HOW TO GATHER ACCURATE AND VALID DATA WHEN INVESTIGATING A TILING DEFECT

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ABSTRACT

This paper is aimed at assisting people undertaking tiling investigations to gather accurate and valid data that helps to resolve the dispute. It is not necessarily about how to analyse that data, but how to gather that data in a manner that is most likely to be acceptable to the parties and allow the matter to be resolved, and not cause the dispute to escalate.

This paper is mostly about how to gather the facts and investigate a tiling defect. It also provides guidance on how to best record and report that information in a valid and reliable manner. It then provides some examples of newer methods of data gathering that improve the reliability and validity of the data gathered.

INTRODUCTION

When problems arise with tile installations, it is usual for the parties involved to undertake inspections and collect data. The data is usually presented in the format of a technical report. Sometimes the matter escalates and becomes a dispute and even litigation. In such cases it is important for the data gathered to be as precise as possible and for it to be able to be verified by the various parties to the dispute. This paper puts forward procedures for data gathering in such circumstances with the aim of ensuring that the data collected is both valid and reliable1. It also introduces some of the newer technology that may assist with investigations.

IN SIMPLE TERMS

The most succinct way to say what is needed to resolve the matter is that the information gathered and shared should make the following points clear:

a) **Where** is the defect?
b) **What** is the defect?
c) **Why** does it classify as a defect?
d) **Who or what** caused the defect?
e) **How** can the defect be rectified?

While this is somewhat simplistic, it is the core of what is necessary. Your findings and opinions must be able to be understood, be verifiable and delivered in a manner that your conclusions can be tested. The parties you are reporting to need this information and they will generally need to share this information with the other parties involved.

It is necessary to expand on the steps above.

a) Where is the defect?

This may be quite simple in a domestic setting, e.g. the bathroom or the kitchen, but it can be quite complicated in multistorey domestic, or commercial or industrial locations.

Other parties have to be able to find the exact location to be able to test the observations you made. The location itself may also open up additional investigations necessary to determine the cause, (e.g. type and level of traffic, climactic conditions, sunlight, snow or salt exposure, chemical resistance or hygiene requirements, etc.)

Some tips on gathering data include things such as: photograph the apartment door number as you enter; take distance as well as close photos, so the location can be oriented; use compass points for direction; mark locations on plans, count tile numbers from fixtures so the exact tiles you examined can be found by others.

[1] In simple terms, a valid test tests what it is supposed to test, and a reliable test would provide the same result if undertaken by another operative.

b) What is the defect? (describe the problem and its impact) Carlos Palmonari & Georgio Timillini did this for many defects in their landmark publication *'Ceramic Floor and Wall Tile Performance and Controversies'*[2] back in 1980s, but there are new construction issues that have arisen since then.

When evaluating defects in completed ceramic tiling works, accurate and detailed descriptions are required. Photos should be taken so others can check your findings. Sometimes, especially with hollow tiling problems, a video taken during a "resonance or tap test" helps. If there are safety implications, (e.g. falling tiles) they need to be expressed to the relevant parties, or action taken immediately. The following is a general list of possible defect classifications.

- **Aesthetic defects** -What can you see that is causing complaint, what angle and lighting is it observable in, from what distance? What is the overall impact of the defect? Does it show up in photographs? Are there industry guidelines for viewing positions and lighting?

- **Workmanship defects** - If it is inaccurate tiling, how much is it out by? How did you measure it? How many times does it occur? What is the impact of it? You should show how you measured the inaccuracy and the equipment you used.

- **Failure defects** - If it is cracked tiles: how many, in what direction, is it related to structural elements?

    - If it is dislodged tiles: how many have dislodged or are loose, are they peaking?
    - Where and how wide are the movement joints. Are the movement joints properly formed? You should show how you tested this.
    - If hollow tiling: how much and where? Undertake a "condition survey" of all or part of the area so others can repeat your testing. This can help define if the problem is static overtime or getting worse. (Schmidt Hammer test can make this type of problem identification more valid and reliable) Present marked up photos and videos.
    - Does the failure impact functionality?
    - Get evidence of the plane of the "mode of failure". How did you establish the mode of failure? What equipment was used?
    - Note the adhesive contact coverage.
    - Note the environment.
    - Determine if replacement tiles are available.

[2] Out of publication but available second hand on-line.

