TECHNICAL BULLETIN

SOURCES OF GROUT DISCOLOURATION REAL AND PERCEIVED

INTRODUCTION & SCOPE

One of the most common complaints that our technical advice hotline receives is discoloured and patchy cementitious grout. The response of the complainant is nearly always that our grout is faulty, but this simplistic assertion ignores the fact that we have a Quality Control regime which is intended to pick up this type of issue. When we receive the dry grout powder to test, we always find that it mixes normally and dries to a consistent colour. Therefore with the exception of a few unusual circumstances, the problem is related to something which has happened on site. There can be a number of causes of this phenomena and this bulletin will look at the issues involved.

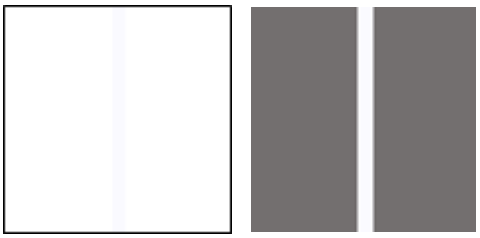
COLOUR DOES NOT SEEM TO MATCH SAMPLES

NATURAL MATERIALS

The grouts are made from materials including cement and coloured oxides. These are based on natural substances and there can be a degree of variation in both the raw feed stocks and hence finished product. This can lead to slight variations in the colour of the grout itself, and the colour quality control at manufacture is actually a range of values, not a single fixed colour measurement.

VISUAL PERCEPTIONS

In some cases there is a visual illusion where the colour of the grout does not to seem to be right when adjacent to the tile. For example, DUNLOP supplied a grout product that came in two different shades of white. Though both looked white, one in fact was slightly blue-grey (blue gives better contrast), but this was not always apparent till put up against a white tile. It is a good idea to try and compare the tiles and grout at the time of purchase.



These two examples show what effect can occur with a faintly blue-white grout such as white against different coloured tiles

It is also important to recognise that fluorescent, incandescent and natural light will all change the perceived colour of an object. The most accurate colour comparisons are done under sunlight, but it may be necessary to compare samples under the light in use at the site.

Below are three examples of the same colour but what can happen when viewed under different lighting conditions.

SAMPLE SWATCHES

The printed colour swatches on the grout packaging are for information only and are restricted by the printing process and may vary from the mixed colour.

The powder grout in the bag is usually a pale colour which is predominantly due to the cement. The mixed colour is darker and different in tone, so the powder shall not be used as an indication.

SHELF LIFE

When grouts have exceeded their recommended shelf lives, the changes in the cement component due to ageing can result in unpredictable colour effects. Some colourants may also alter with time.

Grout passed its shelf life shall not be used for this reason, as well as possible problems with cement curing.

NON UNIFORM JOINT DEPTH

When tiles are laid and properly bedded, the adhesive is squeezed between the tiles into the grout lines. Part of the process is to clean the excess adhesive out of the grout lines; when the tiles are properly bedded, the adhesive squeezes between the tiles and into the grout lines. Part of the laying process is to remove this excess adhesive, preferably whilst it is still soft. However, it is not unusual for this not to happen, and then the next day, the grout is placed into the gaps and finished.
Another effect which occurs, is that because the adhesives are supposed to be applied with a notch trowel and the notch lines are rarely completely collapsed to make a continuous adhesive bed, you have an alternating pattern of

Under fluorescent lights

Natural light

Under incandescent light

adhesive and voids under the tile. Heavier beds applied with larger notch trowels make both situations occur more easily.

What happens next is shown in the attached photo of a complaint, and the explanatory schematic diagram (Figs. 1-3 on the next page). As the grout dries at varying thicknesses in the grout lines, the chemical reactions for cement occur differently, in part because thinness vs thickness changes the way the water stays in the grout to react the cement, but also due to the differing properties of the adhesive vs any voids and exposed substrate. Where the grout is thinner it dries lighter, and where thicker dries darker. This pattern is then reflected in the grout and you end up with a set of zebra stripes in the grout lines. The intensity of this colouration pattern varies, but is pretty easy to spot with darker grouts.

Uneven tile glaze on edges

This can result in variations in colour due to differences in moisture absorption by the tile. This can be limited by misting the edges of the tiles with a fine water spray prior to grouting.

