawn up by the engineer in charge of works preparations. Special tools and equipment are supplied to sites as and when required.

- Hoe
- Shovel
- Spade
- Pickaxe
- Spare Handles
- Crowbar
- Bush Knife
- Axe
- Hand Rammer
- Wheelbarrow
- Sledge Hammer
- Bucket
- Watering Can
- Fuel pump
- Profile Board
- Ranging Rod

Maintenance of Tools

The storekeeper should only issue serviceable tools to the workers. The tools need to be sharp and handles firmly fitted and not damaged. Unserviceable tools should be separated and repaired. Scrapped tools should be exchanged for new tools.

On large projects, it may be useful to employ a repairman to maintain and repair hand-tools. The alternative is to rely on local blacksmiths or carpenters in the nearby villages. The camp should be equipped with effective sharpening tools and a sufficient supply of spare parts. A solid workbench and a vice should be available at the site store to enable the repairs to be carried out efficiently.

Materials

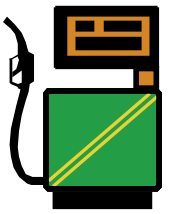
Materials should be supplied well in advance of their planned use. The engineer in charge of the project needs to ensure that sufficient materials are available on site before commencing the works. Materials comprise a significant value of any civil works project so proper handling and storage are important in order to limit any losses due to spillage and theft. When planning the initial materials purchase, the project manager also needs to design and prepare adequate storage facilities.

Appropriate procedures should be installed on site to ensure that supplies are replenished in good time so as not to delay the works. When materials are received on site, it is the responsibility of the storekeeper to inspect and verify that the supplies are in good order and correct quantity. Once they have been inspected they are placed in the store and recorded in the stores ledger.

Fuel, Oil and Lubricants

Fuel, oil and lubricants are stored separately, at a safe distance from other supplies. These items are a potential fire hazard, if not handled properly. There should be no open fires nearby, such as fireplaces for cooking, welding work, etc.

Appropriate procedures should be established to ensure that all consumption of fuel, oil and lubricants are properly recorded and accounted for.



Culvert Rings

For larger projects, the contractor may decide to manufacture culvert pipes on site. A team of workers would then need to be organised specifically for

this purpose. It will require adequate workspace at the camp for the moulding and curing process. Equally, the project needs sufficient culvert moulds, materials and a good water supply to produce enough pipes at the right time.

Once purchased, or manufactured on site, culvert rings are distributed to the planned locations along the road alignment. Supply of culvert pipes should be initiated at an early stage of the project, thus facilitating the early instalment of the culverts and allowing this work to take place when the weather permits it. Some spare pipes need to be ordered in case of breakage.

Cement

Cement is expensive and very sensitive to water, so it must be handled and stored with care. Care should be taken to avoid breaking the sacks during transport and to keep the cement in a dry and flood secure place. Special precautions are necessary when storing cement for longer than a few days. The cement bags must never be placed directly on the ground but on a wooden floor which allows for ventilation under the bags. The roof and walls must be thoroughly checked for leaks. The oldest cement should be used first.

Reinforcement Steel

Reinforcement steel requires safe storage close to where it is loaded and unloaded. There needs to be sufficient space close by where cutting, bending and binding take place. This work area should be near to the loading area, so the steel can easily be transferred to the work sites.

Pegs

Wooden pegs, used for surveying and setting out activities, are normally produced on site. They should be prepared well in advance so that the sites have sufficient supply when they are needed. The production of pegs can be organised under the responsibility of the storekeeper. This is an activity well suited as piece work in which local villagers are paid on the basis of a specific price for each peg.

Obtaining Stores for the Site

The supply of materials, tools and equipment for a particular site is normally earmarked in advance at the main store and set aside until the storage facilities at the site camp are ready. If the work site is situated in a remote location, more purchasing must be carried out centrally. Since it can be difficult for the main store to supply certain items due to general shortage or time-consuming procurement procedures, the project staff must foresee what is required well in advance and initiate the ordering procedures at an early stage.

The camp supervisor is responsible for the stores which are delivered to the work site and must deal with any loss or improper use. As part of the works planning, the project management needs to ensure that the tools and materials are available when needed.

Procurement

Procurement of goods is carried out using clear procedures laid down by the management. The authority for procuring goods and materials is vested with the project manager. This authority

will, however, be limited to certain goods mainly related to consumables required on site on a timely and regular basis. Larger purchases are often carried out by the head office.

The project staff must be fully aware of the prevailing procedures, as they will be held responsible for any losses or illegal transactions. Close communication needs to be maintained on these issues between the camp store, the accounting staff, and the engineer in charge.

Receiving and Storing

After goods have been procured or ordered from the main store or a private supplier, they have to be received and stored. Deliveries are accompanied by a delivery note from the supplier. One copy of the delivery note remains at the store and one is returned to the supplier.

Goods are checked by the store staff to make sure that quality and quantity are as specified in the order or supply documents. The exact number of goods received (if different from the quantity on the delivery note) is noted on the delivery note and countersigned by the person making the delivery. Goods that do not meet the specifications should not be accepted. The storekeeper then indicates on the delivery note how many items have been refused and the reason why.

The storekeeper certifies that the goods have been received in good condition and to the correct quantity. All received supplies are immediately entered into the stores ledger. Each item in the store should have a store record where the following details are recorded:

- description of item,
- unit price and total value,
- suppliers name,
- amount delivered,
- date received,
- stock balance,
- amount issued, and
- minimum and maximum stock levels.

Issuing

When issuing goods it is important to follow certain procedures to avoid unexpected shortages, incorrect issues and theft. These procedures are essential in order to keep track of supplies. Having formal procedures clearly documenting all transactions increases the accountability of all consumption of supplies, and maintains clear responsibilities for the distribution of supplies. Issue of supplies should be checked to ensure that consumption at the work site does not exceed expected levels.

Requests should be made in writing and signed by the requesting officer. It is common procedure that key management staff approves the issue before goods are ordered. A requisition form, requesting issue of supplies, should contain the following data:

- description of item,
- quantities required,
- actual amount provided,
- date issued, and
- name and signatures of staff, requesting the supplies.

Store Control and Auditing

Stores in any organisation contain attractive and valuable items. It is therefore important to establish a comprehensive

control system. Stock level checks must be carried out regularly. Recommended periods for checks are:

- valuable and attractive items - every month,
- dangerous items (e.g. explosives) - every month, and
- general stores - at least every three months.

In addition, spot checks (surprise checks) of some selected goods at any time are useful. This keeps staff alert by showing that management is concerned with the accuracy of store ledgers and the security of the goods.

13.6 Personnel Management

Personnel management is an additional but important task for technical staff in charge of a civil works project. When applying labour-based work methods this responsibility increases, however, if dealt with in a proper manner the workforce is a reliable resource. As opposed to the management of equipment, labour issues are seldom the reason for delays on projects.

When building rural roads, projects employ different categories of personnel, ranging from technical and administrative staff to artisans and unskilled workers. A small number is permanently employed while others are engaged on a temporary basis. When applying labour-based works technology, a large majority is recruited on a casual basis for the duration of the work activities carried out using manual labour.

Permanent Staff

Both the road works agencies as well as private sector contractors employ personnel on a permanent basis in order to provide a certain level of continuity in their work programmes. Permanent staff fill such posts as engineers, technicians, accountants, clerical staff, storekeepers, supervisors, drivers and operators. Contractors may also choose to employ a core group of semi-skilled workers on a permanent basis. Due to their extensive work experience, these workers are valuable assets to the work site by providing practical training and guidance to the rest of the workforce.

When the level of activity increases, additional staff is employed. Road works agencies usually recruit personnel either from government departments, or employ people on fixed term contracts that expire once project funds are exhausted. When private contracting firms receive an increased workload, they also engage more staff. At first, they may engage the additional personnel on a fixed term basis, normally linked to the duration of the civil works contracts to which they are assigned. When these firms eventually increase their work levels on a more continuous basis, the contractor normally takes on some of the temporary staff as permanent employees of the firm.

Conditions of employment vary from project to project, but the terms should be clearly agreed at the time of recruitment, to avoid any misunderstandings or grievances at a later stage.

Any organisation will seek to utilise to the extent possible the staff already in

their employment, so the project manager may have to accept staff assigned to the project by higher level management. When employing additional staff it is useful to include the project manager in the recruitment process.

Staff performance usually improves if the project management has the authority to dismiss or return unsuitable personnel. Most projects operate against demanding production targets and strict control requirements, so the skills and dedication of project personnel is therefore vital for the timely progress of work.

Recruiting Temporary Staff and Labour

Specific procedures and regulations apply to the employment of temporary or casual employees. These regulations are normally found in the prevailing labour legislation. These concern the employment process, the terms and conditions of employment and the payment of wages.

Labour regulations often distinguish between temporary employed workers and casual or day labour. Temporary employment is normally treated as a more formal employment arrangement, in which the staff has the regular entitlements as prescribed for the construction industry.

Casual labour is often treated separately, under the basic assumption that they are employed only for a day at the time. The exact entitlements relating to this employment arrangement are usually far more limited, however, the regulations vary significantly from one country to another. Often, there are also large differences between the obligations of a private sector employer as compared to a government agency.

