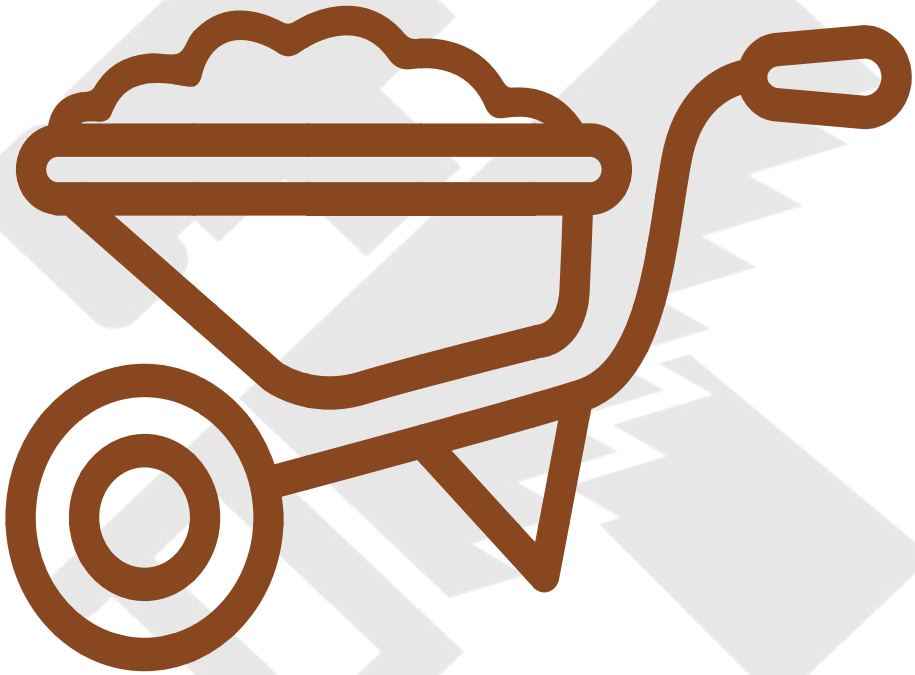
BCATS

BUILDING, CONSTRUCTION AND ALLIED TRADE SKILLS

Basic concrete works



Unit Standard 31813 (v1), **Level 1**

Complete basic concrete works as a BCATS project. 4 CREDITS

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Introduction

This handbook uses two projects as examples of common processes and techniques for basic concrete works. The examples used are:

- making concrete pavers
- making concrete planters.

Your teacher/tutor will decide which concrete project you will do. They may alternatively ask your class to brainstorm to come up with possible ideas or opportunities for your school or community environment or to take home.

Remember:

The projects and construction methods detailed in this handbook are examples only. Your teacher/tutor will provide you with guidance for your particular project.

How you will be assessed

To achieve this unit standard, you need to complete a basic concrete project, such as a planter box, a concrete base for a seat or table, or projects of similar complexity.

You need to:

- calculate the quantities of materials needed
- prepare an order for materials
- measure, cut, and construct formwork to meet specifications
- use/think about relief angles to enable easy extraction of the concrete product once it has cured
- mix concrete correctly
- place, compact, and finish concrete correctly
- ensure concrete is cured correctly
- complete everything 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 materials 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.
Vibration	A hand or mechanical process to ensure the concrete is compacted into the mould and the air is removed.
Concrete	A combination of cement, water, sand and course aggregate which hardens due to a series of chemical reactions between the cement and water.
Plant	Equipment.
Relief angle	Angle placed on the side of a mould to enable the easy extraction of the finished product.
Screed	Straight edge used to level off concrete.
Work operations	How you do a job.

Health and safety

The Health and Safety at Work Act 2015 is designed to:

- prevent harm to employees at work
- promote good practices in health and safety management.

The Act puts responsibilities on everyone to take all practical steps to ensure your own safety and the safety of others.

One way you can help ensure your own safety is to use personal protection equipment (PPE). For this project you will likely need to use:

- hearing protection
- safety boots or covered shoes
- dust masks
- gloves and/or barrier cream
- safety glasses (even if you wear prescription glasses, you must still use safety glasses)
- apron or overalls.

