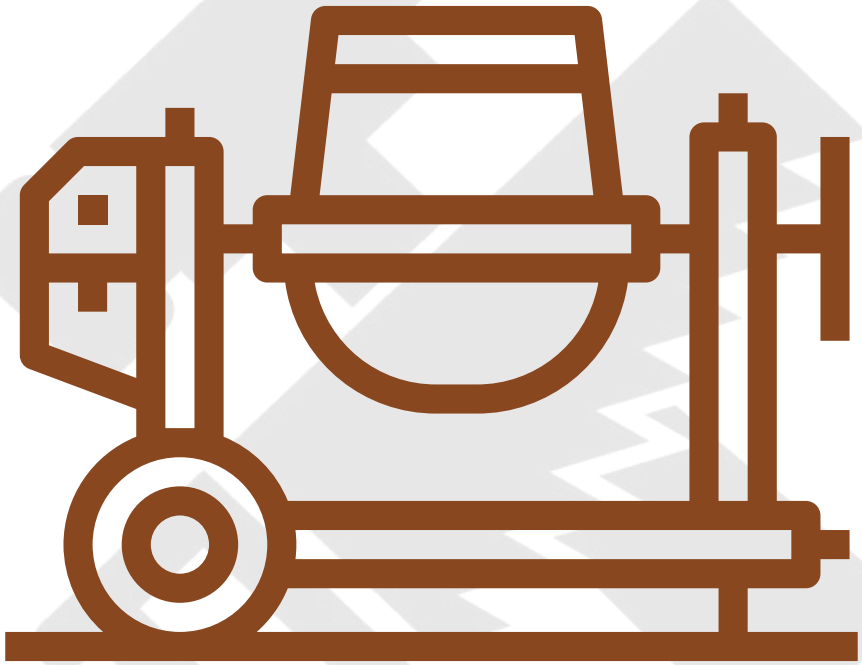
Concrete works

BCATS

BUILDING, CONSTRUCTION AND ALLIED TRADE SKILLS



Unit Standard 12933 (v5), **Level 2**

Complete minor concrete works as a BCATS project.

6 CREDITS

BCITO buildingpeople

Building and Construction Industry Training Organisation (BCITO)

Level 5, 234 Wakefield Street
PO Box 2615
Wellington 6140
0800 422 486
www.bcito.org.nz

Table of contents

	Page
Introduction	4
How you will be assessed	5
Glossary of terms	6
Health and safety	7
Concrete	8
Curing concrete	12
Projects overview	14
Common resources	15
Calculating quantities	16
Preparing an order for materials	17
Excavating, constructing formwork & placing hardfill	18
Project 1 - Outdoor teaching area	23
Project 2 - Curved path	26

Introduction

This handbook is an introduction to excavating, constructing, and finishing concrete projects. It includes two projects as examples of common processes and techniques for laying concrete areas. These concrete examples use an exposed aggregate (or 'exposed ag') finish.

The examples in this handbook are:

- an outdoor teaching area attached to the school library
- paths and patio area around the school Cultural Learning Centre.

Your teacher/tutor will decide which concrete projects you will be doing. You may have the opportunity to brainstorm as a class to come up with possible ideas or opportunities for the school environment or community environment.

Remember:

The projects and construction methods detailed in this handbook are examples only. While the unit standard does not specify that you must use reinforcing steel, some projects will need it for safety and durability. Your teacher/tutor will provide you with guidance for your particular projects.

How you will be assessed

You need to complete two minor concrete works. These minor concrete works may be a path, a slab foundation for a non-consent building/garden shed, a concrete wall less than 350mm in height, or projects of similar complexity.

Your teacher/tutor might give you a work diary to help you record how you made your projects. If you can, take photos at different stages of your projects and of the completed projects.

You need to:

- calculate the quantities of materials needed
- prepare orders for materials
- excavate the ground to meet specifications
- set up formwork correctly
- place hardfill to meet specifications
- mix the concrete needed
- place, compact, and finish concrete correctly
- ensure concrete is cured
- complete all tasks safely
- keep your work area clean and tidy
- 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.
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.
Hardfill	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	Straight edge used to level off concrete.
Slab	A specific area of specially laid concrete such as a garage or house floor.
Subsoil	The underlying ground that supports the concrete.