Recruiting Casual Labour

To ensure that there is a sufficient supply of workers, it is important to plan the recruitment well in advance. The local villagers need to be given due notice about the future labour requirements of the project. They also need due notice so that they can plan and organise their regular commitments and work activities, such as farming and household activities. They can then set aside sufficient time to participate in the road works. The announcement should state:

- date, time and place of recruitment,
- conditions of employment,
- type and purpose of work, and
- who is eligible for work.

The majority of labour intensive work activities should be timed to periods of the year when labour availability is good, such as during the agricultural slack season. The sowing and harvesting periods should be avoided for the activities requiring a large number of workers.

When announcing the employment opportunities in the nearby villages, it is important to stress that both men and women are eligible to apply. Persons below the legal working age should not be recruited. If there is a surplus of labour applying for work, a ballot system can be used to make sure that the recruitment is fair and gives an equal chance for all applicants.

During recruitment, it is important that the workers are fully informed about the conditions of work, i.e. working hours, the wage amount and when it will paid, period of employment, entitlements and general discipline on the work site.

To ensure the required level of effectiveness on the work site, serious attention should be given to the motivation of the labour force. This is ensured by various measures such as appropriate wages, proper supervision, secure working conditions, timely payment of wages and the use of incentive schemes.

Conditions of Work

The workforce employed to carry out labour-based road works are normally recruited within the vicinity of the road sites. They are engaged on a daily basis and are paid only for the days they have worked. They are normally not entitled to any social benefits such as paid leave,

pensions, sick leave, etc. They can be laid off when their services are no longer required. When the road works activities move to a new area, new workers are recruited.

Payment of Wages

The presence of each worker on site is recorded in detail and on this basis wage payments are made. A muster roll is used for this purpose. At the end of the month (or other period agreed with the workers), the muster rolls are used to culculate wages for each of the workers.

The date and place of payment are announced to the workers well in advance to make sure everybody attends on the payday. Wages can only be collected by the worker him/herself. All workers should be properly identified by presenting their identity card for inspection when receiving their wages.

The organisation of the payday requires special attention by the project management. The project manager sets a date and place for this to happen, and organises the logistical support required. It is the responsibility of an accountant or a finance clerk to prepare and actually carry out the payments.

The preparation of the wages needs to commence in good time before the actual payday, as there are a number of activities to be completed:

- The muster roll must be submitted to the accountant in order to calculate the exact wage to be paid to each worker and the total amount needed;
- Authority needs to be obtained to withdraw money from the bank, collect the money in sufficiently small notes so that the exact amount can be paid to each worker;
- Transport and security need to be arranged to carry the money to the work site;
- Payments need to be made to the right persons and the signature of each worker obtained, declaring that he/she has received the wages due and that the amount was correct; and
- A report on the payments made should be prepared and any unpaid wages returned to the bank.

This is a tedious exercise and often requires lengthy procedures and checks to ensure the authority and security of large amounts of cash to a large number of work sites. If the on-site staff does not ensure that muster rolls are submitted on time and the correct procedures are not thoroughly followed, then payment will be delayed and cause discontent among the workers. This may in the next turn cause problems with motivation of the workforce and affect site production levels.

13.7 Site Meetings

Regular meetings among key project staff are an essential part of the management procedures on a works project. These meetings allow management to disseminate information and to ensure that all parties are well informed about recent decisions and revisions to the work schedules. Such meetings are also a useful forum for problem solving and when scarce resources need to be allocated to the most important work activities.

The main purpose of arranging these formal site meetings is to facilitate the timely delivery of works. These meetings act as an important forum in which the contractor and the client can address technical and managerial problems which may arise during the course of the works.

In order to ensure a good working relationship between the contractor and the representatives of the client, it is common practice to arrange site meetings where the two parties meet on a regular basis during the course of a contract. The contract may specify how often these meetings should be arranged and who has the authority to call the meetings.

Written minutes are maintained on all decisions made during these meetings. The minutes should include any instructions relating to changes in the contract, such as revised quantities of works, improved work methods, quality requirements, replacement of staff, changes in work schedules, etc. During the next meeting, it is useful to revert back to the minutes and the decisions made during the previous site meeting and review progress on these issues before making any new decisions.

13.8 Work Safety

At every construction site, active measures are required to minimise accidents. A construction site is a potentially dangerous place to work, and for this reason all parties involved in a project share the responsibility for the safety on site.

Ensuring this is the direct responsibility of the contractor in charge of the works. Contract documents normally contain provisions defining the responsibilities and liabilities relating to accidents on site. Adequate provisions for insurances against damage to people, equipment and property are included in the contract. Provisions for insurances should be included in the general budget line items. If such line items are not part of the bill of quantities, these costs need to be incorporated as part of the overhead costs applied to budget items covering the physical works activities.

The contractor needs to be aware of all laws and regulations relating to security and health on civil works sites. If such regulations are violated, this not only increases the risk to the workers or any third party, but it can also have an impact on the insurers acceptance of insurance claims. When the insurer finds evidence of gross negligence or violations of standard safety regulations, the conditions of the insurance contract may relieve the insurer of any obligations to the insurance contract purchased by the contractor.

It is the responsibility of the contractor

and the supervising engineer to know all the relevant regulations in terms of safety and health on the work site. In addition to installing appropriate measures to protect its workers, the contractor is also responsible for protecting the general public against any hazards caused by the works both during and after working hours.

Prevention

Safety on site needs to be assessed on a continuous basis. For every work activity, there are a number of well-known safety hazards which the workers should be made aware of. During clearing works, activities such as tree felling, blasting and boulder removal pose the greatest risks. During excavation works, unstable slopes and cuts may pose a threat to the workers. Activities involving the use of large construction equipment such as compaction and transport of materials are always a risk on sites employing a large workforce.

The best approach to safety on site is to ensure that the workers, equipment operators and supervisors are properly briefed and trained to identify and deal with potential dangers. Well-organised work sites, where equipment and labour are clearly separated from each other improve the safety standards. Equally, the traffic running through the work site should be directed well away from where people are working.

First Aid

Every site should be supplied with a first aid kit. The medical kits should be administered by someone who is properly trained in using its contents. First aid kits should be regularly replenished, so they are effective when an accident occurs. For more serious accidents, the project management needs to make contingency plans for evacuating the injured from the sites and transporting them to the nearest medical facility.

CHAPTER 14

WORK ORGANISATION

WORK ORGANISATION

14.1 Introduction

Every work site needs to be organised in a structured manner in order to ensure that the outputs of all staff and workers are properly coordinated. The basic building blocks in any work organisation include (i) defining the specific work duties of each staff member and (ii) identifying the person to whom each individual reports. The project management, as well as the labour force at the work site needs to be organised in a similar fashion.

When employing a large workforce, it is important to establish an organisation in which the supervision and management of all the workers are secured in an effective manner. The exact structure of the organisation varies depending on the nature of the works, but in general it would be as shown in the diagram below.

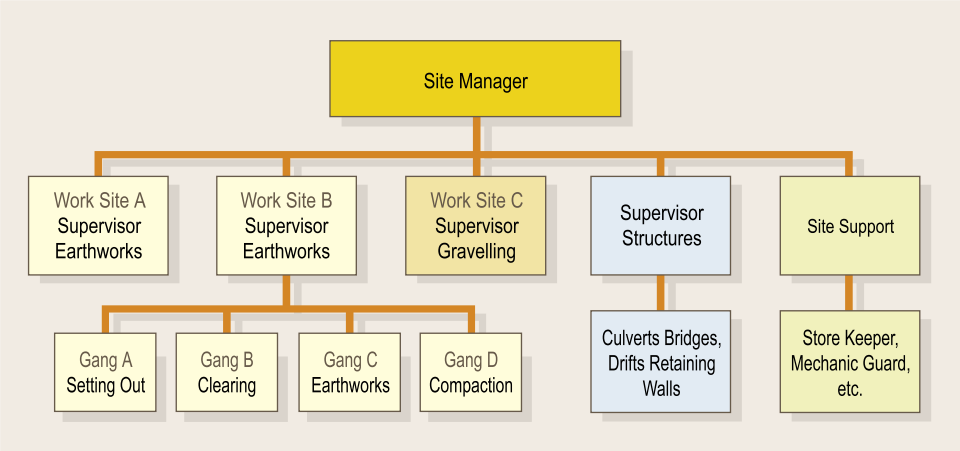
Whether works are carried out using equipment or by manual labour, the essence of effective work organisation is to make good use of the resources available on site. When carrying out works using labour-based work methods there are three basic elements that have a major impact on the work performance. These are (i) good supervision, (ii) the use of incentive schemes, and (iii) establishing an appropriate balance between labour and machines. Amongst the three, the skills and experience of the supervisors have the greatest impact on the productivity and quality levels on site.

When the majority of the workforce consists of unskilled labour, the workers rely on detailed instruction and guidance in order to achieve the expected outputs. This is where supervisors with solid vocational skills and experience play an essential role.

Work organisation consists of arranging and distributing the work activities between the gangs of workers in such a way that the best use is made of the available labour, materials, tools and equipment.

Depending on the size and complexity of the works, the site is managed by an engineer or a technician. On smaller work sites, it may be more feasible to assign a manager to supervise several sites. The optimal size of the workforce depends on the type of work being carried out, the expected level of outputs and the availability of local labour. With sufficiently experienced site supervisory staff, a single rural road construction project applying labour-based methods can employ up to 600 workers during its peak performance. An experienced supervisor should be able to manage 100 - 150 labourers.