The machinery and other equipment you use can cause serious injuries. You **must** use appropriate guards and safety devices. You **must not** use any machine without the safety guards fitted correctly. You **must** receive training in the use of machines and equipment and apply it when you use them.

Before using a machine or portable power tool, check to see if all cords are in good condition. Also check that the compliance tags are current.

Your teacher/tutor will give you all the operating and safety knowledge you will need to use all the new tools and equipment you will be using

Do not use any tools or equipment until your teacher/tutor tells you are safe to do so.

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
- clean, store and maintain tools, plant and equipment correctly.

Always read and check with your teacher/tutor that you understand any product or tool manufacturer's instructions before you start using it.

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 walls, and even boat hulls.

Concrete is made with cement, aggregate (generally gravel and sand), and water. These 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. Concrete has three different states:

In each state, concrete has different properties		
1	Plastic	When concrete is first mixed it is 'plastic' – it is soft and can be easily worked or moulded into different shapes. Concrete is plastic during placing and compaction.
2	Setting	Concrete begins to stiffen as soon as it is mixed and this stiffening increases when it is exposed to air. The stiffening of concrete, when it moves from the plastic state, is called setting. Setting takes place after compaction and during finishing.
3	Hardening	After concrete has set it continues to gain strength and harden. The properties of hardened concrete are strength and durability. Once the concrete has hardened enough to walk on without leaving an imprint, it is important to give it time to cure to reach maximum strength. This curing process usually takes at least 21 days.

Reinforcing steel

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

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

Steel rods, bars and heavy wire mesh sheets are the most commonly used materials for 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
- ready mixed delivered by truck.

DRY PRE-MIXED

Dry pre-mixed concrete is purchased in bags. 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

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 discussed below.

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.

Fun fact: 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 special properties (such as low heat hydration) are needed, other types of cement may be specified.

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 needs more mixing water. Strength losses are likely if the higher water content is not matched with higher levels of cement.

Water. Most natural aggregates are a lot 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 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.

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, which is a 4:1 ratio.

Moulds normally have thinner concrete than needed for paths and foundations and so it needs to be much stronger to reduce the risk of cracking. Three parts sand to one part cement is typical – a ratio of 3:1.

To keep the concrete strength consistent throughout the project, be careful to accurately measure the proportions of each ingredient for each batch made.

Always follow the manufacturer's instructions on the bag when mixing concrete.

Always wear a dust mask when mixing concrete to prevent inhaling the silica dust in the cement.

Projects overview

The examples in this handbook are projects constructed by Kaiapoi High School's building class. One of these examples use cover sheets to produce formwork for the concrete planter, many of which were gifted to family. The second project is concrete pavers, which were used to create an affordable and quality paved area at the school.

To produce good workmanship, you should follow any plans and instructions carefully at every stage of your projects.

- Make sure you understand how to construct the formwork. If you aren't sure, ask your teacher/tutor.
- Do drawings of your projects. Aside from helping to visualise the finished project, this will help you to identify and select the correct materials.
- Calculate quantities of materials required and make up an order.
- Construct all required formwork to contain the concrete. Always allow for easy dismantling of the formwork once the concrete has set. If making a reusable mould as the formwork, always think about how the set concrete will be extracted.
- Apply all necessary finishes required.

For each construction job you carry out, it's also important to:

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

Common resources

Getting started

The first step is to get the job specifications and a drawing from your teacher/tutor or to create your own. These documents will include the size and design of the concrete project/s and the materials to be used.

What tools/equipment will I need?

You will need to safely use a variety of hand tools and possibly a variety of portable power tools and fixed machinery. Make sure all the tools/machines are available and ready for use when required. Remember to put the battery on to charge after use if you use battery power tools.

Below is a list of equipment used for the planter box example. You may use different ones depending on the project, approach taken, and the resources available.