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
- 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

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:

1. Plastic
2. Setting
3. Hardening

In each state, concrete has different properties		
1	Plastic	When concrete is first mixed it is soft and can be worked or moulded into different shapes. Concrete is plastic during placing and compaction. The most important property of plastic concrete is that it can be moulded easily into different shapes.
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 begins to gain strength and harden. The properties of hardened concrete are strength and durability. Hardened concrete will have no footprints on it. if walked on. Hardened concrete can also be referred to as 'cured'.

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. 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.

Most concrete used on construction sites in New Zealand is both workable and cohesive. 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 only water.

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 more cement to maintain the water/cement ratio.

Reinforcing steel

While concrete has a high compressive strength (is very strong under compression), 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.

Safety tip

Use an RCD device whenever you use electrical equipment outdoors (such an electric drill, skill saw, or a concrete mixer). 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.

Concrete ingredients

The ingredients required to produce mixed concrete are cement, aggregates, and water. Cement is available in bags in a range of sizes, but 20kg bags are very common. Sand and aggregate can be purchased ready graded as builder's mix.

Cement is an essential 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 in New Zealand is Portland Cement. An English bricklayer discovered that mixing clay and limestone, burning the mixture, grinding it into a fine powder and mixing it with water, would result in a mixture that 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 it was named Portland Cement.

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. Aggregates are usually 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.

The proportions of each ingredient must be accurately measured for each batch made. This keeps the concrete strength consistent throughout the project.

Always follow the manufacturer's instructions on the bag when mixing concrete. Always wear a dust mask to prevent inhaling the silica dust in the cement.

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 (and sometimes even weeks) to properly cure. The concrete needs to retain enough moisture throughout for the chemical reaction to be completed.

Curing concrete:

- increases its strength
- increases water tightness
- reduces dry shrinkage.

Concrete must be kept wet during the curing period. There are a range of ways to do so, including:

- ponding
- repeated hosing
- sprinklers
- wet coverings
- covering with plastic sheets
- 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.

Boxing should be left on for the whole curing period. This is because the edges of the concrete can be easily chipped if exposed.

At the end of the curing period, remove the boxing. Remove the nails or screws from it and clean it by scraping it with a spade to remove any concrete that is sticking to it. The boxing can then be reused for the next stage or on the next job.

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.

Projects overview

The examples in this handbook are projects that have all been constructed in consultation with Kaiapoi High School's Level Two building class, the School Principal and Board of Trustees. They are quality, lasting community projects.

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

- Make sure you understand the drawings and specifications. If you aren't sure, ask your teacher/tutor.
- From the drawings and specifications, identify and select the correct materials.
- Calculate the depth required to allow for any compacted hardfill, as well as the concrete thickness required.
- Excavate the area. It is always good to excavate before ordering the concrete. You may need to use some compacted hardfill if the excavation is deeper than the required concrete thickness (hardfill is much cheaper than concrete). If the sub soil is soft you will need to excavate deeper to add compacted hardfill to give a good base to pour the concrete.
- Calculate quantities of materials required and make up an order.
- Construct all the formwork needed to contain the concrete. Think about how you can easily dismantle it once the concrete has set.
- Lay any required hardfill and compact it, place any reinforcing metal required, and pour the concrete.
- Apply any 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. If you get the opportunity to help prepare one or both sets of the drawings and specifications, remember to 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. The actual range will depend on the approach taken as well as the resources available.

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.

LIST OF TOOLS AND EQUIPMENT USED FOR CONCRETING PROJECTS			
Hand tools and equipment		**Portable power tools**	**Machinery**
→ rubber boots	→ stiff broom/brush	→ saber saw	→ concrete mixer
→ builder's ruler	→ spirit level	→ battery drill	→ plate compactor
→ tape measure	→ Dumpy level/laser level	→ impact driver	→ compound mitre saw
→ carpenter's pencil	→ grubber	→ electric planner	
→ electrical leads	→ spade /shovel	→ angle grinder with diamond dry wheel (for expansion joints)	
→ RCD	→ crow bar	→ skill saw	
→ claw hammer	→ timber screed		
→ combination set square	→ floats (fibreglass, steel, bull)		
→ roofing square	→ edging trowel		
→ cross cut saw	→ concrete rake		
→ sledge hammer			
→ string line/chalk line			

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 *angle grinder with the diamond wheel*. If this is the case, you must still set up the machine and talk your teacher/tutor through how to use it as though you were using it yourself.

Remember that the processes and machinery you use may be different from the ones used in these example projects.

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.