Gangs, formed for the different



activities, normally range from 10 to 25 workers, depending on the nature and amount of work to be carried out. Among the workers in each gang, one person is appointed as their leader - the Gangleader. This person receives the work instructions from the supervisor and hands them on to the workers in each gang.

Since each gang becomes more and more skilled the longer they do the same type of job, it is good practice to let them work on the same operation throughout the period they are employed. In this way, maximum benefits can be derived from the acquired skills. The gangleaders will need some practical on-the-job training and should be able to read and write. For large projects, gangleader training courses are often included as part of the staff training programme.

Although most of the unskilled labour is usually recruited on a temporary basis, contractors tend to keep a core group of experienced workers from one project to another. These workers are familiar with the work activities and are therefore often used for the gangleader positions.

A gang may specialise in one particular activity, such as earthworks or gravel surfacing, but there should be flexible working arrangements, in which the size and work contents of the gang can be changed at short notice. If group task work is used, a gang may be assigned to carry out an entire operation, consisting of several activities from bush clearing up to camber formation.

14.2 Work Programming

The construction work is divided into a number of operations, each of which is sub-divided into activities.

With proper work programming it is possible to arrange and distribute the work between gangs of workers in such a way that the best use is made of the available labour, material, tools and equipment. This involves detailed planning, taking the following into account:

- The order in which work operations and activities should follow - the construction sequence;
- The number of workers in each group, i.e. gang size and balancing. A large workforce allows for rapid progress, however, good progress will only take place if the workforce is properly distributed to the various activities taking place at any time of the project;
- How to motivate the labour, using incentives, such as task work. When using incentive schemes, the expected work output of each individual worker needs to be defined;
- Correct timing of when tools, equipment and materials are supplied to site. Securing the required tools, equipment and materials forms an important part of work programming. The timely supply of these items can only be established once the project management has developed the detailed work schedule.

Construction Sequence

For planning purposes, road construction works are divided into a number of operations, each sub-divided into a series of activities. Each of the line items in a Bill of Quantities normally represents a single activity. These activities are described in detail in the work specifications.

Site clearing is an example of an operation. This operation is sub-divided into activities such as bush clearing, grubbing and topsoil removal, tree and stump removal, and boulder removal.

The separate operations on a construction site have to follow each other in a logical sequence. Each activity is carried out by a separate group of workers. If the work areas for these activities are too close to each other, the work may be disrupted (e.g. an excavation gang waiting for a clearing gang to finish). On the other hand, when activities are spaced too far apart, the total length of the work site becomes unnecessarily long and difficult to supervise.

Operation	Activities
Concrete	work at site camp, setting out alignment and tasks, water supply and peg fabrication
Site Clearing	detailed setting out, bush clearing, grubbing, tree and boulder removal
Earthwork	excavation and filling, spreading and levelling, drainage, embankments and camber formation
Compaction	watering, compacting and final levelling
Structures	Drifts, culverts and bridges
Gravelling	excavation and transport of gravel, un-loading, spreading, watering and compaction
Erosion Protection	Stone pitching, grass planting, etc.

The operations and activities follow each other in a certain sequence because they depend on each other. For example, excavation cannot be done before the vegetation has been cleared. Equally, grubbing and topsoil removal can only take place after bush clearing has been completed.

An activity should follow the preceding one as closely as possible without causing interference or over-crowding. The distance between the first and last activity should preferably not exceed 2km.

When starting a new project, it is important to stagger the above operations, allowing at least three days before starting the next operation. This also allows the supervisors to organise the work properly and give basic instructions and training to the newly recruited labour. Starting the work with too many new workers at the same time can create disorder and problems for the supervisors.

Gang Balancing

Balancing the gangs implies dividing the labour force between the different operations and activities so that each operation and activity can proceed without causing problems for other operations and activities.

The intention is to ensure that the labour is used in the most efficient way, and that each operation proceeds approximately at the same pace. It is the daily task of the supervisors to determine the optimal size of the gangs. The number of workers

required for each activity will vary according to the work being undertaken, and depends on:

- the amount of work to be done on each operation,
- the task rates being used,
- the number of workers available, and
- the sequence of operations.

Good gang balancing is important because it also determines the length of the construction site. If the gangs are not well balanced, the result may be that the work site spreads out and becomes too long to supervise in an efficient manner, or that it becomes too concentrated with the workers working in a small and congested area. The amount of work that can be carried out in a day varies during the construction period. Therefore, there will be a demand for adjusting the number of workers in each gang.

The supervisors are responsible for ensuring that the workers know which gang they have been assigned to and fully understand the work content. It is equally important that the gangleaders are properly informed about any changes to the work groups and the content of their work.

Example:

On Section A of a road, there is a lot of bush clearing and very little excavation needs, and on the following Section B there is a small amount of clearing but heavy excavation works. This implies that after clearing and earthworks have been completed on Section A, a number of workers needs to be transferred from the clearing gang to the earthworks gang. If this is not done, the clearing gang will advance too fast while the earthworks operation proceeds too slow on Section B - resulting in a stretched work site difficult to supervise.

Balancing Labour and Equipment

When works are carried out using a combination of labour and equipment, the number of workers also needs to be carefully adjusted to the capacity of the equipment in order to achieve the full outputs of both the equipment and labour. An imbalance between the performance of the workers and equipment will leave the equipment or the workers idle while waiting to commence new work.

Equally, when several pieces of equipment are required, it is important to select an equipment configuration that creates a balance in the sequence of work activities.

A good example illustrating this important planning aspect can be found when building and compacting a fill. At the start, a group of workers needs to excavate, fill and level sufficient materials to keep the compaction equipment busy. If the compaction cannot keep pace with the earthworks, there is the choice of slowing down the earthworks by reducing the number of workers – or allocating more compaction equipment to the earth fill activities.

Finally, the compaction activity requires adequate supply of water. This water is normally provided by one or several water bowsers. Depending on the haulage distance, the project management needs to mobilise sufficient bowsers that can keep up with the compaction works.

14.3 Incentive Schemes

In order for a work site to reach reasonable production rates and levels of progress, management needs to define clear goals to which project resources are directed. This implies that overall targets are translated into practical targets which supervisors and gangleaders work towards. On site, this includes establishing realistic production rates for individual workers and equipment.

The construction work cannot be planned, and realistic targets cannot be set unless productivity rates are known. In order to achieve high and sustained production levels, it is essential that the work is planned against specific productivity rates and outputs. With a good knowledge of achievable work norms, it is possible to introduce effective incentives to motivate the workers sufficiently and thereby reach the set production targets.

An effective approach is by introducing a system which provides the workers with some kind of additional benefit or reward for increased work outputs. One way of doing this is through the use of a performance based payment system.

Depending on the nature of the works, there are several methods of organising the workforce and securing continued high levels of production.

Daily Paid Work

Daily paid work is the conventional approach of engaging casual labour to carry out works required during a fixed period of time. In this arrangement, the workers are paid a certain amount for every full working day, regardless of what they produce. Extra benefits may be provided for additional work after normal working hours in the form of paid overtime. Daily paid work is simple to organize and is a workable payment method for virtually any organisation, for any form of work, using any type of construction techniques.

The disadvantage of daily paid work is that the amount of supervision efforts required to maintain reasonable outputs is relatively high. The productivity, and hence the rate of progress and the resulting unit costs are therefore difficult to predict accurately.

These disadvantages notwithstanding, both at the start of a new project and whenever starting a new work task or activity, it is often necessary to pay workers on a daily basis unless there is data available on which to estimate realistic rates for an incentive system. Although this may be a valid issue in certain circumstances, it should not be used as an excuse for not installing a more sophisticated system that includes the use of incentives. It is important to note that with effective incentives offered to the workers, production rates can be increased two to three times. So, even if there are some uncertainties regarding the appropriate work norms, it is more effective to introduce a production-based incentive as soon as possible.

Daily paid work is not directly dependent on output and therefore

offers opportunities for fraud, which the project management needs to guard against. Absent workers can be marked as present on the muster roll or by adding invented names to the roll.

The project management needs to control this by monitoring the output of each gang and by making random checks of the workers present against the recordings made in the muster roll.

Task Work

This system gives the worker one day's wage for a defined volume of work. The worker is given a task to complete and is then free to leave the site when it has been inspected and approved. This is then recorded as a full day's work in the payroll.

Task work is the most common incentive scheme used for labour-based works. As compared to daily paid work, it has several advantages:

- Work planning is simplified because the daily output of each worker is known;
- It achieves considerably higher outputs than daily paid work. The fact that workers know the exact content of their work at the beginning of the day is a good motivating factor. Combined with the value of the extra free time they receive by completing work early, this incentive can generate significant productivity increases;
- Supervision is easier because

each worker is assigned a well-defined amount of work. The set task is applied to all workers. As they are all eager to finish their individual work task early, no one is deliberately working slowly.

Another advantage of task work is that when applied on site, it also sets clear performance requirements for the site supervisory staff. When labour is employed without using a production based remuneration system, there is really no need to define outputs on a daily basis. This certainly produces an easier life for the supervisory staff. On the other hand when applying task work, there are a number of advantages resulting in increased work outputs. By allocating individual tasks the workers are also distributed in an efficient manner, avoiding that certain areas are overcrowded.