LIST OF TOOLS AND EQUIPMENT USED FOR PLANTER BOX PROJECTS			
Hand tools and equipment		**Portable power tools**	**Machinery**
→ tool belt	→ spirit level	→ reciprocating saw	→ concrete mixer
→ builder's ruler	→ spade	→ battery drill	→ compound mitre saw
→ tape measure	→ shovel	→ impact driver	→ table saw
→ carpenters pencil	→ crow bar	→ electric planer	
→ claw hammer	→ short timber screed		
→ combination set square	→ edging trowel		
→ roofing square	→ stiff scrubbing brush (for cleaning equipment).		
→ panel saw			

Depending on your school's policy, you might not be able to use some machinery and portable power tools on your own, such as the compound saw. If you are also working towards achieving the Power Tools or Fixed Machinery unit standards, you must still set up the machine for your teacher/tutor to use and to talk your tutor through how to use the machine safely as though you were using it yourself.

Remember that the tools and equipment you use for your project may be different from the ones used in the examples in this handbook.

Preparing an order for materials

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

- the amount of formwork (boxing)
- the amount of reinforcing wire mesh sheets or steel rods, if needed for your project
- the amount of cement and builder's mix needed, to make up the required volume of concrete.

You 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
- 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.

Your teacher/tutor will give you a template of an order form for you to complete once you have calculated what quantities of materials are needed for your project.

Laying concrete

When initially mixed, concrete is usually plastic and workable. This means it is able to be placed in the formwork and compacted with relative ease. It is therefore essential that your formwork or mould is fully constructed before you start mixing the concrete.

Your teacher/tutor will guide you through how to lay the concrete for your project. The basic steps will always include the following:

1. Construct the formwork/mould.
2. 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.
3. Lightly spray the entire area within the boxing with water. This prevents the formwork sucking moisture from the concrete, which can affect how well the concrete cures.
4. Place the concrete inside the boxing, slightly higher than the edge.
5. If using reinforcing mesh or steel rods, place it/them in the top half of the concrete. The mesh controls cracking and holds the paver together.
6. 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 formwork is completely compacted. This will prevent any unsightly holes and gaps being discovered when the formwork is removed.

If you are using moulds, you may wish to spray the formwork with a chemical release agent. Chemical release agents react with the alkaline products of setting cement to form insoluble soaps. These soaps prevent any bond developing between the concrete and formwork, making for a cleaner and easier release of the cured concrete from the formwork.

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 it can take weeks for concrete to reach full strength. 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
- reduce dry shrinkage.

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

- repeated hosing
- wet coverings
- covering with plastic sheets
- curing compounds.

Curing time depends on the type of construction and the specific requirements for the finished concrete.

Keep the formwork on for the whole curing period to prevent the edges chipping. They can be easily chipped if they are exposed before it has cured.

At the end of the curing period, remove the formwork and clean it by scraping it with a spade and stiff scrubbing brush to remove any concrete that is sticking to it. This is important if the formwork is to be reused.

Project 1 - Concrete pavers

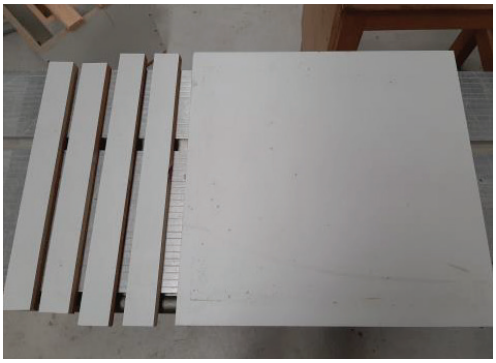
Concrete is such an amazing product to work with. You can mould it into any shape that you wish.

Kaiapoi High School started making their own concrete pavers because they discovered it was going to cost $12 each to buy the 500mm x 500mm pavers needed for an outdoor catering area they had designed for the school's hospitality department. The building class found out who was making pavers and contacted them. This led to the then-owner of Smart Concrete donating ten moulds that had concrete stuck in the corners and providing them with the initial mix to use and the mould release to coat the moulds before pouring the concrete in.

The class then spent a couple of periods cleaning up the moulds and have since made hundreds of pavers. The school has four students, on a rotation system, making two batches a week even when working on projects. Extra pavers made are sold for $6.00 each, which gives the school their own for no cost.

