Complete minor concrete works as a BCATS project

Unit Standard – 12933

Level 2, Credit 4

Name: _____

>>B CONSTRUCTIVE

Contents

Published by: **Building and Construction Industry Training Organisation (BCITO)**
Level 5, 234 Wakefield Street
PO Box 2615
Wellington

What You Need To Do

By the end of this module, you should be able to:

- calculate quantities and prepare an order for materials for minor concrete works;
- excavate ground, construct formwork and place hardfill for minor concrete works;
- mix, place, finish and cure minor concrete works; and
- complete work operations.

How you will be assessed

To achieve this unit standard, you need to complete 2 minor concrete works; for example, a path, a slab foundation for a non consent building or garden shed, or a concrete wall of less than 350mm in height. Your teacher/tutor will tell you which project to complete.

You need to show your teacher/tutor that you can:

- calculate materials correctly and prepare an order for materials (including quantities for formwork, aggregates and cement
- excavate ground to meet specifications
- set up formwork correctly
- place hardfill to meet specifications
- mix concrete correctly
- place, compact, and finish concrete correctly
- ensure concrete is cured correctly
- complete all operations safely
- clean the work area and dispose of waste
- clean and store tools, plant and equipment correctly

Glossary of Terms

Term	Meaning
Aggregate	A combination of sand and gravel or crushed rock used to make concrete
Boxing/formwork	Temporary timbers put in place to contain wet concrete until the concrete has set
Builder's mix	A proportional mixture of aggregate and sand available from a builder's supply merchant
Cement	A grey powder made up of limestone and clay, heated to a high temperature and then ground to a fine powder
Compaction	A hand or mechanical process used to consolidate and pack down the materials that will support the concrete slab
Concrete	A combination of cement, water, sand and course aggregate which hardens due to a series of chemical reactions between the cement and water
Damp proof course	A layer of durable vapour barrier to prevent the passage of moisture
Hardcore fill	Compacted medium-sized aggregate, used to support the concrete slab or foundation
Levelling sand	A layer of medium-grade sand placed over the hardfill and compacted down to provide a firm base to support the concrete slab
Perimeter	The distance around the edge
Plant	Equipment
Screed	Level off
Slab	A specific area of specially laid concrete such as a garage or house floor
Subsoil	The underlying ground that supports the concrete
Work operations	How you do a job

Concrete

For any construction job you carry out, it is important to:

- choose and use appropriate personal protective equipment;
- use tools correctly and safely;
- clean the work area and dispose of waste; and
- clean, store and maintain tools, plant and equipment correctly.

Make sure you read and understand any product or tool manufacturer's instructions that come with it before you start using it.

The construction project covered in detail in this module is a concrete path. However, your teacher/tutor could ask you to complete other minor concrete works; for example, a slab foundation for a non consent building or garden shed, or a concrete wall of less than 350mm in height.

Concrete

Concrete is one of the most frequently used building materials. It is used extensively for a wide range of construction work, such as footpaths, driveways and roads, residential and commercial construction – floors and walls; foundations and footings, for posts, fences and block walls; and even boat hulls.

Concrete is made up of aggregate (generally gravel and sand), cement and water, which are mixed together into a plastic mass. The water reacts with the cement, setting off a chemical reaction that hardens the cement and in turn bonds the other components together to eventually create a hard, rock-like material.

The initial plasticity of concrete allows it to be moulded easily into different shapes.

Reinforcing steel

Concrete is an extremely versatile construction material. However, while it has a high compressive strength it is very weak in tension.

Steel has very high compressive and tensile strength.

The combination of steel and concrete as a composite construction material combines the high tensile strength of the reinforcing steel and the compressive strength of concrete.

Steel rods, bars and heavy wire sheets are the most commonly used methods of reinforcing. Their correct placement is critical to the performance of the reinforced concrete.

Concrete production methods

Concrete can be produced using three methods:

- dry pre-mixed bags;
- site mixed with a concrete mixer; or
- ready mixed delivered by truck.

Dry pre-mixed

Dry pre-mixed concrete is purchased in bags, and water is added on the site. It is very easy to use and ideal for smaller jobs, but can be very expensive if producing concrete for larger projects.

Site mixed concrete

Site mixed concrete is normally produced using a concrete mixer.

Ready mixed

Ready mixed concrete is delivered to the site in a concrete mixer truck. This is the most convenient method of producing concrete for large projects, especially if the site can be organised to allow placement of the concrete directly from the truck chute or by using a concrete pump.

Ingredients

The ingredients required to produce mixed concrete are:

Cement is the essential and main ingredient of concrete. It comes in a powder form and, when mixed with water, forms a paste which sets into a hard mass.