The preparation of tasks needs to take place before the workforce arrives on site - usually the day before. This forces the supervisors to carry out proper work planning and as part of this exercise, provides the supervisors a good opportunity to assess the overall distribution of workers on site.

An essential part of defining a task is to identify the location and volumes of work for each worker. This is done using pegs, string lines and templates. The fact that each task is set out in detail improves the overall quality of the end product.

If an incentive scheme is to succeed, the workers have to understand and support the system. Given the choice, the workforce prefers to work under a system in which their improved efforts are rewarded.

Group Tasks

Task work can be given to individuals (bush clearing, topsoil removal, ditching, etc.) or to groups (especially suitable for large quantities of excavation). If task work is given to a group of workers, care should be taken that the workers are not in each other's way and have enough room to work. The workers should not be released before they have finished their task unless unforeseen difficulties have arisen (encountering hard roots, rock, bad weather, etc.). In these cases the task should be adjusted if it is obvious that the applied task rate is no longer appropriate. It is easier to adjust task rates by increasing or decreasing the number of workers assigned to a certain activity than by increasing or decreasing quantities of work.

Team tasks have a number of advantages:

- They are easier and quicker to set out and control than individual tasks;
- It is more difficult to set out individual tasks as far as earthworks are concerned;
- Unforeseen difficulties are shared among several workers instead of becoming the burden of one or two workers.

A disadvantage is that some workers might be more motivated than others to finish early. These workers might be frustrated because the slower

work of others will delay the time of completion. Individual tasks provide better motivation in such cases.

Piecework

In this system, payments are directly linked to the amount of work actually carried out. This allows the workers to earn more than the standard daily pay by producing more. Similar to task work, the main advantage of piecework is thus higher productivity rates from the workforce.

Piecework is initially more difficult to organize than daily paid work and task work. However, once it works smoothly, piecework provides a great incentive and relieves the supervisory staff of the continuous oversight required when the workers are engaged on a pay system only based on attendance.

Outputs must be measured much more accurately when using piecework. Since the output forms the basis for the amount paid to the workers, it is important that the method of measurement is clear and well understood by the workers. It is therefore essential that adequate supervision is provided to (i) set out and distribute sufficient work, and (ii) carry out the detailed measurement of completed works. To avoid any disputes, it is useful to carry out the measurement in the presence of the workers.

Piecework payments can cause friction among workers because of the differences in earning that may result. Sometimes this can be overcome by paying a large group as a whole, but the larger the group, the smaller the incentive will be to each individual. With larger gangs there may be disputes among the gang members about how to portion out work among the individual workers.

The disadvantage of piecework is that its management is more complicated as measuring and control is more extensive and each individual worker earns a different wage. For this reason, projects often opt for the use of task work, as it is easier to implement. In addition, government labour regulations may prevent the use of piecework.

Payment in Kind

In areas where food supply is limited, payment in kind can be an effective incentive. However, labour laws and other regulations may limit the use of this payment modality. Unless the Government declares an emergency situation in the area, the food payment should be combined with a certain minimum amount paid in cash. Payment in kind also creates additional logistical challenges as the food supplies need to be transported to the project areas and distributed at the right time.

Voluntary Labour

Although it is not an incentive as such, the use of voluntary labour is certainly linked to the motivation and performance of the workforce. Voluntary labour is commonly mobilised to carry out rural infrastructure under the pretext that due to the shortage of funds in government budgets there is no other alternative but to encourage the local population to contribute their free labour to build and maintain the road assets. Furthermore it is often argued that the assets created benefit the local population and therefore they should contribute to the cost of the works.

Experience clearly show that relying on voluntary labour for road works is unsustainable in most circumstances with the rare exceptions in which the labour inputs required are limited to smaller works over a short period of time.

Most roads are built to cater for other types of road users than the villagers living along the road. The road users often consist of long distance traffic, government service providers, commercial enterprises such as merchants, contractors, logging companies and others conducting business in the area. Although the communities recognise the benefits from improved access, they do not accept that the road improvement is a benefit exclusively to them. After all, most villagers do not own a vehicle. Many are subsistence farmers and have limited need of roads.

In the majority of cases, inputs in the form of regular cash wages are necessary in order to secure a continuous high level of work outputs from the workforce. Furthermore, it should be recognised that the labour inputs, even on roads built using labour-based technology, only forms a part of the total construction costs. In addition, there are substantial costs related to materials, equipment and supervision.

14.4 Setting Task Rates

Task work is a system well suited for works applying labour-based methods. It is easily understood and the fixed daily wage avoids problems with overtime calculation or other additional payments. The incentive for the workforce is the early completion of their allocated tasks. Planning is relatively simple since daily outputs are fixed and the labour inputs for each activity can be accurately estimated in advance.

The weakness of the system is the time required to set out the daily tasks. With a large workforce, setting out the task for every worker each day can be time consuming. If the task is not set out early enough, the workers may have to wait to start or, more likely, commence work before the task has been defined. Good work planning is essential as the workers prefer to start as early as possible, thereby allowing them to complete their task before the hottest time of the day.

The correct task rate, i.e. the quantity of work assigned to each worker, is first established on the basis of detailed monitoring of productivity rates under various conditions. This should be done with the assistance of, and close monitoring by, senior site management at the beginning of the project. Setting up an effective monitoring system at the start of the project will help in obtaining the necessary data.

Once the initial rates have been established, it is the responsibility of the supervisors to set and distribute the daily tasks. There are basically two parameters which determine the distribution of tasks:

- the quantity of work (area, volume or quantity);
- the appropriate production rate for the activity taking into account the difficulty of the work – such as loose or hard soils, thick or sparse bush, etc.

To be effective and fair, the tasks must be estimated correctly and clearly defined. The supervisor therefore should know in detail how to set out a task and which task rates to use for the various activities depending on the site conditions.

List of Actions for the Supervisor
On the day before the tasks are executed:
1 Determine roughly how many workers will be working on a particular activity.
2 Set the rates applicable to the road sections and activities concerned.
3 Estimate the quantity of work to be carried out by multiplying the number of workers with the task rates.
4 Establish the exact location where the work will be carried out.
5 Ensure that every worker has enough working space.
6 Show the gangleaders where they will be working the next day, which tools to be used and how many workers will be assigned to each gang.
In the afternoon after the workers have left the site:
7 Using pegs and strings, the supervisors and gangleaders set out the task work for the following day.
8 If the planned number of workers are less than the current labour force, supplement the additional number required by drawing from the workers not assigned to task work or arrange for additional labour recruitment

Activity	Tools	Rates		
BUSH CLEARING	bush knife, axe	150 – 300 m^2/wd		
GRUBBING	slasher, hoe, shovel	100 – 250 m^2/wd		
EXCAVATION WORKS		fm^3/wd for throwing distance (td)		
		td=0-4m	td=4-6m	td=6-8m
Loose, non-cohesive soil	shovel, hoe	5-6	4.5-5	3.5-4
Firm soil	forked hoe, shovel	3.5-4.5	3-4	2-3
Very hard or stony soil, gravel	pickaxe, shovel	2-3	1.8-2.5	1.5-2
EMBANKMENT FILL Excavate from adjacent borrow pit	hoe, pickaxe, mattock, stretcher, basket	1.8 – 3 fm^3/wd		
LOADING				
Loose soil into wheelbarrows	shovel	12 – 15 lm^3/wd		
Loose gravel onto trailers	shovel	7 – 10 lm^3/wd		
SPREADING				
Loose soil	shovel, hoe, spreader	15 – 18 fm^3/wd		
Loose gravel	hoe, shovel, spreader	5 fm^3/wd		
CAMBER FORMATION Loose soil from side drains, heaped on to the centre line	spreader, hoe, shovel	1.8 – 3 fm^2/wd		
COMPACTION (FILL) Loose soil, 10-15 cm thickness	hand-rammer	3 – 4 m^3/wd		
EXCAVATING DRAINS (incl. throwing the soil to the centre line)				
Loose, non-cohesive soil	hoe, shovel	4 – 5 fm^3/wd		
Firm soil	mattock, shovel	2 – 3 fm^3/wd		
Stony soil	pickaxe, shovel	1.5 – 2 fm^3/wd		
HAULING	wheelbarrows			
Hauling distance 10 - 40 m		10 – 12 m^3/wd		
Hauling distance 50 m		7.5 – 9 m^3/wd		
Hauling distance 75 m		5.5 - 6 m^3/wd		
Hauling distance 100 m		4.5 – 5.5 m^3/wd		

fm^3 = firm cubic metres (the volume of in-situ soil)
lm^3 = loose cubic metres (the volume after excavation)
m^2 = square metres wd = workday (one person during one day)
td = throwing distance

Not every activity is suited for task work, since it is necessary that the quantity of work can be reliably measured and the degree of difficulty of the work can be determined. The table above shows common road works activities suitable for task work.

Task rates are expressed as the quantity of work that a person is able to finish during a day's work, such as 2 cubic metres of excavation per workday or 100m^2 bush clearing per workday.

If a task is set correctly, the average

worker should be able to finish it in approximately 75% of the normal working hours. Task work may not be as effective if the workers cannot go home every day to work for their own purposes or to spend leisure time at home. Imported labour may not be motivated by task rate system since their leisure time can only be spent in the labour camp or immediate surroundings.