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

Calculations for task above

Formwork	
Boxing (100 x 25mm)	= 2 x length + 2 x width = 20 + 2 = 22 + 10% for wastage = 22 + 2.2 = 24.2m
Pegs + nails	= peg every 300mm = enough nails to fix pegs to boxing
Hardfill (volume) * 75mm thick	= length x width x depth = 10 x 1 x 0.075 = 0.75m³
Concrete (volume)	= length x width x depth = 10 x 1 x 0.100 = 1m³
Aggregate (builders mix) 80% vol of concrete	= 1m³ x 80% = 800kg = 0.75m³
Cement (20% vol of concrete)	= 1m³ x 20% = 200kg or 10 x 20kg bags

*** Volume** is the amount of space that an object (such as concrete or hardfill) will take up. It is expressed in units cubed (metres³ or m³).

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).

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
- the volume of cement and builder's mix needed, to make up the required amount 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.

Excavating, constructing formwork, and placing hardfill

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

The surface 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.

Excavation

The area must be excavated to the correct level before you start placing the concrete.

Calculating the amount of excavated material

Depending on the area being concreted, the amount of material excavated can be significant. It then needs to be removed from the site, either by wheelbarrow to another area close by or by filling a skip or bin which is then taken away by truck.

As with all compact material that is loosened, the actual volume can also increase by varying amounts, depending on:

- the method used to excavate
- the type of material being excavated
- the moisture content of the material.

This is called the bulking factor. Soil has a bulking factor of between 10 to 30%

Example

Calculate the volume of excavated material, plus a bulking factor of 20%, for an area measuring 5.4 metres x 2.1 metres with a total depth of excavation of 220mm.

Calculation

Volume	= length x width x height = 5.400 x 2.100 x 0.220 = 2.494m³
Bulking factor	= 2.494 x 20% = 0.498

Excavated material (volume)	= 2.494 + 0.498 = 2.992m³ Approximately 3m³ to be excavated and moved from site.

Testing the sub-grade

The sub-grade is the underlying ground. Test the sub-grade's firmness by walking it and stamp your heel into it, or use a piece of reinforcing steel and push it end on into the sub soil.

Its firmness will determine how thick the base course should be. Soft sub-grade needs a thicker base course than hard sub-grade and so has to be dug out deeper."

Excavated to the required depth to allow for the thickness of concrete to be poured. If you find that the subsoil is still of a very soft nature you may have to dig deeper, add hardfill, and compact it.

The excavation depth will depend on what you are concreting and what the sub soil is like. For example, if you are concreting a low retaining wall 350mm in height x 150mm wide for a garden, you would want to excavate at least 250mm below the ground level to ensure that the retaining wall does not lean over once the garden soil is placed behind the wall.

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

Formwork

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

1. Establish a reference height at the highest point.
2. Using a string line and driven pegs at each end, set out the shape and width of the path, allowing for boxing thickness.
3. 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.
4. Drive in intermediate pegs to the line of the string line and mark the finished height on the pegs.

5. 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.

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

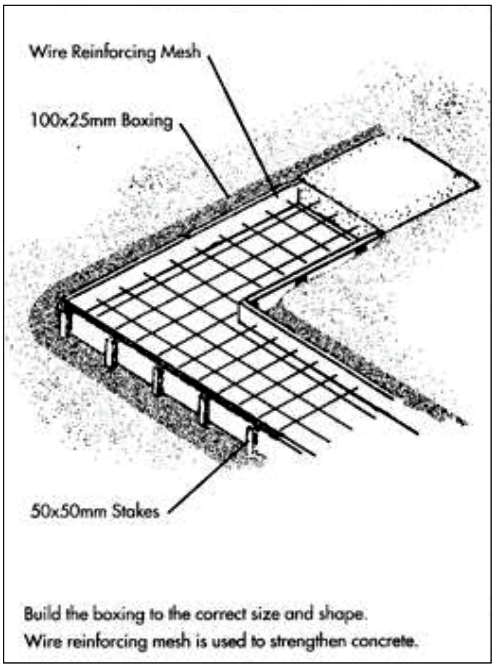
Placing and compacting hardfill

Hardfill is used to provide a solid, even base to support the finished concrete.

7. The hardfill needs to be shovelled and raked into position, taking care not to disturb the formwork.

8. Use a special compacting machine to make sure the hardfill is firm and even.

9. 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". The mesh controls cracking and holds the slab together if there is uneven settlement of the subsoil or fill.