There are many types of cement. However, the only type produced here in New Zealand is Portland Cement. This is manufactured at cement works in two locations in New Zealand – Golden Bay (near Takaka) and just out of Westport. The name Portland Cement originates in England after a bricklayer discovered that by mixing clay and limestone, burning the mixture, grinding it into a fine powder and mixing it with water, the mixture would set into a hard mass. Its appearance was similar to the stone quarried at Portland Island on the South Coast of England, and so Portland Cement got its name.

General-purpose Portland Cement is used for most forms of concrete construction. Where the special properties of other types of cement are required (such as low heat hydration) these can be specified and ordered.

Aggregates consist of the stone material (gravel or crushed stone, including sand) which is added to the water/cement paste to form concrete. These usually form up to 80% of the volume of the concrete.

Aggregate should be relatively clean. Dirty or dusty aggregate will tend to require far more mixing water. Strength losses are likely if the higher water content is not matched by correspondingly higher levels of cement input.

Water – Most natural aggregates are a great deal stronger than the cement pastes found in concrete. This means that the mineral glue tends to function as the weakest link. Therefore, the ultimate strength of the hardened concrete is determined by the strength of the cement paste. In turn, the paste strength is governed by the water content of the original mix. The lower the total mix of water used, the greater is the ultimate strength potential.

Only part of the water used to make workable concrete is actually used to hydrate the cement. Water in excess of that required for cement hydration will decrease the ultimate strength of the concrete. Every effort should be made to use the minimum amount of water possible.

Cement is available in bags in a range of sizes, but 20kg bags are very common. Sand and aggregate can be purchased ready graded and mixed as builder's mix.

Proportions

General purpose concrete is made from a mixture of 80% aggregates and 20% cement; for 100 kg of concrete you will need 80kg of aggregates and 20kg of cement.

The proportions of each ingredient must be accurately measured for each batch made, so the concrete strength is consistent throughout the project. Always follow the manufacturer's instructions on the bag when mixing concrete.

Tools and materials required

- Brush or broom
- Compactor
- Groover
- Line level
- Screed – 150 x 50 length
- Spade
- String line
- Wooden float
- Hardfill
- Reinforcing mesh (commonly used: 665 = 150 x 150mm squares of 5.3mm diameter steel; 668 = 150 x 150mm squares of 4.8mm diameter steel) or mesh chains
- Water
- Bucket
- Garden hose
- Hammer
- Rubber boots
- Shovel
- Steel float
- Wheelbarrow
- Cement and builder's mix , or dry premixed concrete, or ready mixed concrete
- Nails
- Timber for formwork (boxing), pegs and braces

Calculating Quantities

Typically you will have to calculate timber for formwork, volume of hardfill and volume for concrete. You should also allow extra for wastage, for example, 10%.

Formwork is ordered in lengths, for example 100 x 25mm rough sawn timber, and is held in place with timber pegs or lengths of steel reinforcing. To work out how much you require, work out the perimeter of the area being concreted.

A path 10 metres long, 1 metre wide and 100mm thick needs to be concreted with general purpose concrete mix.

Formwork

Calculate the lengths of boxing required.

Lengths of boxing (100 x 25mm) = 2 x length + 2 x width
= 20 + 2
= 22 + 10% for wastage
= 22 + 2.2
= 24.2m

Allow for pegs every 300mm and enough nails to attach them to the boxing.

Volume is the amount of space that an object (such as concrete or hardfill) will take up. It is expressed in units cubed (metres^3 or m^3).

Volume can be worked out by multiplying the length of the area by the width of the area by the height of the area (length x width x height, or l x w x h).

Hardfill – *75mm thick*

To calculate the volume of hardfill required underneath the path detailed above:

Volume of hardfill = length x width x depth
= 10.0 x 1.0 x 0.075
= 0.75m^3

Concrete

To calculate concrete required for the path detailed above:

Calculate the volume of concrete required.

Volume of concrete = length x width x depth
= 10 x 1.0 x 0.100
= 1m^3

Aggregate *(builders mix)*

80% of volume of concrete = 1m^3 x 80%
= 800kg
= 0.75m^3

Cement

20% of volume of concrete = 1m^3 x 20%
= 200kg or 10 x 20 kg bags

Preparing an Order for Materials

Use the project drawing or plan to calculate the quantities of the materials required, including:

- the lengths of formwork (boxing);
- timber, pegs and nails for boxing;
- the volume of hardfill required;
- the amount of reinforcing mesh or steel; and
- the volume of cement and builder's mix needed, to make up the required amount of concrete.

When placing an order with a supply merchant for building material, the following information is required. This will ensure that the right material is supplied to the right place at the right time, and the correct information is supplied for budget and accounting purposes.