In a more sophisticated system it may be possible to deduct wages if a task is not completed in one day. But such an arrangement is difficult to administer and normally not permitted by prevailing labour regulations. If the workforce frequently fails to complete their tasks, the rates are probably set too high, supervision inadequate or the workers see no advantage in finishing work early. Normally, workers should be directed to remain on site until their task is complete, even if it occasionally takes more than eight hours.

Adjusting Tasks

It is important that the tasks are correctly estimated. When task rates are changed for reasons which are not clearly understood and appreciated by the workers, discontent and other difficulties can be expected. On the other hand, if, for three consecutive days, a group of workers finishes their daily tasks to soon (say, in 40 percent of the normal working hours), the task rate should be adjusted. Similarly, if a task is not completed within the normal working hours for three consecutive days, it is necessary to review the task rate.

14.5 Managing the Workforce

Good management of the workforce is important in order to achieve high production targets. A well-organised and content workforce is usually a productive workforce. The site management must look out for problems with the workers and take appropriate steps to deal with such issues at an early stage.

Giving and receiving instructions is a major part of the responsibilities of the site supervisor. The manner in which instructions are given influences how they will be carried out. Before issuing instructions, it is important to understand:

- the exact nature and content of the work,
- how it should be carried out,
- who will do it, and
- the possible difficulties involved in completing the work.

Instructions can be given either directly to the person carrying out the work, or indirectly through a gangleader. Direct instructions to all concerned workers including their gangleader are more effective. Indirect instructions can be given through a gangleader when he/she as well as the workers are familiar

with the task and the work methods. Questions should be asked to check that the instructions have been fully understood.

If the task is not familiar, careful attention should be given to explaining the work in detail to the entire gang. In many cases, it is useful for the supervisor to actually demonstrate the work and how it is properly done.

Those receiving instructions, should be asked to repeat them, and encouraged to ask for clarification if something is unclear. Whenever practical, instructions should be given in writing or written down when received. This applies in particular to instructions concerning measurements and technical designs. During site inspections, it is good practice for the supervisors to carry a notebook in which all instructions and decisions are noted down. During the next site visit, the instructions from the previous visit can be reviewed before commencing further discussions on work progress.

Control of Works

All works need to be inspected and approved before the workers are released for the day. The supervisors should be notified by the gangleaders when a particular task has been completed and is ready for inspection.

If the work has been satisfactorily completed, the group or individual may be released for the day. If the work is not complete, it should be corrected before the group or individual worker is allowed to leave the site.

If the task is not completed before the end of the normal working day, the supervisor needs to find out what caused the delay - whether the fault lies with the workers or with his/her own setting of the task.

If the reason for non-completion is one of the following, the workers should be released:

- major difficulties not considered when the task was set (i.e. heavy roots, big rocks, etc.),
- incorrect measurement or calculation of the task,
- smaller workforce than ordered (if a group task was set),
- bad weather conditions during parts of the day.

When inspecting completed works, check that:

- the set-out measurements have been kept correctly,
- the edges are straight and well trimmed,
- the soil is placed correctly, and
- all work as defined in the task is complete.

If the reason for non-completion lies with the workers, they should complete the task before being released, even if it is after the end of the normal working day. Alternatively, the workers may return to the work site the following day to complete their task. The workers should only be recorded in the muster roll when they have fully completed their daily tasks.

Complaints and Grievances

On a construction site where many people are working together, there is likely to be complaints and grievances from time to time. Many complaints are about small matters but they often represent greater and very real problems. Complaints should therefore always be taken seriously and it is important to try to define the causes behind any discontent. People's concerns should never be ignored or their complaints considered unimportant. A complaint is a way to express a grievance but grievances may also lead to other results such as indiscipline, accidents, poor performance or quality of work.

As any one of these issues is often caused by a grievance, it is important to find out what the real trouble is. To do this, it is necessary to listen to the workers and show an interest in their concerns. Listening not arguing is important so as to ensure that the discussion focuses on the real problem.

When the true cause of a problem has been identified, a summary of what has been said should be made but, at this stage, no promises should be given. Depending on the nature of the problem, the supervisor may need to seek guidance from senior management before deciding on the actions to be taken. The chosen solutions should also be discussed with the workers to explain the rationale behind the decisions and to verify that they are appropriate and acceptable to all parties.

14.6 Organising Subcontractors

Separate contracts may be let for specific activities such as delivery of gravel, foundation works and construction of culverts and bridges. The subcontractors may be hired directly by the client or indirectly through the main contractor on site. The client would usually leave the responsibility for coordinating the inputs of other contractors to the main contractor. If the main contractor hires the subcontractors, the full responsibility for the supervision and timely delivery of the work of the subcontractors is with main contractor.

The involvement of subcontractors places additional challenges to work organisation on site. Before a subcontractor arrives on site it is essential that any preparatory works are complete and that the work site is clear and ready for the subcontractors to commence their work. Equally, it is important that the subcontractors mobilize their services on time and thereby carry out their part of the works as scheduled in the overall project work plan.

In this respect, it is important that the planning of the various inputs of other contractors starts at an early stage of the project to ensure that their work is carried out at the appropriate stage of the project. A good example is when using separate contractors for the construction of structures. The ideal situation would be to start the culvert and bridge works first, thereby ensuring proper access when the road works activities commence. Equally, all earthworks and structures need to be completed before the involvement of any pavement contractors.

The same concerns apply when hiring equipment for specific activities. Once the equipment arrives on site, the supplier will normally charge hiring fees no matter whether the equipment is used or not. In order to fully utilize the equipment, the works for which it is intended must be ready for commencement. If the equipment is to be used in combination with certain materials, other pieces of equipment or labour, these inputs need to be supplied and readily available on site.

14.7 Traffic on Site

An important part of organising work on site is to make appropriate arrangements for the traffic to pass despite the fact that extensive construction works are taking place. Rural roads, although they normally do not cater for high levels of traffic, still provide essential connections to the rural areas. Often these roads are the only access to the villages, so in light of this, the roads must remain open for traffic during the works.

This requirement places extra challenges to the site planning and organisation. Solutions involve carrying out works on either side of the centre line while allowing traffic to pass on the other side. When constructing cross drainage structures, temporary bypasses need to be organised away from the work site.

During the dry season, bypasses are easy to construct as long as they do not encroach upon cultivated land. In periods with rain, bypasses need to be constructed with some basic drainage facilities. In some cases, it may also be necessary to import quality materials for the surfacing of temporary roads.

Having traffic present on a work site poses certain safety risks for the workers. Proper guidance of the traffic is necessary to keep it away from where works are taking place, and to ensure that they find and use the temporary roads and bypasses. Equally, the work site needs to provide the traffic with sufficient advance warning about the works ahead of them. Finally, the workers need to be properly briefed on safety aspects relating to the traffic hazards.

Maintenance of Works

Before completed works are officially handed over to the client, the contractor is responsible for maintaining the completed road assets. This implies that the contractor must repair any wear and tear caused by regular traffic passing through the work site. It is therefore useful to establish a work unit with the responsibility for preventive maintenance of the completed road sections.

Traffic will also be travelling on sections where works are still not complete. Ongoing works therefore need to be organised in a manner in which damages to recently completed works are rectified before the next work activity commences. A good example is the construction of road fills. Before the next layer is spread, the damage caused to the previous layer needs to be repaired, ensuring that the original levels are reinstated. This may seem fairly obvious, however, it does require management to allocate sufficient resources for this specific purpose in order to make sure it is done properly. Equally, it is essential that traffic is redirected to a separate passageway before the final repair work is carried out.

In most cases, the costs of maintenance works before handover have no specific line item in the budget to which it can be charged. Instead, these costs need to be incorporated in the other line items in the budget.

CHAPTER 15

REPORTING AND CONTROL

15 REPORTING AND CONTROL

15.1 Overview

Reporting and control is an essential part of the management system in civil works projects. A proper reporting system enables the project to objectively monitor the progress and quality of work, even at an early stage, and assess whether defined targets are being reached. It is then possible to revise plans and take remedial action at an early stage to improve performance and secure the original set targets. Reporting and monitoring also form the basis for developing and improving planning figures, used for preparing future civil works projects.

Slow progress is caused by a number of factors and is not necessarily the fault of anyone particular in the project. It may be due to wrong assumptions made at

the planning stage, bad weather, delays in securing equipment and materials, delays caused by the slow performance of other contractors involved in the project or many other reasons. The main intention of works monitoring is to keep track of progress from an early stage and be in a position to take remedial action at an early stage when delays occur. With good follow-up of site activities, it is possible to deal with problems before they become un-manageable or result in serious cost implications. Monitoring of works is therefore an essential part of project management and constitutes an important input to the continuous planning activities required on a construction site.

Work activities and all the resources used are monitored in detail, however, reports are produced to varying levels of detail depending on its purpose and audience. A site supervisor needs to know the detailed performance of each of the work gangs while senior management staff is more concerned with overall progress on a work site. Different types of control procedures exist, including quality control, production control and cost control. At the work site, the production and quality controls are the most important.

Reporting and control also forms a central part of contracts management. Contractors engaged on civil works projects are paid at regular intervals. In most civil works contracts the services of the contractor are paid on the basis of quantities of completed works. Before the contractor is paid, the completed work is controlled to verify that it is has actually been carried out and that it has been delivered to the prescribed quality standards.