- **Contractual defects** - If necessary, relate the issue to the plans, specifications, or the contract. Were the works completed in accordance with the documents, if not, how do they vary? Were the specified products used. Rate alternative products used if possible. Were they equivalent? State the impact of the deviation from the documents has had on the works. Supply copies of the documents you relied upon so all parties can check them.

- **Maintenance defects** - Is the problem related to a lack of maintenance? Has poor maintenance made it worse? What maintenance is lacking, what maintenance has been done? Log the cleaning chemicals used. Were ride on cleaning machines-if so, what type? What tests did you undertake, (e.g. water repellence of sealer, gloss meter readings, slip resistance test results, etc.) Are damage prevention measures possible? If so, list them.

- **Fitness for purpose defects** - Were the products used fit for purpose? If not, how are they lacking. Would shortcomings have been reasonably known at the time of product selection? Would alternative products have performed satisfactorily? Who was responsible for product selection? Can you show how the products fail to perform? Was there a point at which the works should have been stopped?

C) Why does it classify as a defect? Some defects are indisputable such as cracked or missing tiles, others such as drummy or hollow sounding tiles are less so. It is best to state clearly what makes the defect a defect. Is it a breach of a standard, code or guideline, if so which one, where? It is best to reproduce an extract of the documents as many others may not have access to them. If the works were not completed according to the instructions, reproduce those instructions or data sheets and state where the deviation is. If a warranty has been breached, state how and where. Has it failed to provide the intended performance? If so, how? Can you predict what is likely to happen to the tiling in the near future? Is discretion and judgement needed in deciding if it is a defect? For example, a slight amount of hollowness on a bathroom wall may be acceptable, while the same amount of hollowness on an exterior façade may not be acceptable for safety reasons.

D) Who or what caused the defect? (If this can be determined)

Was it poor design, or products used? Has the structure contributed to the problem? Who made the design or product selection? Is there guidance available that should have been used in the design or product selection? If so, reproduce it.

Are there workmanship shortcomings? If so, what are they? List them all and possibly rank them by how much they contributed to the problem. State, if in your opinion, there is a shortcoming, but it has **not** contributed to the problem and therefore should not be given weight.

For example, state if the waterproofing membrane has been applied more thinly than specified, but there are no water penetration problems. Are there unusual or difficult environmental aspects or exposures that have contributed to the failure?

E) How can it be rectified? Are there different ways to address the problem apart from complete removal and replacement? For example would, localised repairs, injection of adhesive, or slip treatment provide acceptable rectification. If you feel qualified, you may put forward a specification for the rectification. If you feel qualified, you may even put forward a cost indication for the various repair options.
Are replacement tiles available? If not, can more be obtained before they become obsolete? If no matching tiles are available, can some be saved from an out of the way location, or is it acceptable for a decorative pattern to be made that would lessen any negative visual impact of a repair? Consider any negative environmental impact of replacing tiles that would have performed satisfactorily.

GATHERING DATA

Notes, photos, and videos are often taken. Sometimes it is necessary to take samples for later reference or scientific analysis. On occasion the data you are gathering may be specifically for one party. This means, to some extent, it should be kept confidential. This may be difficult when the representatives of several parties are present. This may mean voice to text recordings are not advisable. In such cases it is probably best to keep your opinions to yourself until they are fully researched and considered.

A range of test and testing equipment may make the data you gather more empirical. Some small and easily deployed equipment such as gloss meters, thickness gauges, levels and straightedges should be available. Sometimes it may be necessary for a third-party testing house to be involved. This may need special approval and specific instructions drawn up.

THE REPORT

The information gained during the investigations usually needs to be presented in a Technical Report. The technical report should be complete and considered. There are numerous templates available for technical reports, select ones that reflect the size and detail required for the particular matter. Often, if the matter proceeds down the path of litigation, the technical reports will need to be in a format that is acceptable as evidence in proceedings. In many cases you will be provided instructions from a legal representative for one of the parties. These instructions need to be followed and copies included in your report. If you have reported a condition that does not impact on the defect you need to show you have considered but discounted that condition.

EXAMPLES OF METHODS FOR MORE RELIABLE AND VALID DATA GATHERING.

A range of tools and equipment are used for gathering data from site. Most of these are obvious, such as a camera, tape measure, note pad, etc. but a few pieces of specialist equipment can help. Here is a brief description of some of that equipment, and how it can be useful.

