

BY PETER HARTOG

FRACTOLOGY & BEYOND

WHAT TO DO WHEN THINGS START CRACKING UP

In this invited two part paper, Peter Hartog of Building Diagnostics Asia Pacific analyses the tricks of the trade employed by building consultants, who are asked to investigate cracked or drummy expanses of floor or wall tiles. Peter brings a touch of humour to a problem which continues to occur all too frequently.

THE BACKGROUND

Tiling fails when tiles crack, fall apart, come loose from their substrates (a.k.a. *backgrounds, beddings, adhesive layers*) or stain indelibly in ways that don't satisfy designers, specifiers, building owners and tenants. When tiles crack, buckle, heave, blister, crumble or fall and the ordure (metaphorically speaking) of unhappy clients hits the fans of consumer and trade practices tribunals and courts, it helps to know why the tiling is failing in the first place.

That's not always as easy. Arbitrators' inspections of distressed tiling in shopping malls, hotels and luxury apartments have been known to attract holiday-time crowds of enlightened general purpose experts, Dispute Resolution Consultants, professional polymaths, leather-elbowed Adjunct Senior Lecturers, far-flung free-lance technical representatives and anonymous interested on-lookers, all acting on behalf of different parties in dispute and all miraculously holding, with equal conviction, mutually exclusive and contradictory explanations for the problems at hand.

It is amazing how often a modest assemblage of simple physical evidence can be construed to point simultaneously to structural movement, excessive substrate dampness, moisture expansion of tiles, errors in the specification and/or mixing of adhesives, miscellaneous poor workmanship, mislocation of movement joints, premature traffic on recently finished tiling, rolling loads and impact damage from poorly maintained and overloaded supermarket trolleys thereafter, shock waves from abandoned Russian space stations re-entering the atmosphere over Easter Island and the phenomena of plate tectonics when combined synergistically with membrane stresses in high wind conditions and late night shopping, diurnal temperature movement, and brine.

Arguments between experts often display more skills of confabulation and sophistry than experience of construction and familiarity with deductive logic. During lulls between litigated claims, several eminent experts in this field are known to supplement their incomes by writing light romantic novels and science fiction. One is reputed to draw storyboards for Pokemon cartoons. I personally have been unable confidently to relate dislodgement of bathroom wall tiles to

delayed effects of the Chernobyl nuclear disaster, holes in the ozone layer or the El Nino oscillation. Nevertheless, I live in hope that one or more of the multi-disciplinary Building Consultants and Inspection Services listed in the Yellow Pages phone books of our major cities (currently six pages worth in Sydney alone), will eventually take the necessary leaps of faith, lateral thinking and professional indemnity insurance. Should that occur, the context will probably be *A Very Large Claim Indeed*, i.e. one in the category where costs of exhaustive expert investigations and legal fees associated with running the dispute, through a formally costumed and adjudicated hearing, will exceed the cost of complete rectification of the alleged defects by a factor exceeding 2.75 plus 10% GST.

It should be recalled that the reason Humpty Dumpty was not put together again, is that the teams of contending experts appointed by solicitors for all the King's Horses and all the King's Men, did not reach a consensus as to cause and liability before the defendant walling contractor was driven into receivership and exile - to Australia as it so happened - by legal and expert witness fees. This was one of the very clear lessons of the Dumpty Royal Commission (1782-1787) and the legislative reforms still foreshadowed to follow.

Before variously accredited experts, forensic investigators (a recent and splendidly erudite addition to the cast) and ambivalent grey-suited Body Corporate Botherers arrive to complicate and obfuscate the issues, a beleaguered tiling contractor facing such problems might consider using simple and logical methods to eliminate a few of the less likely explanations for tiling failures. As the British tiling authority Sherlock Holmes reflected on deductive method in his seminal text book on hard finishes, *The Sign of the Four*:

How often have I said to you that when you have eliminated the impossible, whatever remains, however improbable, must be the truth?

On a related theme, the celebrated French ceramicist and monographer Maupassant observed that:

In everything there is an unexplored element, because we are prone by habit to use our eyes only in combination with the memory of what others before us have thought about the thing we are looking at. The most insignificant things contain some little unknown element. We must find it!

This is, admittedly, a fairly free translation of Maupassant's epigram. The fundamental message, however, is clear. Start from first principles and small details. This article, and another in the next issue of *Tile Today*, explain some of the principles and practices by which to distinguish different causes of failures in ceramic and natural stone tiling and paving. And in putative experts' opinions.