Monitoring work progress involves keeping track of:

- the inputs, i.e. the number of workers allocated to each activity, amount of tools and materials and usage of equipment. Inputs also include overheads such as running a site camp, supervisory staff, insurances, etc.;
- the output which is essentially the quantities of completed work. The main unit of measurement is obviously the length of completed road sections, however, it is also useful to measure progress on each of the detailed works activities, such as square metres of clearing, cubic metres of excavation and completed culvert and bridge works.

The methods of control are inspections, materials testing and reviewing records and reports. As with planning, reports are based on time (daily, weekly, monthly), activity (clearing, earthworks, gravelling) or items used (vehicles, materials). The project management has to deal with all of these types of reports.

The progress reports also provide essential information to those who planned the works. When the production figures are analysed it is possible to establish the extent to which the original production targets are being achieved. If there are substantial differences between the

The purpose of a reporting system is to:

- measure performance of ongoing works,
- provide a uniform method of collecting production data,
- ensure the correct and efficient use of funds, machines, materials and labour,
- identify weak components of the production chain,
- enable the management to effectively re-plan and reschedule remaining works,
- calculate payment of completed works,
- provide reliable information to others about the project activities, and
- collect experience data to improve planning of future new projects.

planned targets and actual results, the management needs to find out why the targets have not been reached. Either the targets have not been set correctly or the work has not proceeded as planned. With the information coming from the work site, it is possible to revise and improve the current plans as well as improve planning and costing of future projects.

The progress reports also give an opportunity to analyse good performance, i.e. when the targets have been exceeded. Accurate and timely reporting is also an indication of the skills and abilities of the supervisors.

Flow of Reports

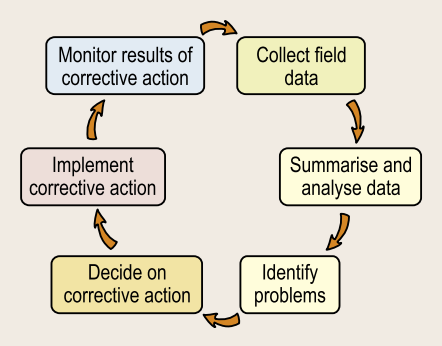
The flow of reports from the work sites to headquarters follows the formal line of command. The supervisors report to the technicians, the technicians to the site engineer; the site engineer to the client and to headquarters. The responsibility for reconciling daily reports into weekly and monthly summaries is usually assigned to the technicians. This exercise allows the site management to compare results with current plans and assess whether any specific action is required in order to improve progress.

It is important that the aggregate figures are provided to the supervisors, thus informing them about how their work is progressing according to plans and giving them an indication whether the actual outputs are satisfactory.

The reporting of quantities of completed works provides the contractor with important information relating to when it is appropriate to submit the next invoice and forms the basis on which claims are calculated.

15.2 Monitoring Works

Works monitoring is necessary in order to check progress in relation to plans and budgets. When deviations occur, the management needs to establish the reasons why works are not reaching set targets, and devise remedial action which puts progress back on track again. The effect of these management decisions needs to be carefully monitored to ensure that they lead to the intended results.



Monitoring Progress

In order to effectively evaluate the data recorded, the engineers and supervisors must be aware of the productivity and performance targets. Production targets are initially set during the planning stage, but need to be reassessed on a regular basis during the course of the project. The quality of works is defined by technical drawings and work specifications.

Apart from field inspections, the most important monitoring activity is the desk review. On a regular basis, the site manager needs to carefully analyse the information provided from the work site and compare the actual progress with the most recent plan.

When actual performance differs from the plan, it is important to investigate the possible implications of targets not being achieved, in terms of both cost and time over-runs. The findings should be discussed with subordinate staff in order to decide on the corrective action to be applied. The corrective measures decided upon will only be

effective if they are understood and agreed upon with those involved in carrying them out.

The management needs to concentrate on the failings in performance that have a significant impact on overall targets and objectives, and not waste time on activities which have a limited effect on overall work progress. For rural road construction, the most significant operations are the earthwork, surfacing works and structures. These operations have a major impact on both progress and costs incurred on the project.

Cost Monitoring

Monitoring costs is necessary to avoid cost over-runs and to prevent unauthorised expenditure. Every civil works project needs to operate within the budgetary limits set in contract agreements and annual work programmes. The three most common reasons for cost overruns are poor work organisation, inefficient utilisation of available resources and inaccurate estimates of the quantities of work. There may also be unforeseen circumstances at the project site, which increase the overall cost of the works.

Whatever the reason are for incurring cost increases, it is important that it is detected at an early stage. The reasons for the change in costs need to be examined and on this basis new projections should be made. With the new projections, there may be a need for adjusting contract agreements and budgets. This involves major decision-making by senior managers, and can only be done on the basis of reliable cost monitoring and projections.

A project may also have cost savings. When this occur, the senior management should be informed at the earliest possible so that the unused funds can be redirected to other activities. In some cases, savings on certain work activities can be used for covering cost increases on other work operations. If it appears that the entire works project will cost less than originally estimated, unused funds

Bill of Quantities

Item	Description	Unit	Quantity	Unit Rate	Amount
1.1	Clear site of grass and light bush	m^2	24,000	0.01	240.00
1.2	Grubbing and stump removal	m^2	5,600	0.02	112.00
1.3	Tree felling and removal	no.	75	4.50	337.50
	Sub-Total				689.50
2.1	Excavate side drains to form camber	m^3	7,710	1.37	10,562.70
2.2	Construct mitre and catch-water drains	m	281	1.12	
2.3	Construct scour checks	no.	300		

the unit rates are the budget ceilings for each work activity

can be transferred to other projects.

The majority of costs incurred on a civil works project are related to the individual work activities. The bill of quantities provides the budget, which the project needs to work within. Each line item in the BoQ provides the detailed budget available for each work activity. Although there may be deviations from the quantities of work estimated in the BoQ, the final outputs of work should not change too much from the original estimates. In any case, the unit rate provided for each work activity acts as a budgetary limit for that specific type of works.

This implies that the cost monitoring needs to look into the detailed costs of each activity. All inputs such as labour, equipment and materials used for a particular activity need to be closely monitored and costed, and compared to the original estimates.

Special attention must be paid to overhead costs (supervision, administration, transportation, etc.). The percentage of funds spent on overheads can easily become excessive if it is not controlled.

When production is running at a low level, savings in overhead costs should be looked for (such as reducing the site administration, rationalising the use of vehicles and sharing of office facilities).

Vehicle operation is expensive and should therefore be carefully monitored and controlled. High fuel consumption, frequent repair costs and vehicle misuse are common causes of over-expenditure on vehicles.

As with performance monitoring, all relevant information must be carefully scrutinised when costs are monitored. For example, the proper utilisation of hauling equipment cannot be found from the vehicle cost reports alone. It is necessary to cross check with the quarry operations, haulage distances and equipment availability for the same period in order to obtain a clear picture.

Equally, it is important to focus attention on the large work operations, which carry the largest quantities of works. This work incurs the highest costs, so any savings and productivity increases here have a higher impact on the overall project cost.

15.3 Drawings and Work Specifications

All civil works projects are described through a set of drawings, which graphically describe the works to be carried out. The level of detail in the drawings may vary, depending on the complexity of the works and to what extent the works adheres to common building practices and design standards. Drawings for road works normally refer to a standard design used for the specific type and class of road the authorities have decided to build. Road works drawings therefore concentrate on how these designs are applied in the terrain through which the alignment passes, describing the levels of the road and its curvature.

A further description of the works in terms of quality requirements for materials and the completed works are contained in the work specifications, in which detailed instructions are provided on how the various work activities should be carried out. In addition, the specifications describe how to measure and pay for completed works.

Specifications are either prepared by prescribing the quality of all inputs and specifying the work methods or by describing the features of the end product. The most common method of describing the works is by issuing design and method specifications. This implies that the works are described in terms of quality of materials to be used and by specifying the work methods. Method specifications often also include minimum requirements and the type of equipment to be used.

The opposite of such specifications are performance-based specifications, where the results or intentions of the finished product are described. In this type of specification, the details of materials and how to carry out the work are left to the contractor to decide, only ensuring that the end product meets certain performance requirements. If the selection of materials and work methods prove to be inadequate, the fault is then entirely with the contractor who will need to redo the works using higher quality materials and improved work methods.

The advantage of using performance-based specifications is that it is then possible to fully utilise the experience and knowledge of the contractor in terms of executing the works. In most cases, the specifications consist of a combination of the two principles, i.e. prescribing specific work methods and materials as well as the end result.

15.4 Inspection of Works

Inspection and control of works is carried out for two main purposes, (i) to ensure that the workers and operators carry out the works in the manner which they have been instructed, and (ii) to ensure that the completed works reach the prescribed quality standards.

Daily Inspections

Inspection of works starts with the supervisor's inspection of the daily outputs of the individual workers or work gangs. Before the workers are released for the day, their work must be inspected and approved by the supervisor. When inspecting the work, the following should be checked:

- has the correct quantity of work been finished?
- is the quality up to the prescribed standards?
- has the correct type and number of workers, tools and equipment been engaged in the work?
- if works are unsatisfactory, what are the reasons for the deficiencies?

Approval

When work is approved, the workers are released for the day. If task work has been applied, they may leave earlier than the standard working hours and still be entitled to a full day's pay. The input for each activity, i.e. the number of workers, is then recorded in the daily site report.