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

Laying Concrete

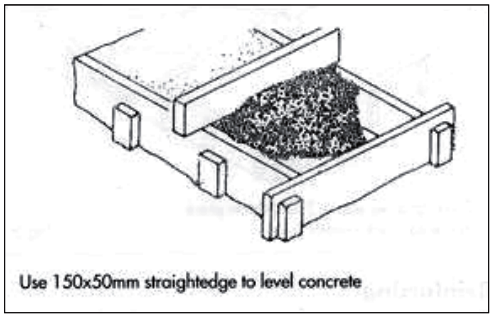
10. Mix the concrete according to the manufacturer's instructions. Make sure you use the correct amount of water, as this affects the strength and curing time of the concrete.

11. 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.

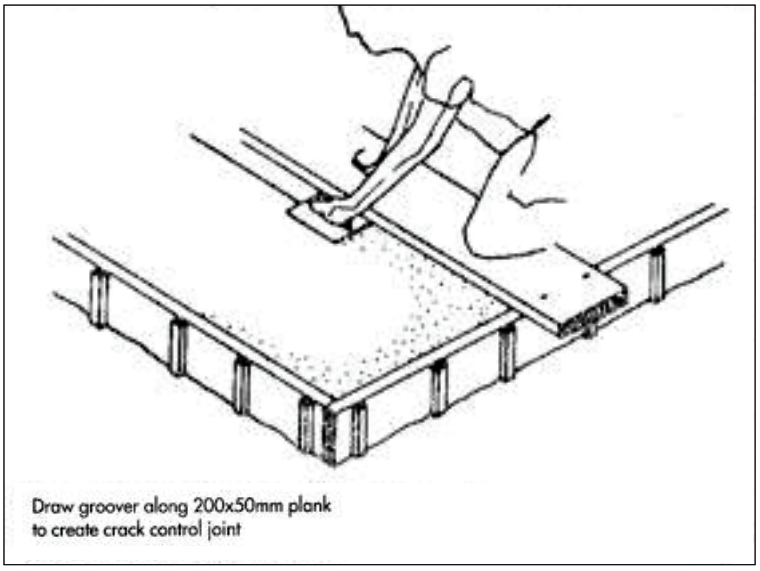
12. Place the concrete inside the boxing, slightly higher than the edge.

13. 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.

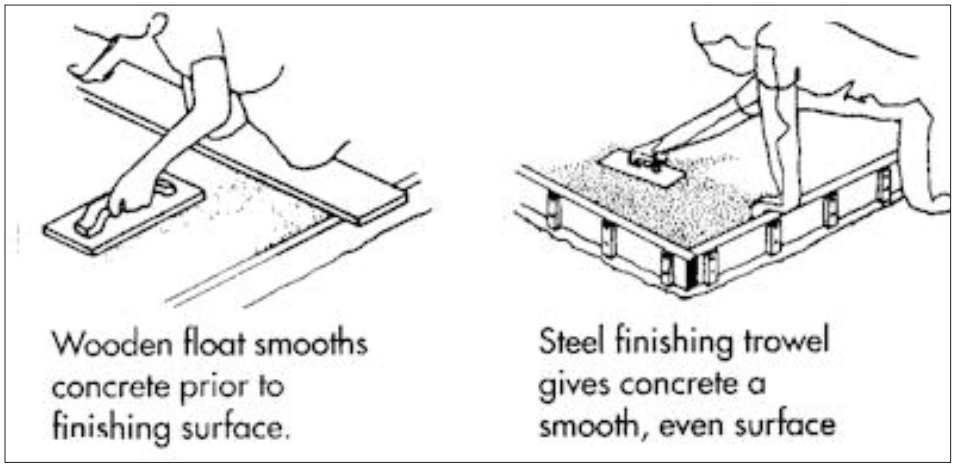
14. Use a 50mm screed to level the concrete. Lay the screed on top of the boxing on each side, and slide it back and forth using a saw-like action.


Use 150x50mm straightedge to level concrete

15. Use a grooving tool and straight edge, square to the path edge, to form crack control joints. 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.


Draw groover along 200x50mm plank to create crack control joint

16. 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.



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.

17. 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.

Project 1 - Outdoor teaching area

The design of this project includes a combination of poured concrete, with an exposed ag finish, and pavers. The finished concrete and paving area had to be the same height as the foundations on one edge of the project area. Students worked together to design and plan the project. This had the extra benefit of everyone understanding what needed to be achieved and why.

Set the site out

1. Set up all the profiles needed to pull string lines for all of the edges of the required concrete paths.
2. Hammer the pegs firmly in.
3. Set up the dumpy level and shoot a common height on all the pegs. The datum height (reference height) for this job is the top of the neighboring foundations.
4. Once these heights are on the pegs, screw the top edge of horizontal boards flush with the marks on the pegs. Then put nails in these boards to take the strings. The nails need to be in line with the edges of the paths.