THE TRICKS OF THE TRADE

This is, more or less, the start of the serious part of this discourse. Editor please note. The first essential task in any investigation is to survey and record the details and distribution of distressed tiling as objectively, accurately and consistently as possible. This should be done **before** anyone starts looking for general or characteristic patterns

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of failure and before tiles are pulled, lifted or prised away. Consistency requires that all involved in the survey have some common criteria for distinguishing cracks, for example, as variously straight, curved, severe, minor, wide, narrow, tapered, stepped, bifurcated, radiating and so on.

Graph paper of various grid sizes is very useful for producing quick and reliable diagrams of rectilinear grids of wall and floor tiles. It is important to establish a consistent routine for identifying separate tiles. For example, one might use letters of the alphabet top-down to designate courses of wall tiles and numbers from left to right to designate vertical rows. Tile 22MS-D7 would thereby be a unique designation easily correlated to the seventh tile, from the left hand corner, in the fourth course below ceiling level, at the south wall of the Men's Toilet on Level 22. Note: In practice, numbering and counting from the top course down is easier than from the bottom course up. The exception is where the top courses step or ceilings slope.

Coloured Post-It and similar notes, particularly those which don't immediately curl up from one edge and flutter away, are useful for labelling courses and grids in a survey. Felt-tip markers can be used to write directly onto glazed tiles but care must be taken when wiping away the dried ink. Otherwise grouted joints can be permanently stained. For a very large survey of walls of recurring dimensions, such as all the tiles in toilet walls of a high-rise commercial office building, it is worthwhile making a graduated flexible plastic or fabric tape which can be attached to walls with adhesive or suction cups. BDAP has altered normal soft measuring tapes for this purpose. In the course of one investigation, more than 250,000 wall tiles were tapped for drumminess and examined for cracks. Another involved about 30,000 large tiles in a community swimming pool.

A technique developed by BDAP, and used successfully for recording the progressive spread and patterns of drumminess in wall tiling of a 65-year-old bank headquarters undergoing refurbishment, adapts supermarket price labelling guns to apply colour-coded paper dots to tiles at the perimeter of affected areas. The paper dots have a deliberately weak contact adhesive and come with a small part of the edge folded back to make removal easy. The strength of the adhesive is critical. Conventional pricing labels use very strong adhesives, so that they cannot be easily removed.

When dealing with such large numbers, it is essential to set up a rational and reproducible system by which to identify every tile in the installation. A pocket compass, perhaps clipped to a camera shoulder strap, helps maintain consistent orientation. The orientations of walls shown on architects' and other consultants' drawings are not always accurate or consistent. Site North as shown in floor plans for a particular building may actually be close to north-west or north-east. That only becomes a cause for confusion when different investigators rely on street directories, compasses or intuition, because they do not have or need access to the original drawings. This may seem trivial, but in a current dispute over failures in a facade, two consultants differ over the number of failures in each elevation, because they have used different north points in separate uncoordinated surveys. Just think of the cost of debating that matter in the presence of a clutch of solicitors and barristers.

Once a wall or floor is properly gridded-up (or down), the survey can commence. Loss of adhesion is one of the most common causes of disputes in tiling, so tapping to detect shallow voids or delamination is an obvious and simple survey method. Or so it seems. Intact well-bedded tiles and pavers give different sounds, when tapped, than do tiles and pavers above shallow voids (a) between the tile and the adhesive layer, or (b) between the adhesive layer and the bedding layer or render, or (c) between the bedding layer or render and the load-bearing background, or (d) along cleavage planes within weak mortar bedding layers, or (e) combinations of all of the above. Sometimes the only reliable conclusion that can be drawn from tapping alone, is that adhesion has failed somewhere immediately below. Thin wall tiles, locked in place and compressed by surrounding tiles, can seem sound even when almost fully delaminated. Sound wall tiles over sound render can sound hollow, because adjacent tiles or nearby render have dislodged.

The possibility of detecting the depth of a plane of delamination becomes much more complicated, where thick

pavers are fixed over thick sand-cement mortar beddings of differing densities, strengths, levels of saturation and edge contact with grouted joints. Evidence submitted in an arbitrated dispute over pavement failures in a building in Bourke Street, Melbourne, cited the *distinctive bonking sound* generated during the witnesses' surveys. In the transcript, this was perceived as *bonquing*, possibly a recent French variation of an ISO standard method. Again, the only valid conclusion that can be drawn in many tapping surveys of floor and paving, is that the system has failed somewhere in its depth.