Installation & Site Moisture Issues

The grout application can have a bearing on the final colour due to both practice and site conditions.

Over-watering

The grout is designed to be mixed with a certain ratio of water to form a soft paste of roughly creamy consistency that holds its shape like toothpaste. Where the installer has added too much water, this can alter the colour due to both alterations in the cement properties and also separation of the colouring oxides from the mix. Also, the excess water takes longer to dissipate from the grout leading to apparent darkness, however the final resultant grout can be paler than expected, and also streaky or blotchy in appearance.

There is no simple remedy to this problem other than re-installation.

Poor mixing

If the grouts are badly mixed, then the colours can be variable because the colourants are not properly dispersed through the grout.

Ensure grouts are thoroughly mixed before application and mixing should be sufficient to ensure water is absorbed. The grout powder is added to water and mixed to achieve a consistent paste, let stand for 3 minutes, restirred and then applied.

Contamination

As trivial as it may seem, Dunlop has seen examples of grout colour complaints that resulted from using dirty mixing buckets. Always use a clean bucket, and drinkable water.

Efflorescence

Efflorescence (which means "to flower out" in French) is the loss of water (or a solvent) of crystallization from a hydrated or solvated salt to the atmosphere on exposure to air. This is a physical condition that occurs where water soluble salts rise to the surface and then when the water evaporates the salts deposit out as a powdery or crystalline crust. There are two types of efflorescence:

Primary Efflorescence

> "Primary efflorescence typically occurs during the initial cure of a cementitious product. It often occurs on masonry construction, particularly brick, as well as some firestop mortars, when water moving through a wall or other structure, or water being driven out as a result of the heat of hydration as cement stone is being formed, brings salts to the surface that are not commonly bound as part of the cement stone. As the water evaporates, it leaves the salt behind, which forms a white, fluffy deposit, that can normally be brushed off". (http://en.wikipedia.org/wiki/Efflorescence)

These salts mainly come from cement based substrates such as the floor slab, adhesives or grouts.

Secondary efflorescence

> Secondary efflorescence does not occur as a result of the forming of the cement stone or its accompanying hydration products. Rather, it is usually due to the external influence of concrete poisons, such as chlorides or mobile carbonates. This 'saline' solution is absorbed into the concrete, where it can begin to dissolve cement stone, which is of primary structural importance. Virtual stalactites can be formed in some cases as a result of dissolved cement stone, hanging off cracks in concrete structures. (http://en.wikipedia.org/wiki/Efflorescence).

In areas of high water table and rising damp these salts can come from the ground water and contain chlorides and sulphates.

Grout

Efflorescence is typically associated with the grout lines due to these being more porous than the tiles although the efflorescence may have come from other cement based sources.

With grout, efflorescence is typically

Figure 1.

An example of light-dark shading in grout lines due to apparent varying thickness of grout

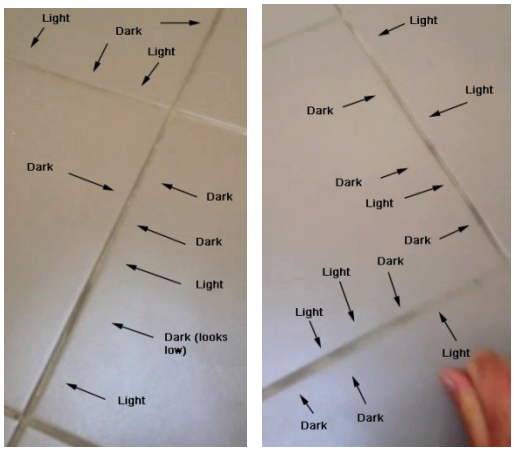


Figure 2.

