

SMALL-SCALE CONCRETE

WORKSHOP NOTES

copyright © Andrew Goss

not to be reproduced without permission

781 2nd Ave W., Owen Sound, ON, N4K 4M2, Canada. gossdes@bmts.com

Concrete is an artificially engineered material made from a mixture of portland cement, aggregates (such as sand or gravel) and water. It is the most commonly used construction material in the world. It is strong, cheap and durable. Portland cement combines with water (hydrates) to bond the aggregates together into a solid whole. Portland cement is made from heating limestone and chalk, combined with silicates.

PORTLAND CEMENT:

Portland cement holds the aggregates together and is available in different grades and colours. The type you can buy at the local hardware or lumber store is grey in colour. White portland cement has the tetracalcium aluminoferrite removed, resulting in a pure white powder, with no loss of strength.

AGGREGATES:

STONE: Crushed stone or gravel can range in size from 1/4" to 1". For small-scale sculpture you probably won't need any larger than 1/4" or 5mm. You may not need it at all unless cost is a factor: stone is cheaper than cement. Stone adds strength in larger work and also controls shrinkage.

SAND: Sand should be "sharp" – that is, have sharp edges, so that the cement grabs it. It is usually called sharp sand, brick sand or mortar sand. The grains of pit run sand or beach sand are usually too round.

FINE: Stone dust, a waste product from quarries or stone works, can be added to smooth mixes for small-scale work. It adds strength (?), reduces shrinkage on setting, and may add to the visual appearance of the concrete. Limestone (dolomite) or marble dust are two types of stone dust.

EXTREMELY FINE:

SILICA FUME: A waste product, this admixture is from metal smelting. It is a very fine dark grey powder. Particle sizes are 1/100 the size of portland cement particles. If used at about 8% by weight of the portland cement it can double compressive strength, reduce permeability, increase density. Difficult to handle as it is very fine, and makes the wet mix "sticky". Difficult to source.

METAKAOLIN: Metakaolin (used at about 8% by weight of the portland cement) can double the compressive strength of the concrete, lowers permeability and increases density and also makes the mix creamier, less sticky, and is plain white. Particle size is smaller than cement but bigger than silica fume. It is a fairly new additive and may be difficult to find. One brand is *Metamax*.

PLASTIC FIBRES:

Fibre additives, such as *FiberMesh* and *Fiber Ad* (polypropylene or nylon) are chopped (about 1/2", 1 cm) strands of plastic that disperse into the wet concrete mix preventing shrinkage cracks as the concrete sets. On a very small scale the fibers also add a small amount of tensile strength. They are almost invisible in the final product and can be burned off the surface with a torch. New: **PVA fibres** (polyvinyl alcohol - not widely available) have a better bond with cement and increase tensile strength. Their effectiveness decreases when used with latex or acrylic liquids.

GLASS FIBRES:

Glass fibres added to a concrete mix must be alkali resistant, or the alkalinity of the cement will eventually break them down. Their purpose is to add tensile strength to the concrete, replacing steel reinforcing in special circumstances. This makes them a useful addition for art work where the concrete might be cast in a space where steel reinforcing could not be used, or in thin-walled forms. ARGFs, such as *Cem-FIL*, are typically 12 mm long, and are folded in to the wet mix.

STEEL REINFORCING:

Steel is the most commonly used reinforcing to give concrete tensile strength having the same expansion and contraction as concrete. In construction projects it is used as rebar, 1/2 to 1" diameter rod. Smaller art projects can use much thinner steel rod or wire. There are also varieties of galvanized steel meshes or screens available, e.g. expanded steel mesh used as a stucco base can be cut with metal snips (carefully). There are other square grid galvanized hardware cloths, 1/4", 1/2" and so on. Chicken wire, used for fencing, is also a flexible and easy to use material if used in multiple layers.

AIR ENTRAINERS:

Air entrainers are used in concrete that may be exposed to frost, or repeated freeze-thaw cycles. They work by creating tiny air bubbles in the wet mix. *MicroAir* is one brand. Very small quantities are used. Recommended only for large outdoor work.

SUPER PLASTICIZERS:

In mixing concrete you try and get all the dry particles in the mix to be wetted, yet using as little water as possible – water not chemically combined stays in the dry mix and causes weakness. Plasticizers help to wet the surfaces, enabling the mix to use less water. One brand is *Pozzolith*. Tiny amounts are used. Recommended only for larger outdoor work.

ACRYLIC or LATEX:

Acrylic or latex additive is sometimes used in concrete, adding it to the water first. It acts as a plasticizer (to use less water, see above), increases strength, water impermeability and adhesion (for example, when adding a surface to an older piece of concrete). Highly recommended – particularly acrylic – for small-scale work.