The order should be clearly written or typed, and include the following information:

- date of order;
- customer's name, billing address and account number;
- job identification or number;
- order number;
- supply merchant's name;
- description of goods required and quantity;
- address where the order should be delivered;
- date and time required;
- any other delivery details; and
- authorised purchaser's signature.

Send the order to the supplier, allowing enough time for them to prepare and deliver it. (You should also keep a copy of the order for your records.) It is a good idea to follow up with a phone call if you do not receive confirmation that the order has been received.

Excavating, Constructing Formwork and Placing Hardfill

Most concreting jobs require some sort of formwork or boxing to hold the freshly poured concrete in place and mould it to the correct shape and size. In some situations, the boxing will be constructed above ground level. In other cases, some excavation will be needed to achieve the required level.

The finished surface that the concrete will be poured on to should be slightly arched. This means the concrete around the edge will be deeper, which provides strength to the structure. Depending on what you are constructing, you also need to allow a slight "fall" so that any water will drain away rather than forming puddles.

It is also important to allow for hardfill and/or concrete when you are calculating how far to excavate.

The finished excavation should also be level and firm, with no loose earth, leaves etc.

An example of the process involved in constructing formwork is described below. The same principles apply to other small concreting projects.

Formwork for a concrete path

Establish a reference height at the highest point.

Using a string line and driven pegs at each end, set out the shape and width of the path, allowing for boxing thickness.

Using the established reference height and the string line, establish the finished height of the path, allowing for a slight slope across the path, away from any buildings, so that water will drain off.

Drive in intermediate pegs to the line of the string line and mark the finished height on the pegs.

Check the alignment of the pegs as this will affect the straightness and shape of the boxing. Any pegs that are loose, out of alignment or in soft ground may require bracing.

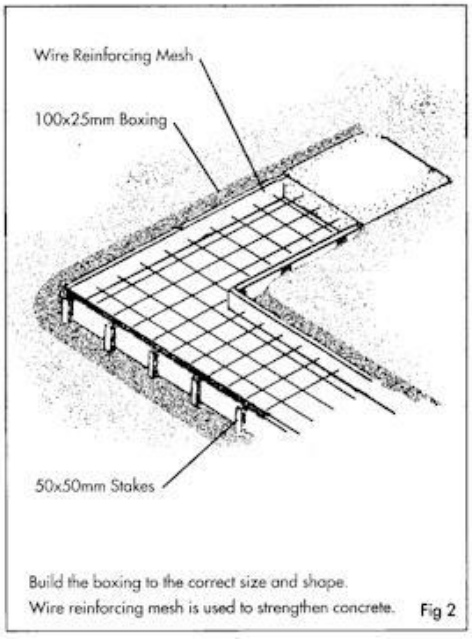
Nail the boxing to the pegs to the correct finished height marked on the pegs.

Placing and compacting hardfill

Hardfill is used to provide a solid, even base to support the finished concrete. If used, hardfill should be placed and compacted.

The hardfill needs to be shovelled and raked into position, taking care not to disturb the formwork. You need to use a special compacting machine to make sure the hardfill is firm and even.

You can then place any reinforcing mesh in position – you may need to suspend this from the boxing or place it on special plastic holders called "chairs".



Build the boxing to the correct size and shape.
Wire reinforcing mesh is used to strengthen concrete. Fig 2

Laying Concrete

When initially mixed, concrete is usually plastic and workable. In simple terms, this means it is able to be placed in the formwork and compacted with relative ease. However, in some cases the concrete is harsh when first made and although capable of compaction by pressure or prolonged vibration, it could not be described as workable. Other concretes are almost fluid, and flow so readily that little compaction is required.

The bulk of the concrete used on construction sites throughout New Zealand is a product which is both workable and cohesive – without being too fluid or over wet. Both workability and cohesiveness are important characteristics of good concrete in its plastic state.

- Workability - determines the ease with which the concrete can be placed and compacted.
- Cohesiveness counters the tendency of the concrete components to segregate during handling and placing.

Influence of water content

For given proportions of cement and aggregates in a concrete mix, the higher the water content, the more workable the concrete will be. However, increased water content will increase the difference in the water/cement ratio and this will reduce the concrete's strength and durability. (It will also increase the potential for cracking caused by drying shrinkage.) Therefore, only very minor adjustments to the workability should be made by adding water only.

Influence of cement content

Because the cement paste acts as a lubricant while the concrete is in its plastic state, the higher the cement content at a fixed water/cement ratio, the more workable the concrete will be. Therefore, it is important that any adjustments to the workability made by adding water should be accompanied by an addition of cement to maintain the water/cement ratio.

Mix the concrete according to the manufacturer's instructions. Make sure you use the correct amount of water, as this affects the strength and curing time of the concrete.

Lightly spray the entire area within the boxing with water. This prevents the fill or subsoil sucking moisture from the concrete, which can affect how well the concrete cures.