Schematic diagram showing how the light dark shading effect occurs

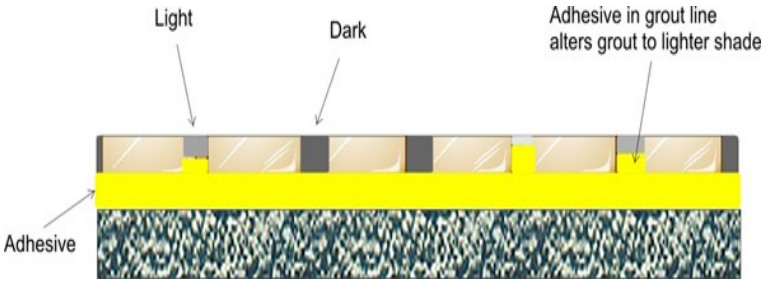
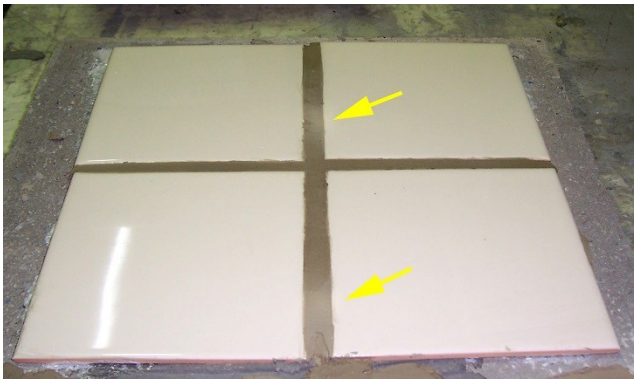


Figure 3.

An example of grout shading deliberately created in a laboratory trial, by not fully removing the adhesive from the notch lines. The areas of thin grout are arrowed. Note that the horizontal line of grout is correct colour. This test grout came from another site complaint



whitish in colour and results from soluble Calcium salts being deposited. It can be blotchy or produce an overall light colouration. Primary efflorescence occurs immediately and secondary occurs at a later date.

Dark coloured grouts are more likely to show efflorescence due to colour contrast and *all* cement based materials can show efflorescence.

Efflorescence occurs due to several conditions and is made worse by cool temperatures and overall dampness, therefore winter and coastal or very humid environments are more likely to show efflorescence.

Sources

Where the tile installer has used excess water in both mixing the grout and also clean up, soluble salts can be leached from the grout cement (this also applies to the tile adhesive) and then deposits on the grout surface as drying occurs.

Cool temperatures at the time of installation both prolong cement curing and also retards water evaporation. This can increase the likelihood of efflorescence.

Where there is ground water, rising damp or damp slab, soluble salts can move with the ground water, or be

leached from the slab, tile adhesive or grout and deposit on the grout, since this is the most porous area for evaporation to occur. Efflorescence may also appear on porous tile surfaces and brickwork. Ground water and rising damp are beyond the scope of this bulletin, but should be addressed as they lead to other more serious problems.

Rain water running down tiled facades between the masonry walls and the tiled surface can generate significant efflorescence on the grout lines. Run off can also create efflorescence on the edges, but also within the field of decks and verandahs (Figs 4a-4b and 5) on next page.

The tile grout has been applied too soon after the tile adhesive which has not fully dried. The moisture from the tile adhesive then leaches through the grout carrying soluble salts which deposit at the surface.

The slab or screed was not dry, or insufficiently cured and then moisture travels up through the grout.

Figure 4 below shows some examples of secondary efflorescence.

Solutions

i. Stick to the correct water mixing ratios during installation.

ii. Check that the slab or screed is properly cured and dry. Slabs typically take 28 days to cure, though drying is typically 25mm per month (1mm per day) of slab thickness.

iii. Screeds take around 7 days to cure, and dry around 1mm per day.

iv. Check that rising damp is not present.

v. Try to work at temperatures above 10^0C and have adequate ventilation to promote water evaporation.

vi. Allow adequate curing times for the tile adhesive.

vii. Where rising damp occurs a sub-floor membrane may be required.

Cement derived efflorescence can be washed off by several processes -

viii. Where it is light, use of a white nylon bristle brush can loosen the powder enough to be vacuumed up.

ix. Where the efflorescence is slight to medium, scrubbing with a white bristle nylon brush and several water washes should progressively remove the deposits. A more aggressive method is to use white vinegar (commonly around ~5% acetic acid) which will neutralise the deposits and dissolve them. Thorough water rinsing is required afterwards.

x. Use of commercial efflorescence removers. Follow the manufacturers recommendations.

xi. As a last resort only, medium to heavy efflorescence may require more vigorous methods of cleaning. This involves using a dilute solution of Hydrochloric Acid (<5%) and a stiff white nylon brush. The acid will need to be neutralised afterwards either by household Ammonia or 10% Sodium Carbonate solution (10gms 'washing soda' dissolved in 100ml water).

xii. All treatments are then followed by water washing to remove the residues.