In 2014 I presented a paper at Qualicer titled "The assessment of hollow or drummy tiling". Here is additional information that can improve the accuracy and reliability of methods mentioned in that paper. First, marking out the extent of the hollow sounding areas of tiling and recording it in photographs and videos allows others to repeat your testing and test its accuracy. An example can be found at: https://www.youtube.com/shorts/b_Qg_qZcyg4

***Figure 1**. Here a small hammer and chalk are used to mark out the drummy area.*

Below are two photos taken about a year apart of areas of hollow tiling marked out by different parties that allowed for relatively accurate comparisons to be made of the area of tiling that was tested.

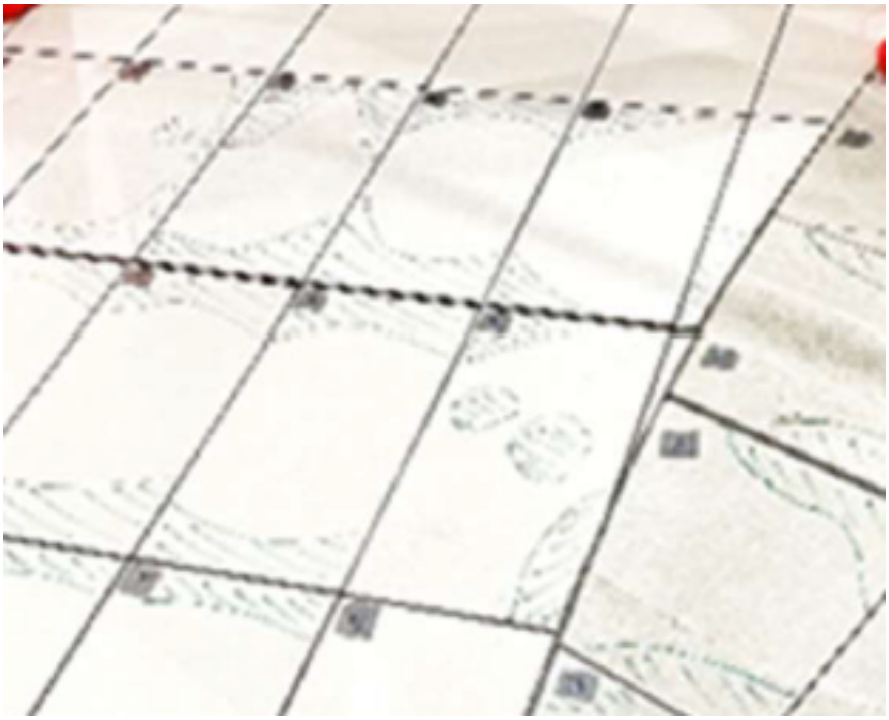


***Figure 2**. The first condition survey mark-up hatched in the hollow areas.*

***Figure 3**. The repeat mark-up by a different operative about a year later, taken without reference to the first photo found a slightly greater area of hollow tiles. This could indicate that the hollowness is expanding, or it could just be operator variation in perception or equipment used. Either way the assessment of the hollow sounding areas has been made more valid and reliable because it can be repeated. This is good but not perfect.*

Below is an example of a grid version rather than a photographic version of a mark-up from the same project.

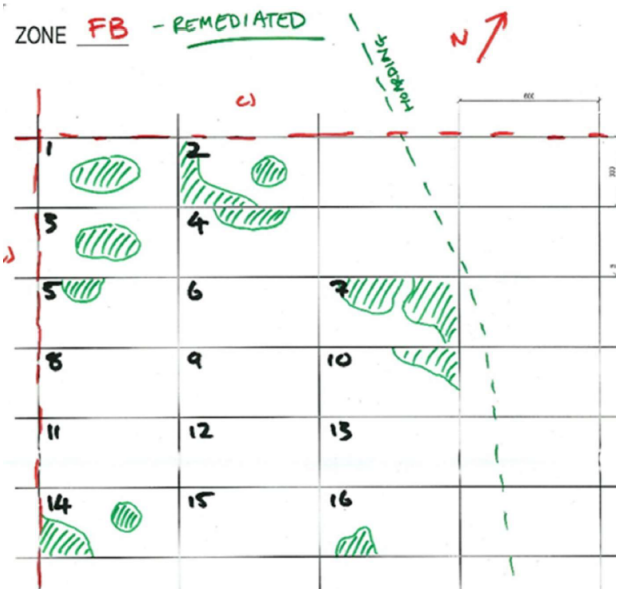


***Figure 4**. A typical "tap" or resonance testing mark-up.*

Hollow or drummy areas hatched on a plan or photo with location and orientation allow the testing to be accurately repeated.