It is theoretically possible to use sophisticated electronic instruments to locate the depth of a void in paving, by measuring the timing or decay in energy of a reflected sound impulse. In practice, the time and cost required to calibrate such instruments for accurate location of voids between relatively thin layers, will probably exceed the duration and expense of a full-blown Supreme Court hearing and one or two protracted High Court appeals. Some consultant *guruwallahs* claim to be able to identify the depths of voids precisely by tapping with rubber mallets and broomsticks. I have certain misgivings. Furthermore, the erection of voodoo altars and ceremonial sacrifice of chickens, evidently integral to the success of this technique, has much potential to alarm building owners, tenants and passers-by. In short, tapping alone is very useful to identify the general plane area and extent of distress, but it should not be relied upon to locate the depth of delamination. The latter requires that sample tiles be extracted in ways that do not further confuse the issue. Sampling for evidence will be covered in the second instalment of this article.

An amazing variety of off-the-shelf tools and home-made devices are used for tapping surveys. The number of undamaged Australian 50 cent coins in circulation appears to have declined of late, in inverse proportion to the rising number of disputes over drummy tiles. BDAP's advice is that it is not strictly illegal to use the coinage of the realm for this purpose up to the point at which manifest damage would become reasonably discernible to the average competent practitioner, regularly conducting tapping surveys of a similar scale in a similar environment. However, the resulting deformation of faceted rims of 50 cent pieces, is known to cause their rejection by the new generation of parking meters and vending machines in hotel toilets. This subject receives more attention in a forthcoming QUALICER Conference paper. Panel beaters' hand tools and the dense resin handles of screwdrivers are useful. Black rubber handles can leave thin smears on tiles and should be avoided. A quantum leap in this technology has recently seen the welding together of two resin-handled screwdrivers to provide a double-handled tool with a reach of 90 centimetres. Golf balls, dropped onto paving or epoxied to flexible telescopic car

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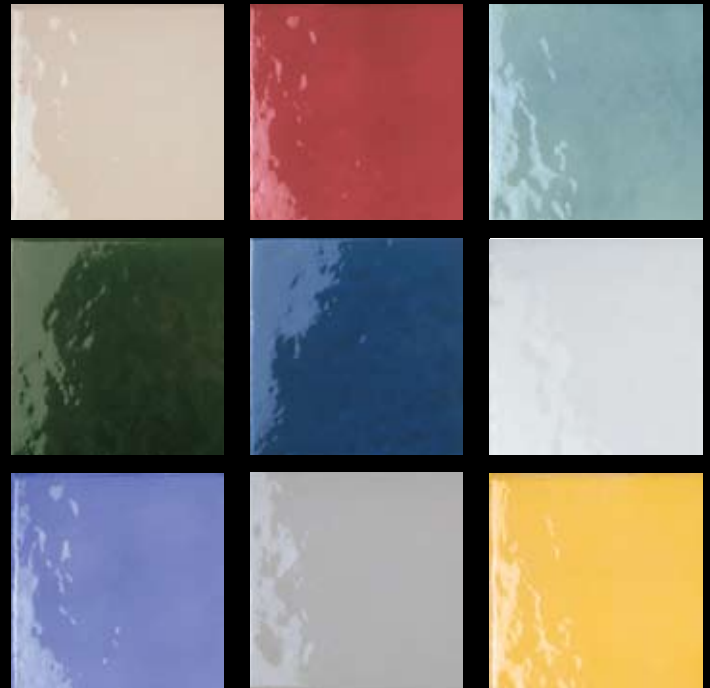
radio aerials, have actually been used for tapping granite pavers on the podium of a Sydney office development and shopping centre. Their use tends to mark the surveyor as either a superior person who plays or is closely acquainted with the game of golf or a dangerous martial arts fanatic. Head butting walls and knee-dropping onto tiled pavements have been observed in the field but are not recommended; they are probably signs of intense frustration rather than orthodox investigative techniques. Above all, allow for some quick and cheap trial-and-error to match the tapping tools available to the size and depth of tiling, in order to achieve a sufficient and distinctive resonance - the characteristic *bonking sound*.