WARNING – WHEN USING HYDROCHLORIC ACID (MAY ALSO BE CALLED MURIATIC ACID OR SPIRITS OF SALTS) , IT IS COMMERCIALLY AVAILABLE IN APPROXIMATELY 32% SOLUTIONS WHICH ARE HIGHLY CORROSIVE AND ALSO RELEASES IRRITATING ACID VAPOURS. READ ANY MATERIAL SAFETY DATA SUPPLIED BY THE ACID PRODUCER.

NEVER ADD WATER TO ACID WHEN DILUTING THE ACID. ALWAYS ADD ACID TO WATER WITH STIRRING.

WEAR SAFETY EYEWARE, PREFERABLY GOGGLES. IF THE ACID GETS INTO THE EYES, WASH IMMEDIATELY WITH FLOWING WATER FOR 10 MINUTES AND SEEK URGENT MEDICAL ATTENTION.

WEAR PROTECTIVE RUBBER GLOVES.

SUPPLY GOOD VENTILATION TO REMOVE ACID FUMES.

THIS ACID WILL READILY ATTACK UNPROTECTED STEEL, ALUMINIUM AND MAY ALSO MARK STAINLESS STEEL.

IN ADDITION SOLUTIONS MAY REACT WITH CONTAMINANTS IN SOME TILES (SUCH AS UNGLAZED TERRACOTTA AND BRICK) AS WELL AS ATTACK CONCRETE PAVERS, TILES AND CEMENT MATRIX TERRAZZO.

DISCOLOURING UNDER SEALERS

Where a sealer has been applied too soon after the grout has been installed, the moisture from the grout, and probably the adhesive can rise to the surface under the sealer and produce colour variations and patchiness.

The grout and adhesive must be allowed to cure and fully dry for at least 14 days before sealers are applied.

COLOUR LEACHING IN POOLS

Where a coloured grout has been used in a pool or chlorinated pond, the chlorine acts as a strong oxidiser or bleaching agent and will over time fade the grout colour. Therefore Ardex does not recommend the use of coloured grouts other than whites in these situations.

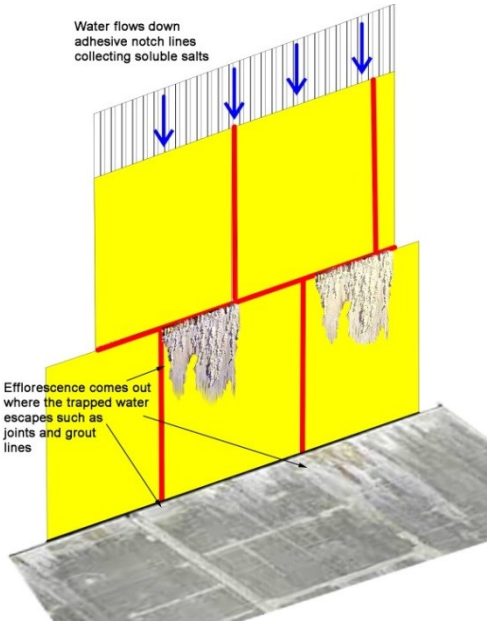
Note: Bromine compounds used in spas are even more aggressive than chlorine chemicals.

MOULD GROWTH

Mould and algae are ancient forms of plant and well adapted to survival. Black

Figure 4a-b.

An example showing how secondary efflorescence can develop in a masonry wall due to movement of moisture under the tiles, and in contact with cementitious materials. This problem is not caused specifically by the grout.