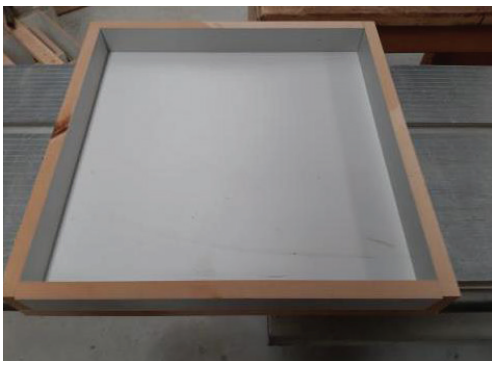
An alternative to purchasing or getting donated moulds is to make your own. In this example the mould is for a 400mm x 400mm x 40mm square paver. However, there is no end to the shape or size that you can make – you are limited only on the area that you want to pave and what decorative features you want to build into the paving layout design.

1. Cut the base and sides. Make sure you have a 4-5 degree relief angle on the sides to help ease the paver out of the mould.



2. Screw the sides to the base. Using screws instead of nails means you can unscrew the sides if the paver gets stuck in the mould. Once it is disassembled it is also a lot easier to clean the components, ready for their next use.

   Using melamine off-cuts for your mould gives a great finish to the surface of the pavers. (Your local kitchen manufacturer may have some they'll be happy to donate.) You can get the melamine in a gloss finish as well as an embossed finish. The embossed finish gives more of a non-slip finish to the paver's surface.



3. When re-using a mould, the first step is to ensure that there is no surplus concrete left in it. Take extra care to get the corners cleaned. Then tip in a bit of mould release and wipe all the surfaces of the mould to ensure the pavers come out clean.

4. Next mix the concrete to pour into the moulds. Making quality concrete is important. These pavers needed to be strong enough to take a lot of school foot traffic while other pavers will need to be strong enough for vehicles. **Read the manufacturer's instructions and follow them.**

   This school used a concrete mixer. (If you don't have one available, making small batches using a concrete wheelbarrow and shovel also works.) They filled ten-litre buckets with the ingredients, partly to make pouring the ingredients easier and partly to help keep the 3:1 ratio mentioned in the 'Proportions' section earlier.

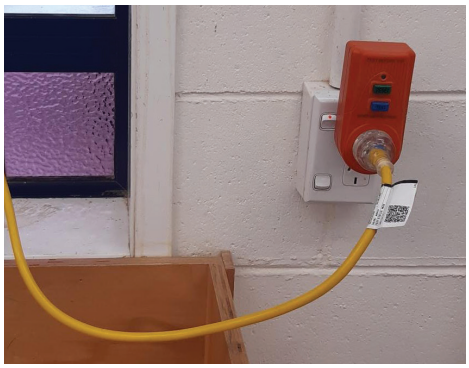
Concrete paveers

- Put in a couple of litres of water in the mixer first to stop the premix and cement from sticking to the bowl.
- Then add the first portion of premix, then enough water to make it a wet mix, and then three quarters of a ten litre bucket of cement.
- The rest of the water and the final portion of bucket of premix can then be added.
- Your teacher/tutor will help you to check that the mix is wet enough to work in the moulds but not so wet it would cause shrinking and cracking when the pavers harden.



Remember to wear PPE when mixing and pouring concrete. These Kaiapoi High School students are wearing safety glasses, dust masks, and gloves and – when the concrete mixer is going – ear muffs.

Safety reminder: Always use an appropriate electrical safety device, such as a residual current device (RCD) or an isolating transformer, when using a concrete mixer.



Wall socket RCD

Multi-socket RCD

→ Make sure the RCD device is plugged directly into the power socket and power cords are positioned so they will not be run over or get damp.

→ Test the RCD device before using electrical equipment.

Never stand in water or allow electrical leads to lie in it even when an electrical safety device is being used.

Concrete pavers

5. Pour the mix into a wheel barrow.

6. Work together to put the mix into the moulds. (An old trowel for this job is just the right size.)
   - Put dollops of it in each corner of the mould.
   - Use fiberglass floats to work it in to all the corners and edges while one of your classmates taps the outside of the mould with a claw hammer. This helps to work the concrete into the corners and edges.
   - Keep adding mix until the concrete is flush with the top of the mould.
   - Do a final check that the mould is full by running a straight edge across the top of the mould.

7. If one is available, place the paver on a vibrating table. This helps to get rid of any air that has been trapped during the filling of the mould.