Should a tile be recorded as drummy if a hollow sound emanates only from one edge or from say the centre 25% of its area? That could be the difference between an isolated but tolerable lapse in adhesive coverage and the slow propagation of delamination. Much depends on the purpose of the survey. BDAP's earlier advice, on distress transmitted through dense plastic spacer crosses embedded in joints (see *Tile Today* issue 26, page 44), was partly based on surveys in which 200 x 200 tiles were tapped 13 times in a consistent sequence. This is a quick path to madness, but it did demonstrate that drumminess was propagating from corners of otherwise sound wall tiles. A survey is often intended to establish only the perimeter of large affected areas, so a broad-brush approach, in which a resin handle or similar tool is rapidly swept across wall or floor tiling surfaces within the identified perimeter, may suffice.

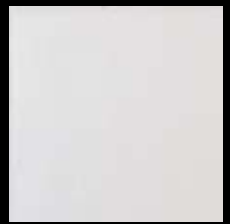
When the extent of drumminess has been determined and recorded on grid paper and similar survey sheets, those sheets will probably be soiled, crumpled and contain doodles and extraneous information. Photocopy the sheets, file them securely for future reference and consider whether it is worth redrawing the survey results for submission in formal reports and evidence. Never risk loss of the original sheets.

It may still be necessary to take photographs of whole walls and small details, such as fine patterns of cracking, displacement of grout in joints and slight, but significant lippage between abutting pavers. Photography from a position close to perpendicular to a wall of glazed tiles, using a conventional camera with an attached flash, tends to produce bright and indistinct images of the reflection of the flash. The best way to photograph planes of light-coloured and glazed tiles is to use an off-camera flash, which illuminates the subject from an acute angle. Sideways lighting accentuates differences in the smoothness or level of a seemingly flat surface. This requires either separate floodlighting or an off-camera flashgun, i.e. one attached to the camera's hot-shoe by a long flexible cable, or fired by an infra-red signal or flash from an on-camera source. We are talking serious money at this level. Unless one has regular use for such sophisticated equipment, the combination of a camera on an inexpensive tripod, fast film (say 400 ASA) and a small portable floodlight is normally sufficient. Another technique, also worthy of experiment, is to diffuse direct flash light with a neutral density filter, or even a piece of tissue paper taped onto the flash.

Conventional colour print film is cheap and processing fast. Some failure investigators use digital still cameras, which have the advantage of near-instantaneously confirming that

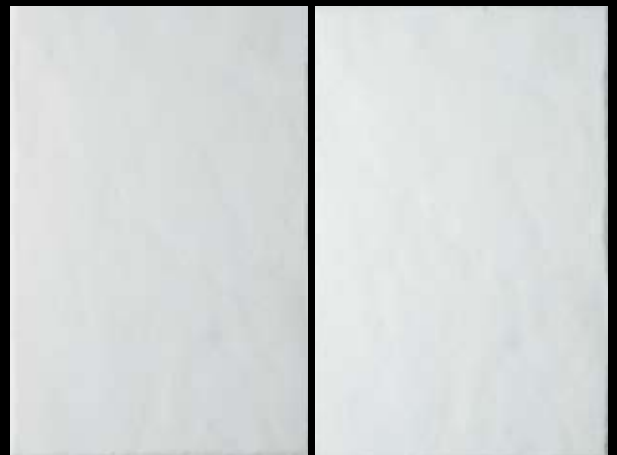


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you have recorded what you need. It is not unknown to discover, a day or two after arranging access to photograph disputed defects in a building protected by irascible property managers and anguished owners, that conventional photographs don't show the necessary detail. It's even worse when a cherry-picker or scissor-lift was hired for the occasion. I am, however, one of the vast majority who have reason to suspect that digital cameras are an abomination unto the deities of most major religions, are assembled by slave labour in the Kurile Islands and are often contaminated by millions of virulent micro-organisms known as *pixels*. A more serious objection is that few digital cameras yet permit the use of mapping-quality wide-angle lenses, high-resolution macro-lenses such as a Minolta AF-100 and many useful accessories. Digital images are also amenable to computer enhancement or degradation, which some courts might come to regard as verging towards the outer limits of ethical behaviour. The popularity of digital cameras for this purpose is bound to increase.