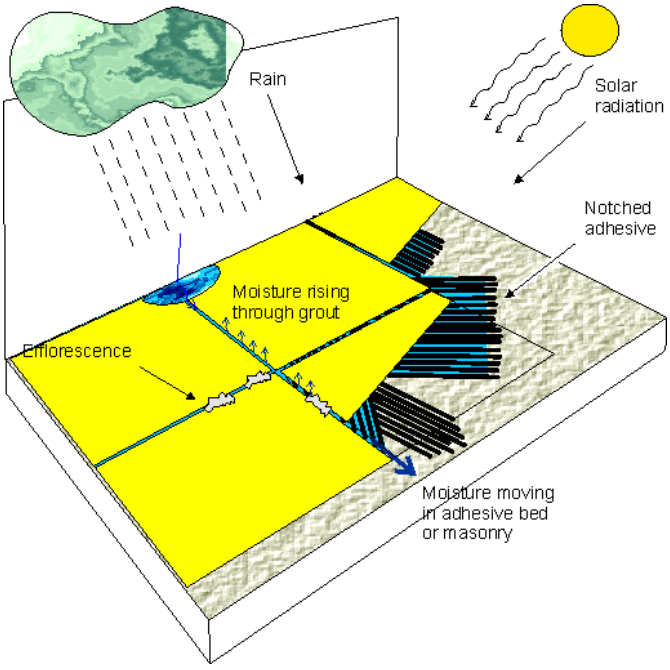


Figure 5. Another situation where water trapped in adhesive voids moves down the falls, or even ponds, and collects soluble materials. Solar heating of the tile surface drives the dissolution more aggressively and then encourages re-deposition of the salts rapidly where the water can escape.

mould can grow on the grout surface where the installation is dirty, the area is dark and ventilation poor.

The simplest solution is to clean the surfaces regularly, and have adequate air movement to allow moisture to disperse.

CONTAMINATION

Dirt and other rubbish can change the grout colour due to settling on the grout before it dries, or from dirty tools and/or work areas. Always ensure tools, mixing containers and work areas are clean before starting the job.

Never add extra colourants or other additives not approved by Ardex as these can alter the grout properties in unpredictable ways.

CLEANING

Cement based grouts are porous even when they contain additives such as grout booster. As a result they can discolour over time with cleaning, and this is particularly noticeable where the grout is a light colour.

Use of excessively concentrated acid when cleaning will cause severe discolouration and decomposition of the grout.

RESOLUTION OF THE PROBLEM

So when conducting a grout inspection, and any of these problems are present, the first thing to do is mix unused material with the customer and then show that it dries correctly (leaving them a piece and taking the other half). This reinforces the argument that site issues are involved, not faulty grout, an example of such a complaint is shown in Fig.6.

Other actions may be required such as replacement or the use of an epoxy grout paint.

NOTES

Always refer to the product data sheets for specific usage details.

The information contained herein is to the best of our knowledge true and accurate.

No warranty is implied or given as to its completeness or accuracy in describing the performance or suitability of the product application. *Users are asked to check that the literature in their possession is the latest issue.*

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GLOSSARY

Overwatering-When mixing the grout mortar, addition of water that exceeds the recommended amount by more than around 5%can result in problems with the grout.

Rising damp-Moisture which rises from the surrounding ground into the masonry construction.

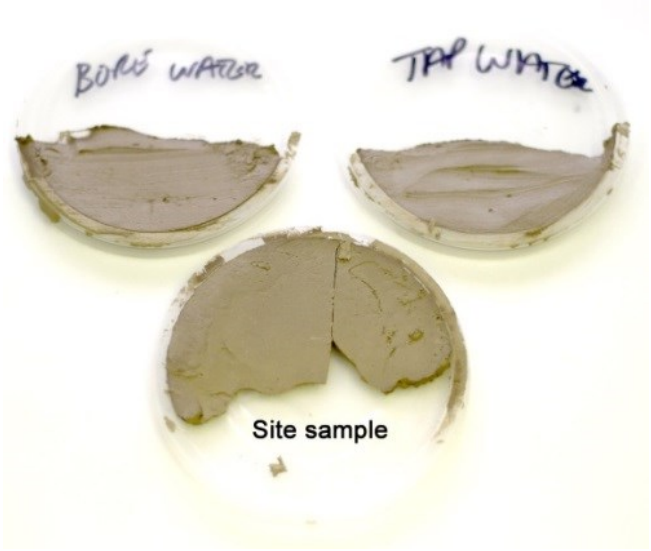

Figure 6.

Examples of grout from a site complaint to check colour fidelity. As can be seen, the samples are consistent colour, including the sample mixed with bore water. This grout is the same as the complaint in Figs., 1 and 2.