Concrete pavers

8. Place them on pallets that have been checked for level and double check that the concrete thickness of the pavers are consistent. Pavers all of the same thickness are easier to lay and keep the finished surface height flat and even.

Double checking the paver's thickness.

9. Remove from the moulds once they have hardened enough, which normally takes two to three days. Stack them carefully and allow them to finish curing. Keep them out of direct sunlight during this period and spray them periodically with water to help prevent cracking.

Project 2 - Concrete planter boxes

The concrete planter box in this example has a fielded panel set in each side to add a decorative element to the finished box. You can create this in any shapes you like.

The formwork for these planters were free off-cuts of melamine from a local kitchen manufacturer. Using the off-cuts saved the manufacturer from having to pay to dispose of them and saved more waste from the landfill.

Melamine has a glossy finish that helps give a smooth finish to the surface of the planter. The concrete also comes away easy from the formwork.

Your teacher/tutor will help you select the best available material for your planter box. They may also have different techniques and processes than those below that are more suitable for your project.

Make the outer mould

1. Cut the four sides and the base.
2. Cut the four fielded panels which have the relief angle on all four edges.
3. Measure where the field panels will be on each side and then screw them on.
4. Screw the four sides together, then attach the base.

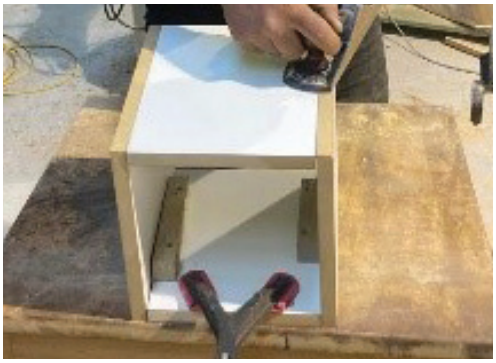



Construct the inside core

5. Construct the inside core of the mould.

   Take care to create a good relief angle on all four sides to allow for easy extraction of the inside core once the concrete has set and cured. It is better to have more angle than less.

   Construct it in an order that will make it easy to take out each piece one at a time. You will need to screw blocks to the base and sides and screw through these blocks so you can then unscrew each piece from the inside with ease.



Checking that all the edges are flush so that when you unscrew a side it will come out cleanly. (Left.) The relief angles on the inside core. (Right.)

6. Screw two pieces of wood across the top of the inside core to support it flush on the outside mould.

7. Once the inside core is set in the outside mould, line it up with an even gap on each side, then screw it in place.

8. Mark the top of the outside mould with reference lines. This makes it easy to re-locate and screw back in place, without having to re-measure, when you take out the inside core to pour the bottom of the mould.

Make the concrete

Only one planter box was being made so the concrete was mixed in a wheel barrow instead of a concrete mixer.

9. When mixing the concrete for planter boxes we increase the cement to premix ratio to ensure a strong result and less chance of the planter cracking while dismantling the mould. We use a 3:1 ratio. When adding the water, be careful to not to put in too much. The least amount of water you can use and still have the mix workable, the stronger the concrete will be and less chance of cracking.



Remember to always use a dust mask and gloves when mixing cement.

Fill the mould

10. Remove the inside mould. This allows easier access to fill the base and to ensure we have complete cover of concrete.

11. Insert and screw in place the inside mould, lining it up with the reference lines you made before you removed it.

12. Fill the four sides, adding a bit to each side as you go to ensure too much pressure isn't put on one side, which would force the inside mould off centre.

13. As it is being filled, ask one of your classmates to compact the concrete with pieces of timber (800mm x 50mm x 25mm) to remove all the air pockets. Ask another to tap the outside of the mould with claw hammers to help settle it in further.

14. Once the mould is full, insert 12mm reinforcing rods in each corner to add strength.

Remove the mould

Wait for the concrete to be ready to be removed from the mould. It will harden enough to do this between three and seven days depending on the weather and the time of the year.

15. Remove the screws from the outside mould.

16. Place a block of wood on the edge of the side and hit it with a hammer to release the side. Sometimes the fielded panel will stay in the side of the planter. If it does, remove it by inserting a screw with the impact driver through the fielded panel. Once it contacts the concrete the panel will pop out.

17. Remove the inside mould by simply removing the components in the reverse order of how you constructed them.