Even greater accuracy of the assessment of hollow tiling can be made with the help of a Schmidt Hammer.

Schmidt Hammer testing, also known as rebound hammer testing, is a non-destructive method used to estimate the compressive strength of concrete, rock, and other hard materials. The rebound value is usually denoted as R or Q. It is a rating between 0 & 100.

***Figure 5**. A "low impact" Schmidt Hammer with mushroom head (circled) for testing thinner more brittle surfaces such as ceramic tiles. (NOTE: Some surfaces such as thin ceramics and mosaics may still be damaged by the mushroom head).*

The Schmidt Hammer test is similar to ISO 10545-5: "Determination of impact resistance by measurement of coefficient of restitution".

The Schmidt Hammer can be used to correlate physical resonance testing or 'tap testing' of tiles (e.g. figure 4 above) to estimate if solid sounds recorded are linked to a tile bond sufficiently high to indicate well bonded tiles. From experience, Q 1-30 equals a low compressive or bond strength, A Q above 50 indicates a high compressive or bond strength. A Q reading between 30-50 could indicate a suspect bond or tiling system possibly installed over a decoupling system, a crack isolation and/or waterproofing membrane.

These results can then be compared to a small amount of destructive testing (50mm square adhesion "pull-off" testing to ISO 13007.2). If the pull-off results are equal to or better than those required for the adhesive, then the tile can be considered to be satisfactorily bonded. A determination can then be made as to the rectification method, which could include "no action", injection with a bonding/filling liquid, or replacement. This provides empirical evidence on bond strength upon which reasonable decisions can be made.

The above methodology can also be used if the tiling is shown as hollow when using a FLIR camera.

FLIR (Forward Looking infra-Red) are thermal imaging cameras usually used in construction to monitor energy and water leakages in structures, but they can also be used to undertake non-destructive bond testing of ceramic tiles.

***Figure 6**. FLIR thermal imaging cameras can be large, or as small as accessories for mobile phones.*

When used with either hot water, a heat gun (hairdryer) or sunlight, the thermal image reveals the extent of hollow areas, see figure 7.