5. Check the dig out depth, allowing for any required hardfill and thickness of concrete, and then dig out.
6. Box the formwork up to contain the concrete and place all required reinforcing steel.

   When pegging the boxing, stretch a string line between the profiles at each end of the path. It is a good idea to also lift the string line to the height of one of the tongues on a builder's rule. Use this as a feeler gauge at each peg when putting the screw through the peg to hold the boxing. This helps you get a perfectly straight line by stopping the line of the string from touching at any of the pegs or boxing.

Pour the concrete

This project used 13mm exposed ag mix from Ready Mix, delivered by a local supplier straight from the truck. Included in the mix was 5kg of black oxide to every meter of concrete to give the finished surface a nice dark look.

Kaiapoi High School always pours their concrete at about 5am. This enables them to get on the surface with the water blaster about lunch time in the summer, or about 2pm in the winter.

7. Have a person working each end of the screed and at least two people on concrete racks to level out in front of the screed. This helps to keep the screed light enough to move. Working together like this helps the spreading of the concrete to happen quickly – the longer the concrete is out of the truck, the harder it is to work.

   Don't add unnecessary water. It can cause the concrete to crack from shrinking, it reduces the finished strength of the concrete, and takes longer for the concrete to set.

8. Once the concrete is level, scatter coloured pebbles evenly over the surface.

9. Use a bull float and large fiberglass hand floats to flatten the surface again.

10. Tidy up the edges with an edging trowel.

11. Apply the concrete retarder to the surface using a garden knap sack sprayer. The job of the retarder is to stop the top 5–6mm of the surface from setting hard.

12. Waterblast once the concrete is firm enough to walk on without leaving footprints. It is important to keep the spray end of the gun back from the concrete surface. You can always move closer but if you start too close you will blow holes in the surface of the concrete.

Make sure that one student helps by holding the hose clear of the concrete's surface.

Water blasting removes the top 5-6mm of the concrete to expose this project's coloured pebbles.

13. Remove the boxing once the concrete has cured. Use the water blaster to clean the removed boxing and stack it safely away, ready for the next job. Strapping the boxing and the pegs stops them from twisting and makes tidy stacking easy.

14. After 3 or so weeks the teacher, with students watching from a safe distance, washed the entire surface of the exposed concrete with a hydrochloric acid solution. This burned off all the white lime that leached to the surface of the concrete. He then used a water blaster to clean off the surface, being careful to ensure no run off went into storm water drains or onto any plants or grass.

15. Once the surface is completely dry (preferably the next day) and before any dirt or leaves get on it, apply two coats of clear sealer. Some of your classmates will need to use brushes to do the corners and the edges. Others need to use rollers and paint trays for the main surface. Safety precautions include using PPE and trying to plan it for a day with a steady breeze to reduce inhaling sealer vapour.

Project 2 - Curved path

This curved path and patio area project was around Kaiapoi High School's Cultural Learning Centre. Most of the concrete areas had straight sides, which involved the same processes as in the first project example.

However, either side of the main entrance is a curved strip of exposed ag to edge where pavers would be laid. The processes below focus on how to make concrete strips curved.

Think about the height. For this project, the main path fell 300mm over its length and they had to ensure that the paved areas did not hold water when it rains. To ensure the water would run off, the curved boxing was slightly higher than the path at the same distances as it moved away from the building. This was so that water would run out onto the main path, then out on to the driveway, rather than towards the building.

1. Dress the boxing down to 10mm thick. This is to make it flexible enough to pull it around the shape that we wanted to create.

2. A lot more pegs are needed to hold thin boxing into a curved shape than needed for straight edges. Work together, with some holding the boxing at the shape needed while others hammer in the pegs.

3. Once all the main pegs are in place, some students need to hold the boxing length by length to the required height while others use impact drills to screw the boxing to the pegs.

4. Once all the boxing is place, put a bracing peg on the main pegs to stop the weight of the concrete spreading the boxing apart as it is poured.

Curved path

5. Form two runs of D12 (12 mm in diameter) reinforcing around the curves. Keep them 50mm inside the boxing and 75mm below the surface of the concrete. This prevents the reinforcing steel from being exposed to the air and rusting.

6. Add horizontal braces across the top of some of the pegs, from inside to the outside, to wire the reinforcing in place for the pour.

7. Excavate, place hardfill, and pour and set concrete in the same way as for the first project.