PIGMENTS AND DYES:

Pigments or dyes can be added to the mix, or applied to the surface of set concrete. Special dyes are made for this purpose because common pigments can be broken down by the alkalinity of the cement. The range of colours are in the earth tone range: black, grey, brown, ochre, dark red. Blues and greens are available but costly for large projects. Pigments are available as liquids, or as powders. Concrete can also be surface coloured with acid stains which penetrate slightly, or opaque stains made for outdoor use. The latter has a wide range of colours, but some may not be long-lasting.

SEALERS:

In some circumstances it is advisable to seal the concrete surface to reduce water penetration, which aids frost resistance and resists acid rain.

ACRYLIC: Most of the readily available sealers are acrylic-based. Some may affect the surface finish leaving it glossy. They may also yellow slightly over time, and need renewing if used outside.

SILOXANE: Silane or siloxane sealers combine chemically inside the concrete leaving a natural surface. Siloxane does not change the surface appearance of the concrete. The solvents in these sealers demand a lot of ventilation.

V-SEAL: *V-seal* types are water-based penetrating sealers for concrete, claiming to be more effective over time than the siloxane or silane sealers. This "highly modified catalyzed potassium hybrid" is clear and odourless and works by chemically combining with any free lime in the mix, to "form a gel. The gel then hardens and consequently densifies the concrete, decreasing the moisture permeability and porosity." (*manufacturer's quote.*) If the concrete is bad quality or very porous this sealer may not work well and you might be better off with the older acrylic or vinyl sealers.

GENERAL COMMENTS:

Mix the dry ingredients first.

If you are using liquid additives, add them to about half the water first, add that to the mix, then add water until the mix is right. This way all the additives are in the mix.

Always use as little water or liquid as possible; the less water the stronger the concrete. A casting mix has to be wet enough to slump into place, just barely, with vibration. A mesh mix should have no slump.

After 24 hours, concrete **needs** water. Keep the work covered with plastic, damp, for a week.

Some shaping and sanding can be done 12-24 hours after the pour. Patching holes, or adding layers should be done within 24 hours for a complete bond, but can be done up to three days later (less bond strength).

More info?

<http://www.makersgallery.com/concrete/>
Concrete Handbook for Artists: Technical Notes for Small-scale Objects; Andrew Goss

SUGGESTED CONCRETE MIXES by volume

Very Small Scale (jewellery)

1 tbsp stone dust (screened, limestone or marble)
1 tbsp portland cement (grey or white)
half tsp metakaolin
pinch fibres
(optional) 1/2 to 1 tsp metal filings (silver, bronze)
acrylic or latex solution (full strength)

Mesh Sculpture (applied in layers, trowelled)

This is a mix suitable for outdoor use. (**Alternate mix**)

1.5 litres (**3 L**) sand (sharp, brick or mortar sand)
1 litre (**2 L**) portland cement
175 ml (**500 ml**) stone dust (screened)
80 ml (**250 ml**) metakaolin
1/6 tsp (**1/3 tsp**) air entrainer
1/2 tsp (**1 tsp**) super plasticizer
1 to 2 tbsp (**3-4 tbsp**) fibres
water (as little as possible) or acrylic admix (if you use acrylic admix [dilute 50:50 with water], you don't need air entrainer or super plasticizer)

Cast Sculpture (poured or placed in a form)

Basically the same mix as above, but you can add washed crushed stone, size depending on the size of the casting. (**Alternates in brackets.**)

8 to 16 litres (**none**) crushed stone (can leave out)
8 litres (**1 L**) sand
4 litres (**1 L**) portland cement
half litre (**250 ml**) metakaolin
80 ml (**2 tbsp**) fibres
1 tsp air entrainer (**50:50 acrylic**)
4 tsp super plasticizer (**50:50 acrylic**)
water (as little as possible) or above acrylic sol'n

Smooth Coatings

To rub into cracks or holes, or as a final smooth layer.

300 ml portland cement
150 ml stone dust (for smooth you can leave this out)
40 ml metakaolin (if no stone dust, increase to 80 ml)
acrylic or latex solution (full strength and as little as possible)

HAZARDS:

Cement can be hazardous. It is caustic when mixed with water and not cured. This means it will attack your skin. Wear protective gloves and glasses. The dust, either from mixing or sanding dry concrete, is toxic (chromium contaminants, silica dust causing silicosis, cancer, allergies). Wear an appropriate mask (one approved for toxic dust). Always wet sand rather than dry sand whenever possible. "Allergic dermatitis" means that once you develop a sensitivity to cement, in the form of a skin allergy, you may not be able to use it any more. So use preventive measures. Always read the MSDS information on your materials.

updated February 2006