Disapproval

If the work is not approved, the supervisor needs to find out why it has not been completed or why it is below standard. If the reason for non-completion lies with the workers, the labourers should complete the work before they are authorised to leave, even if it means working after the formal end of the working day. However, if the workers cannot be blamed, due to unforeseen difficulties or bad weather, they should be entitled to a full day's pay and released by the end of the working day.

The input and actually completed sections of work are then recorded in the daily site report. If work was not completed as planned, the main reasons for this should also be recorded in the site report. This information may be important for future works planning. There are a number of reasons why works are not completed as planned. The most common reasons are:

- the calculated task rate was too high;
- the task was not properly set out;
- the calculation contained mathematical errors, indicating a lower volume than the actual;
- the work contained unforeseen

difficulties such as roots, boulders, etc.
- workers were issued wrong or poor quality tools;
- rains obstructed the works;
- the work pace and productivity of the gang was below the expected norms.

If the quality of the completed work is below standard, it can be a sign that better instruction is required on site. The best instructions are those which are followed by a practical demonstration. Carrying out several inspections, especially at the beginning of the day, allows the supervisors to address any problems encountered by the workforce, and avoid disapproval of work at the end of the day.

15.5 Quality Control

Controlling the quality of works is a daily activity, which needs to be carried out during a work activity and again at the completion of works. When an activity is organised as task work, the quality is controlled at the end of the day before the task is accepted as complete. Usage of equipment needs to be carefully monitored to ensure that it is operated correctly and that its use actually achieves the set quality standards. In addition, the works are evaluated by carrying out a series of quality control tests.

Testing materials is an essential part of ensuring that works reach prescribed quality standards. The work specifications

provide detailed descriptions on the quality requirements of the materials as well as the end products. The work specifications also include directions on when and how tests and inspections are carried out. Tests are performed both on site and in a controlled environment such as a laboratory. The results are presented in writing and submitted to the client for final approval.

Common quality controls include:

- Soil testing which includes analysing the distribution of particle sizes of the material, its moisture content, the achieved degree of compaction, material strength and plasticity;
- Control of surface levels to ensure that the completed levels correspond to the work drawings, evenness and gradients;
- Inspection of foundations before structures are erected;
- The quality of concrete and reinforcement steel, and the final quality of the concrete works after curing;
- Inspection of the formwork and binding of reinforcement steel before pouring concrete.

Some activities are so essential to the quality of the end product that it is common practice to maintain close supervision during the entire activity to enforce that prescribed methods are adhered to. A good example of this is the process of pouring concrete.

Often, these quality controls need to be completed before the contractor is allowed to proceed with ensuing works. To avoid any delays due to late inspections, the project management should carefully plan ahead and fix certain dates when the formal inspection will take place.

15.6 Quality Assurance

Quality assurance is achieved through a series of interventions before, during and after carrying out the works. Rather than waiting until mistakes or poor quality works occur, good management will install effective measures to ensure that problems of such nature do not occur – or at best are minimised.

(i) Before works commence, the project management needs to ensure that all tools, materials and equipment are available. Materials should conform to prescribed quality standards and tools and equipment should be in good condition, thus providing the site with the necessary inputs to carry out the works properly.

(ii) When embarking on a specific task, it is important that all parties involved are fully conversant with how to carry out the work. First of all, this implies that the supervisors understand the drawings and dimensions and are experienced in the work methods to be applied. Furthermore, the skilled workers and equipment operators need to know the quality requirements for the completed works. Unskilled workers need to be fully briefed on how their tasks are carried out and how it will be assessed as satisfactory. A good example of where proper instruction is required is during compaction

works. On the basis of an initial soil analysis and trial runs with the compaction equipment, the operators are instructed on how many passes they need to run the rollers and how much water should be applied to the soils. Without this information, the operators may have problems determining when the job is done.

(iii) Works should be verified before starting the next activity. Some activities require a formal inspection before the next can start. A good example is inspecting formworks before allowing concrete to be poured. Equally, each layer in a road fill should be inspected before commencing works on the next layer.

(iv) Proper supervision during the works provides essential work guidance and ensures that instructions are actually carried out as intended. For some important activities, it may be necessary to keep technical personnel present during the entire duration of the work activity.

After each work activity has been completed, quality controls are performed to check that the end product measure up to prescribed requirements. These tests are done using standardised procedures and testing equipment. The results are noted in written reports and submitted to the project management and if required to the client. By securing these quality assurance interventions in a systematic manner, the final control tests should merely be a final verification that works are in good order.

The overall goal of the above approach is to reduce the amount of sub-standard work to a minimum by organizing the supervision in a way in which poor or wrongly executed work is detected and rectified at an early stage. Poor quality work may result in having to do the work all over again. This leads to delays in progress and extra costs to the contractor, and in the long run damage the reputation of the company.

Timely quality assurance as described above is a cost effective approach to quality control. Making sure that supervision is provided at the right time ensures that the correct work methods are used from the very start.

15.7 Measurement of Works

In most civil works contracts, payments are directly linked to the actual amount of works completed by the contractor. Since the contractor would like to recover incurred expenditure as soon as possible, the contract normally indicates when and how often payment claims can be submitted to the client.

When payments are due, the contractor prepares an invoice detailing the quantities of work completed since the previous claim. These quantities are based on information compiled from the site production reports.

Before the client issues the payment, a final control of the works is necessary to verify that the quantities of work have actually been carried out, and that the works conform to prescribed quality standards. Any errors in the claimed quantities are then rectified. Equally, the client may deduct poor quality work from the claim. Based on the revised volumes of work, the client can then finalise the payment.

Measuring completed works is a common cause of disputes between the contractor and the client. For this reason, the method of measurement is often described in detail in the works specifications. Of more importance is that the volumes of work due for payment are recorded using the unit of measurement stated in the bill of quantities or activity schedule. If the contract documents have been properly prepared, the units of measurement in the bill of quantities correspond to the ones referred to in the works specifications.

15.8 Records and Reports

In order to achieve uniformity in reporting and securing the essential data for monitoring and planning purposes, reporting is usually carried out using a set of standardised report forms. To ensure that the forms are used in the same way by all staff, the report forms are issued with a set of procedures and directions relating to how and when they are used and how the information is passed on to superiors.

Depending on the size of the site, the responsibility for maintaining these report forms can be divided among the supervisors, storekeeper and site office staff. The supervisors remain responsible for the end result and need to verify the accuracy of the reports.

Record keeping is a routine job which takes time and despite the fact that it may be perceived as tedious, it is extremely important, since the whole chain of planning, progress monitoring and control and payment processing is based on the site reports.

The most commonly used reports are described here:

Muster Rolls

The muster roll is an attendance record, which forms the basis for the wage calculations and the payroll. It is a ledger in which the presence or absence of individual workers are noted on a daily basis. The muster roll is used as the main supporting document for accounting labour expenditure.

		Road Name:													District:									Province:													
		Muster Roll																																Payroll			
No.	Full Name	Pos.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Total WD	Wage Rate	Total Amount	Payee's Signature

The muster roll is updated in the morning with occasional checks in the afternoon. The entries are done at a central place, such as outside the store or site office before work starts, or as the supervisor visits the different gangs, depending on the distance from store to site, the use of task work and the system applied for distribution of tools. The workers must be properly informed about the conditions of employment, including the rules applied when coming late to work or being absent for more than a stipulated period of time. Being absent may result in removing the person concerned from the muster roll and employing a new worker in his/her place.

At the end of the day, the supervisor should make crosschecks of the daily attendance recorded in the Muster Roll with the labour inputs entered into the daily site records.

The muster roll should be maintained every day and be readily available for inspection. Every week or at the end of each month, depending on how frequent the project carries out wage payments, the muster roll is reconciled to calculate the wages for the workers. This exercise determines the exact amount of payments required at each site and for each worker.

Daily Site Record

The daily site record forms the basis for the reporting and control of physical work progress on site. It records the "input" (number of workers and use of equipment) used for each work activity. The site record is filled in at the end of each workday when the supervisor inspects the work of the individual workers or gangs.

The daily record is a sort of diary in which the main events on a work site are entered on a daily basis. This includes:

- The location at which the various activities are carried out. For road works the location is described by indicating the chainage where works are ongoing;
- The outputs achieved at the end of the workday. Outputs are recorded using the same unit of measurement as applied in the Bill of Quantities;
- The input assigned to each work activity such as labour and equipment;
- The overall productivity rate is calculated from the inputs and completed outputs at the end of the day.
- It is also common practice to report general site conditions including issues such as weather conditions, any problems encountered, accidents or unusual events on site.

The exact design and contents of the report form will vary from one programme to another. However, in one way or another, it contains the information as shown in the table below.

In some projects, the daily site record is combined with a daily work plan, outlining the planned activities, planned inputs and expected results by the end of the day.

To simplify the monthly report writing, the daily records are summarised at the end of each week into a weekly report. The project management needs to compare the daily, weekly and monthly work outputs with project work plans. This comparison also needs a close review of the inputs used to ensure that these do not exceed the estimated inputs used when calculating the unit rates in the BoQ.

Monthly Progress Report

Monthly summaries of performance, based on the weekly totals of the daily reports, are prepared by the site office. The main purpose of this exercise is to enable the management to monitor progress against planned targets. Together with the daily and weekly progress reports, this information also provides the basis for the invoicing of completed works.