Place the concrete inside the boxing, slightly higher than the edge.

It is a good idea to place reinforcing mesh or mesh chains in the top half of the concrete. The mesh controls cracking and holds the slab together if there is uneven settlement of the subsoil or fill.

Tamp the concrete down with a stick. This removes any air bubbles and makes the concrete mass stronger. Check that the concrete at the edges of the boxing is completely compacted, to eliminate any unsightly holes and gaps when the boxing is removed.

Use a 50mm screed to level the concrete. Lay the screed on top of the boxing on each side, and slide it back and forth using a saw-like action.

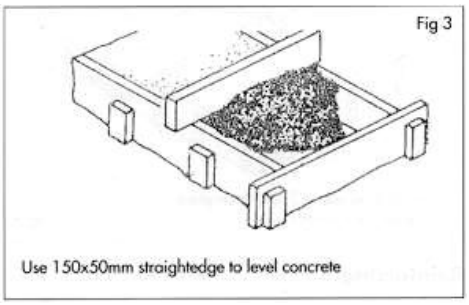

Use 150x50mm straightedge to level concrete

Fig 3

As the water evaporates from the concrete as it dries, it can crack as it hardens and shrinks. Forming crack control joints encourages the concrete to crack in neat straight lines. Effective crack control joints should be one third of the thickness of the concrete slab, and placed about every 2 metres for a path. Use a grooving tool and straight edge, square to the path edge, to form the joints.

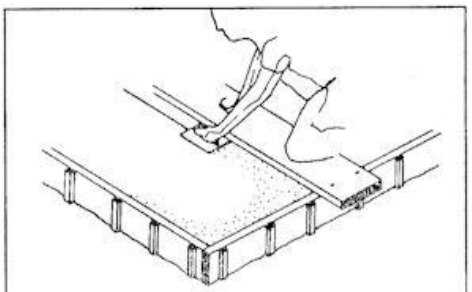
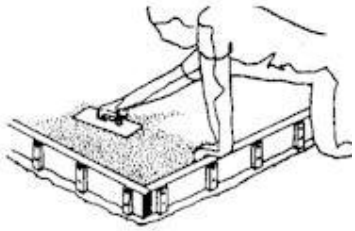

Draw groover along 200x50mm plank to create crack control joint

Fig 5

Once the free surface water on the slab has evaporated, use a wooden float in a circular motion to remove screed marks and fill any gaps between aggregate particles. This produces a rough grip surface.


Wooden float smooths concrete prior to finishing surface.


Steel finishing trowel gives concrete a smooth, even surface

If a smooth finish is required, use a steel float in a circular motion to fill any gaps left by the wooden float. Use a sweeping motion to give a smooth finish without trowel marks.

To produce a non-slip surface of parallel lines and disguise trowel marks, drag a soft broom or brush across the surface while it is still reasonably wet.

Curing Concrete

Curing means controlling the loss of water content from the concrete after it has been placed and while the chemical reaction between the cement and water is occurring. This process happens quite fast over the first few days, while the concrete is hardening, but weather conditions may cause it to take days (even weeks in some cases). The concrete needs to retain enough moisture throughout for the chemical reaction to be completed.

All concrete should be cured to:

- increase concrete strength;
- increase water tightness; and
- reduce dry shrinkage.

During the curing period, the concrete must be kept wet by a range of methods, including:

- ponding;
- repeated hosing;
- sprinklers;
- wet coverings;
- covering with plastic sheets; and/or
- curing compounds.

Curing time depends on the type of construction and the specific requirements for the finished concrete. For a concrete path, the curing time should be about three days.

If the edges of the concrete are exposed, they can be easily chipped, so the boxing should be left on for the whole curing period. At the end of the curing period, the boxing should be removed, denailed, and cleaned by scraping it with a spade to remove any concrete that is sticking to it. This allows the boxing to be reused on the next stage or on the next job.

Activity

1. A concrete path is required measuring 7.8m long, 0.850m wide and 0.100m thick. Hardfill to a depth of 0.075m is needed, along with pegs to support the boxing every 0.5m. Calculate the materials required and complete the following order.

Material	Amount required	Amount ordered (rounded)
Hardfill		
Aggregates		
Cement		
Boxing (metres)		
Pegs		
Nails		

2. When excavating an area for placing concrete, what are 2 things you need to allow for?

3. Why do you need to check the alignment of the pegs holding the formwork?

4. How do you compact hardfill and why?

5. When mixing concrete, why is it important to accurately measure the proportions of each ingredient?

6. Why should water be lightly sprayed over the entire area within the boxing before laying concrete?

7. How and why do you compact concrete?

8. How can you produce a non-slip surface on concrete?

9. Name 4 ways that concrete could be kept wet during the curing period.