By contrast, the use of video cameras, even those with single-frame capture facilities and gyroscopically-stabilised lenses, will hopefully decrease. Few amateur videographers can resist excessive fast zooming and painfully slow panning which, in combination, may induce vertigo or hypnotic states in unprepared viewers. If the subjects were in themselves exciting, the results might be tolerable. However, poorly sequenced and unedited ten minute cinema verity documentaries of distressed tiling, usually accompanied by hesitant and spontaneous voice-over commentaries - *This is the, er, other side of the part near the bit that you saw a minute ago to the left, no, right, of the, er, balcony tiling* - are of interest only to a very perverse cult audience.

In the known universe, there is only one subject for photography recognised as more boring than a flat expanse of plain monochrome wall and floor tiling, whether it be drummy, cracked, stained or not. That subject is plasterboard. The investigator who does not correlate the subjects and sequence of photographs during the site survey stage may later be confronted and perplexed by scores of seemingly indistinguishable images. The best solution is to have some unambiguous information within the image that identifies the intended subject; either labels and markings on the subject itself or data-back numbers, dates etc. imprinted on the film negative. It is a mistake to rely on distant backgrounds to identify where you were when you took a photograph. A recent survey report on cracking of limestone veneer on walls, parapets and balustrades of apartment buildings in Hong Kong contains panoramic photographs of the The Peak, Wanchai, Central and the Perfumed Harbour, all with small areas of limestone in the foreground. The surveyor has had no difficulty recognising where he was at the time of each photograph, but the primary subjects on his work remain somewhat obscure by contrast.

In any circumstances, it is wise to establish a logical or narrative sequence before taking photographs on site. Think about the sequence that would be followed in writing about the problem and take photographs, as far as possible, in a corresponding sequence. For example, one might start with the wall on the left-hand side of the entry door to a room and then proceed clockwise. Start with wide-angle photographs, from opposite corners, to identify objects that will help locate closer views.

Overall photographs of a particular wall or floor, should precede close-up views of small details on that wall or floor. Only then should one proceed to the next wall or floor. In a dispute over problematic tiling of a community swimming pool in Queensland, an expert's report presented slightly different photographs of the same test sample as evidence of different defects in two separate areas far apart.

The captions attributed quite different properties to tiling, which the photographs confirmed to be at same spot. This is the sort of minor error that causes barristers' nostrils to flare and temples to pulse in anticipation of what is politely known as rigorous cross-examination. *If you cannot be certain of the locations of your own photographs, sir, how can you expect the Court to rely, more than a year later, on your flawed recollections and, indeed, your evidence as a whole?* Now tell us, who really took these photographs and who later added the imaginative captions. Or words to that effect. It's not pleasant to be on the receiving end of such finely-honed and port-mellowed sarcasm, when the rules of evidence limit opportunities for valid retaliation. One can always respond *I didn't understand the question* and ask that it be repeated and explained in simple English, but this is only allowed three times in any one cross-examination.

In any context, there is a great advantage in using teams of two persons for surveying building defects. BDAP rarely permits this work to be done by lone inspectors. Two people in a team tend to work more efficiently and maintain higher alertness than the same two working separately. Curious bystanders are also less likely to ask for explanations of what's going on. Honest answers carry the risk of embarrassment and unwanted publicity. Misleading answers carry the additional risk of law suits for defamation. At this point it should be emphasised that no tiling and paving failures in Australian history have been shown to be caused by errors, ambiguities or omissions in specifications, drawings, details pencilled on walls, or other documents prepared by architects. Furthermore, both latent and patent defects in tiling are, by definition, imperceptible during architects' periodic inspections and construction managers' quality assurance excursions. The likelihood that the Dogma of Architectural Infallibility will change, is considered extremely remote.

Performing defects investigations in the presence of the building owner, manager, janitor, tenants, other parties' proposed experts, other sub-contractors, solicitors and so on can have an inhibiting effect, particularly when you see things you want to measure, record, poke a stick at and photograph, but don't necessarily want the whole circus to recognise and later celebrate, at your expense, in prose, poesy and ballad. Resist invitations to joint inspections of all the parties to a dispute or else take so long and be so painstaking and obnoxious, that the other parties' consultants and prospective witnesses, all probably working on hourly rates upwards of \$100, will tire and retreat. Then get on with the real task. The real task may include close examination and measurement of cracks in and between tiles. That's known as fractography, or sometimes fractology, the really exciting part of an otherwise dreary preoccupation and the subject of the enthralling second instalment, *It Ain't Necessarily What It's Cracked Up To Be*, to appear in the next issue of Tile Today. ♦