The summary reports contain output and productivity data for the current month and for the total period so far since the project commenced. This enables management to review performance for the last month and the average performance during the year so far, against planned outputs and productivity.

Summary reports are designed to meet the monitoring needs of each level of management. Report forms are designed so that the information needed for performance monitoring is displayed in a clear way that is easily understood and recognised. The higher up in the management organisation, the more general picture will be required of the performance statement.

Activity	Chainage		Inputs		Output		
	Start	End	Labour	Equipment	Unit	Quantity	Norm
Setting Out	1+800	2+100	5	setting out tools	m	300	60
Bush Clearing	1+550	1+800	15	bush knifes and axes	m^2	1500	100
Levelling	1+350	1+550	50	hoes, shovels, wheelbarrows, water bowser and rollers	m^3	100	20
Side Drains	1+115	1+200	30	hoes, pickaxes, shovels and spades	m^3	53.55	1.8
Embankment	1+200	1+350	75	hoes, pickaxes, mattocks, stretchers, wheelbarrows, water bowser and rollers	m^3	150	2
Camber	1+000	1+115	39	hoes, pickaxes, stretchers, water bowser and rollers	m^3	69.57	1.8

Activity	Unit	Total Quantities		Output	Month				
		Actual	Plan		JAN	FEB	MAR	APR	MAY
Earthworks	km	10.8	11.0	Actual	0.4	0.9	2.1	3.3	4.0
				Planned	0.5	1.0	2.5	3.0	4.0
Gravel Works	km	4.0	4.5	Actual				1.5	2.5
				Planned				1.5	3.0
Culverts	km	3	4	Actual			1	1	1
				Planned		1	1	1	1

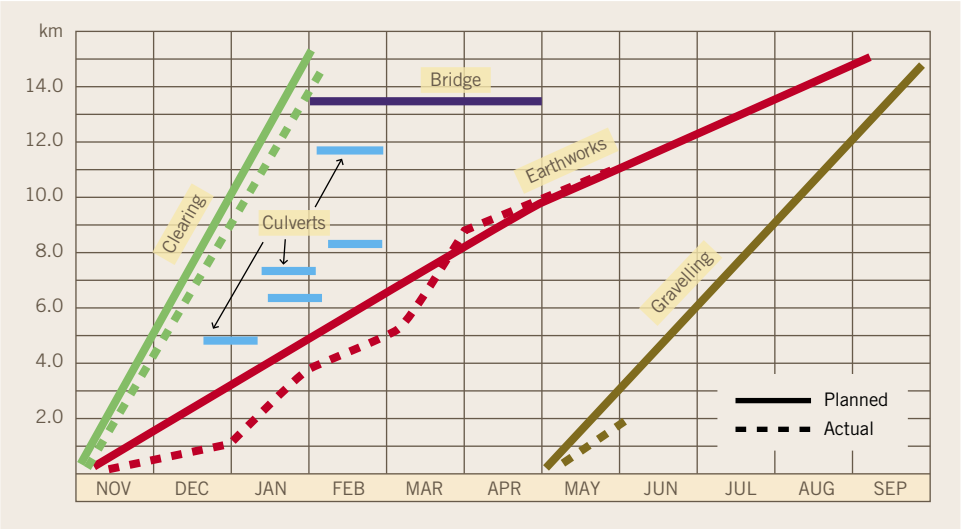
Comparison to Planned Progress

The monthly progress data is essential for planning overall progress and assessing the performance of a work site as compared to the planned performance. This exercise includes both calculating the aggregate figures for each month as well as summing up performance since the start of the project. The comparison between planned and actual results is carried out for inputs of labour, usage and costs of equipment, consumption of materials and finally for the work outputs.

Monthly planned and actual outputs can be presented in table form, as bar charts or using time-location charts. The use of time-location charts is a very common method for presenting progress of road works, since this graphical presentation depicts the entire history of work progress at any stage through the project period and at any location along the road alignment. With these charts, it is also easy to predict completion dates on the basis of current production rates.

Payment Certificates

It is common practice that the contractor is paid on a monthly basis. The payment is based on a claim submitted by the contractor. The claim needs to be justified with details on where the work has been carried out and the exact quantities completed under each activity listed in the bill of quantities.



Payment Certificate

		% completed	Amount
1.	Measured Works:	23	14,657.54
2.	Deductions:		
	Less 15% Retention	(1) x 0.15	1,099.32
	Other: **Repayment of tools**		1,500.00
3.	**Total Amount Due:**	(1)-(2)	**12,056.22**
4.	Details of previous payments		

Cert No.	Date	% completion	Measured Works	Retention
1	15.07.08	14	9,015.36	1352.25
2	15.08.08	20	12,853.25	1927.95
3	16.09.08	21	13,476.87	2021.53
Total Previous Payment				5301.73

5.	Total Contract Value:		63,007.18
6.	Contract Balance:	(5)-(4)-(3)	15,603.48

At the end of each month, the supervising engineer and the site manager carries out a final inspection to verify that the reported works have been carried out according to prescribed quality standards. During the field visit, the supervising engineer checks that actual progress compares to the monthly site report records. A monthly payment certificate is then issued and submitted to the client for payment.

Store Records

Accurate records need to be kept on all materials supplied to the project and also where and when they are used. These records give details about date, movements (issued or received), quantity, origin and destination. Each entry is signed by the responsible supervisor or storekeeper. At the end of each month, it is common practice to count the contents in the stores and check the current holdings against the records of consumption.

On a regular basis, the project management reviews the contents and quantities of materials stored on site and assesses whether it is sufficient for the projected work activities. Before embarking on new activities, the staff in charge of procurement needs to stock up on necessary materials well in advance of the start of the work. Any items that are no longer in demand should be transferred to other sites or returned to the main store.

Tools Inventory

Tools on site are monitored at two levels, on a daily basis when they are issued to the workers, and as a whole, relating to the total amount of tools on site. The daily recording of tools issued to the workforce is carried out in order to make sure that all the tools are returned when the workers have completed their work. Secondly, the project needs to establish an overview of all the tools available on site in order to assess whether they have the right type and amount for the works taking place.

The tools inventory also records the condition of the tools and keeps track

of repairs and when tools are worn out and need replacement. Similar to the materials records, the tools inventory also provides the details of when tools were supplied to the project. The regular control of tools is the responsibility of the storekeeper.

Vehicle Logbooks

Each vehicle and piece of equipment should have a logbook in which the use of the vehicle is recorded. Information on the consumption of fuel, service and repairs is also noted in this book. For vehicles it is common practice to enter the authorisation for their use in the logbook. Keeping logbooks on the equipment is essential for the purpose of obtaining objective information about the performance of the equipment.

By recording fuel and oil consumption and all repairs carried out, it is possible for the lead mechanic to make qualified decisions regarding the future of the equipment. When the equipment reach a certain age, the owner needs to decide whether it is worth continuing to operate it, whether to carry out a major overhaul, or instead scrap it or use it for less demanding work. Equally, the project management prefers to allocate more reliable equipment with less downtime to activities that are essential to the work progress. The logbooks provide necessary information on the pieces of equipment with the best performance.

Other Site Reports

When culvert manufacturing takes place on site, records are kept on the materials used and the number of workers engaged in this activity. These reports also keep

track of the curing schedules of the batches of culverts being moulded, thus providing the project management with projections on when culvert pipes are available for the work sites.

Similarly, detailed records should be kept for works related to structures such as bridges, drifts and culverts. When bridges are constructed with a piled foundation, the client may insist on keeping records of the piling works.

The results of laboratory test are recorded in specific forms designed for each test. These forms are normally standardised and will clearly show the prescribed quality requirements and compare these with the actual test results.

Each of the reports described above provides a wealth of information. Often, the management is requested to provide summary presentations of progress and costs relating to recent project activities. This information normally contains aggregate figures covering all works since the start as well as data for the most recent reporting period, such as the last month. In order for the regular recipients of such reporting to fully understand the contents of these summaries, it is useful to install a standard for such purposes. This also allows the readers to compare current reports with those prepared at an earlier stage.

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BUILDING RURAL ROADS

Rural roads are the last link of the transport network, however, they often form the most important connection in terms of providing access for the rural population. The permanent or seasonal absence of road access is a constraining factor in terms of providing rural communities with essential services such as education, primary health care, water supply, local markets as well as economic opportunities. The availability of such services and opportunities are difficult to sustain without a good quality and well-maintained rural road network, which provides regular and efficient transport access throughout the year.

Building good quality rural roads is a particular skill in itself, requiring proper planning, experienced supervision, good workmanship and the selection of the correct technology and work methods. Their design and construction need to cater for the common type of vehicle loads and allow access throughout the year and in all kinds of weather conditions. Due to the size and extensive distribution of rural roads, road agencies are under pressure to find low cost solutions that allow authorities to build and maintain an extensive network of roads.

This manual attempts to present a set of technical solutions and work methods commonly applied in a number of countries where the use of local resources is given serious consideration when building rural roads. Its success, in terms of emphasising the use of locally available resources such as labour, tools and light equipment, combined with good workmanship and high quality standards, has given this technology its due recognition. Based on best practices from rural road-building programmes in Africa, Asia and the Pacific, it describes a set of work methods and procedures proven to be effective both in terms of cost and quality.

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