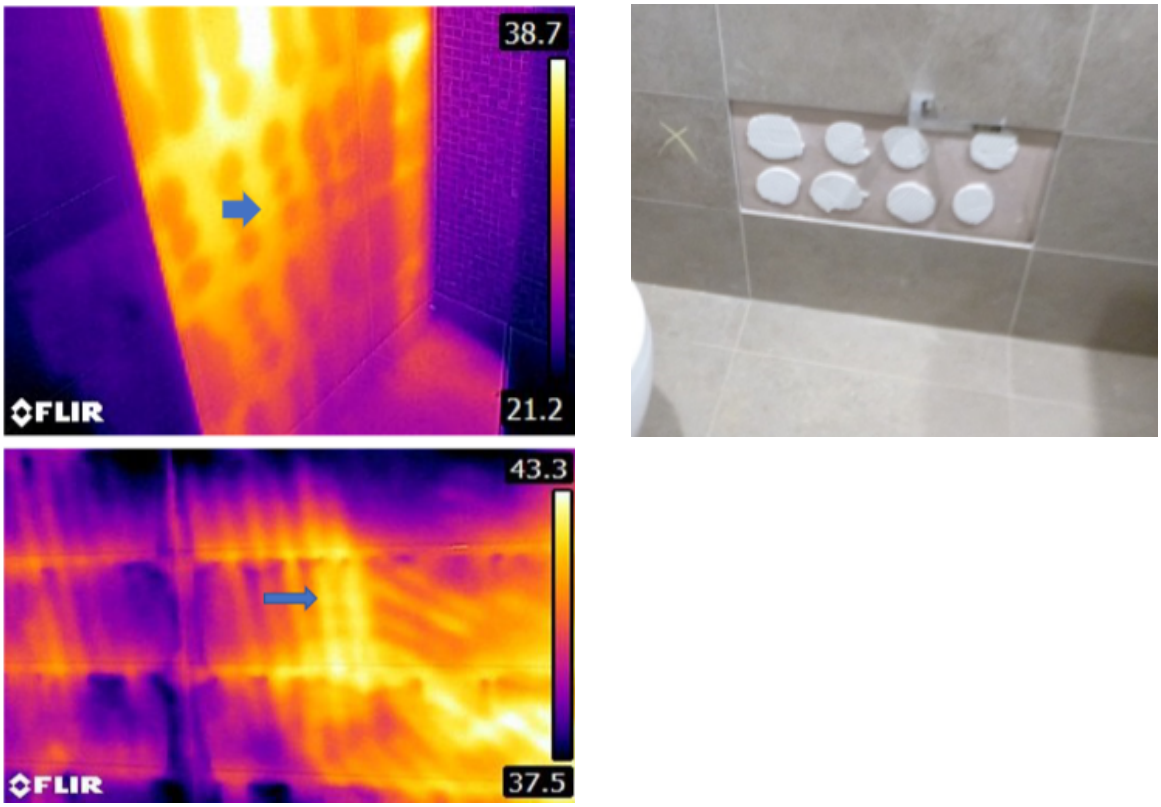
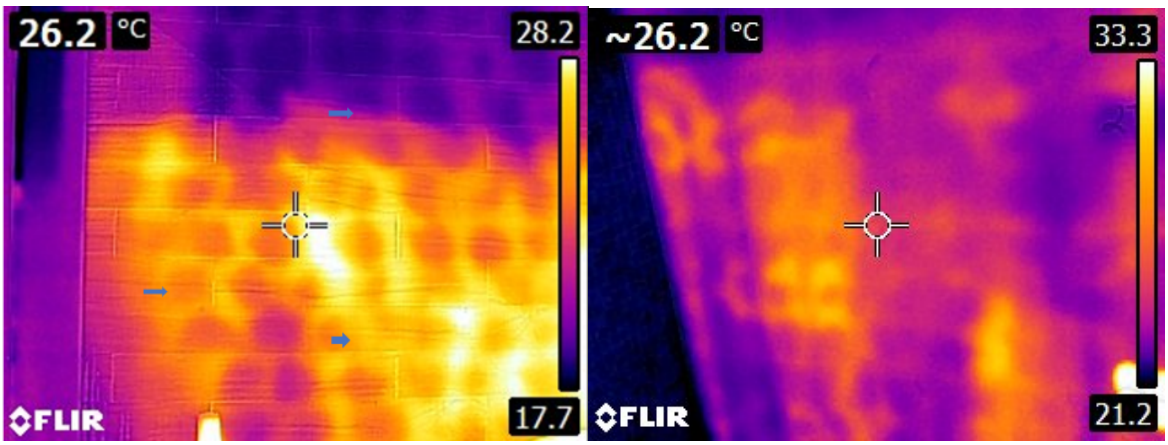


***Figure 7**. Hot areas show up as yellow and cooler areas as blue. Top images are of "spot fixed" tiles, bottom image is notched trowel fixed tiles.*

FLIR imaging can also assist in reviewing how effective void filling by injection has been. See figures 8 & 9.



***Figures 8 & 9**. The left image is of an external wall with the lower part in direct sunlight. Spot fixing is apparent. The right image is of the same wall after injection with bonding material. The greater area of blue indicates greater thermal mass and more adhesive contact.*

So, FLIR imaging results can also be used to compare destructive bond testing results (50mm^2 square "pull-off" testing to ISO 13007. 2), so a decision can be made as to the remedial action recommended in a similar manner to using the Schmidt Hammer test results.

CONCLUSIONS

Disputes over defects in tiling systems are more likely to be effectively resolved if the technical information provided is gathered and presented in a manner that is accurate, credible and considered both valid and reliable. The result should be as objective as possible, and subjectivity of opinions reduced as far as possible.

Others need to be able to check and validate your investigations, findings and conclusions. This is easier if the following information is clearly laid out:

- **Where** the defect is.
- **What** the defect is.
- **Why** it classifies as a defect.
- State **Who or what** caused the defect (if this can be determined), and, if possible, provide options on **How** the defect can be rectified.

Some newer technology is allowing for the data gathered during a tiling defect investigation to be made more valid and reliable. These technologies can sometimes be used in tandem to improve the accuracy of the diagnosis of the defect.

It may also mean that some expensive and environmentally damaging tile removal and replacement works can be avoided.

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