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SDS

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Site Investigations, Shale & Infill Testing,
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A COMPREHENSIVE GUIDE TO SHALE & IN-FILL TESTING

IN DOMESTIC PROPERTIES

If you are reading this, the chances are you have been told you need a shale test, in-fill test floor test or bore test.

In this guide, I have provided some useful information on shale & infill tests for you.

If you have any queries or want to book a shale test, or simply want further advice, please feel free to contact me :-

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This guide has been written for two reasons; primarily to enlighten people as to why a shale test is required, and what it entails, and also to give estate agents, mortgage brokers and other professionals within the property market, a source of information, regarding shale and in-fill testing.

CONFUSION

For a long time, there has been an awful lot of confusion regarding all aspects of this type of Investigation.

I think that particularly in Teesside and surrounding areas, the confusion arises due to local terminology.

Years ago in Teesside, there was awareness that some types of Cleveland shale that had been used as an in-fill beneath floors in properties could cause structural issues with an ability to expand and “push” against walls and floors.

But over time, it became very apparent that Cleveland shale is only one of many materials that can cause issues in properties with many other materials possessing the capability to cause just as much damage or even more.

Despite many years of trying to explain that this investigation is to test the many different types of in-fill; some industry professionals still prefer to call it a shale test rather than an in-fill test.

The result of this is that we quite often get people saying that samples "don't need testing because it’s not shale, and we were only asked for a shale test".

We do try to explain that it is not just shale that can cause problems, and other materials have to be checked out also.

However, in some cases despite our best efforts to give an understanding of what is required, people still insist that the samples are not to be tested.

When this happens, we simply provide a report which states they requested us not to test the samples.

This invariably leads to them ringing us back up at “zero hour”, asking us to test them, because "the lender has insisted on testing before monies are offered".

This either delays the sale or costs them more money to pay for the swift turnaround analysis – that may not be possible in some cases.

So just be aware that shale is just one of many materials; in fact, If we were to look elsewhere in the UK, we can find other local terminology and variations for infill tests, which include but are not limited to:

Bore test, floor test, floor survey, subfloor fill test, red ash test, burnt red shale test and concrete test.

WHY IS A TEST REQUIRED?

The use of hardcore in-house construction first became common in the immediate post-war period when construction materials were in short supply.

Solid floors, comprising a concrete floor slab over hardcore, largely superseded suspended timber floors (without concrete sub-floors) that were typically used in the 1930s.

Also, waste materials, such as burnt colliery spoil and blast furnace slag were promoted by government as being appropriate materials for use.

Unfortunately, little or no guidance on the selection and use of suitable materials was available in the early post-war years and there was some use of deleterious materials.

Hardcore, derived from many industrial by-products, was included in the construction of hundreds of thousands of domestic properties from the 1940's to around the late 1970's / early 80's.

The legacy has been a continuing occurrence of damage to floor slabs and abutting walls due to deleterious hardcore.

(Hardcore is a fill material used in building construction to raise ground levels and provide a dry, firm and level base on which to cast a concrete ground floor slab or 'over-site' concrete beneath suspended floors).

Because of this, a lender is often reluctant to lend on properties built during this era until it has been shown that the infill is of an acceptable type.

HOW MUCH IS A TEST

The cost of a test varies and is determined by the location of the property (different areas have different requirements) and also the type of material required.

For an up-to-date quote, give us a call and we can advise you accordingly.

INSURANCE COVER IS UNLIKLEY

The removal of deleterious in-fill material is rarely covered by household insurance, as the cause is deemed to be a ***"latent construction defect"***.

Thus, in most cases, owner-occupiers have had to pay (typically £10-20k – or more) out of their own pockets for repair.

This situation has promoted a blight of numerous housing estates where cases have occurred (or may occur), and now prospective buyers and professionals concerned with house purchase and mortgages have naturally been very cautious when dealing with properties that may have problems.

To this end, as stated previously, an in-fill Investigation is often required by a mortgage lender to determine whether a particular property has an already existing or potential future problem.

IF MY NEIGHBOURS HOUSE WAS OK, WHY MIGHT MINE NOT BE?

Each dwelling needs to be considered on its own merits (just because Fred's house at number 42 passed doesn't automatically mean that John's at number 44 will also pass).

Although this might sound confusing at first, there is a simple explanation.

The materials used as in-fill do not generally occur in the location of the property.

They have been imported from elsewhere.

What this basically means is that the wagons that delivered the in-fil could have brought the material in various sources.

Whether that is various locations of stock-piled shale, colliery spoil, ash and slag from the steel works and other locations – so it really is “potluck” as to where the material has come from, how it has been stored prior to its placement and other variables.

So hopefully the above has given some insight as to the reasons an infill test is required – so let’s look at the most common questions we are asked about actually carrying out the tests.

HOW MANY HOLES ARE DRILLED?

That depends on a number of factors, the norm is two to three, but there are exceptions.

The problems we face are mainly access related.

If a property has no attached or Integral garage, and has laminate or other specialist flooring throughout, most lenders will happily accept that one borehole is allowable, e.g., in an under-stairs cupboard that has not been laminated.

In other cases, we may carry out a borehole in the main property, and find something that doesn't need testing, then, find something that requires laboratory testing in an integral garage. In this case, we would excavate another hole in the main property if possible.

Even in a house that has no access problems, there is still a limiting factor as to the number of holes excavated.

Ideally we would excavate lots of holes; the problem is we are bound by financial constraints.

Fortunately, mortgage lenders realise this and usually accept what we can get for them.

On the rare occasion they want extra holes, it is often necessary to bring in a specialist to lift and replace the laminate etc, this would incur extra costs.

Similarly, if a buyer wants additional holes despite a lender being happy with the investigation we provided, this would incur additional charges.

THE ON-SITE TEST PROCEDURE

The test is carried out INSIDE the property.

There are two main types of floor construction that are generally encountered: solid concrete floor slabs and suspended timber floors.

The Investigation for both types is essentially the same.

If the floor is of a timber construction, the joists are located, and a circular saw is used to cut a number of floorboards; The number is usually two, though more boards may be needed to be removed if there is a large void below the timber floor.

If M.D.F type boards are present, we either take a full sheet up if practicable or cut a sufficient square as appropriate).

Occasionally, an extra cost may be incurred due to technical considerations; but this would be discussed in full before any works took place.

Once the boards are removed, it will be seen that there is generally a concrete "subfloor".

A hole in the region of 4 - 5" diameter is drilled in the concrete to expose the underlying in-fill.

The in-fill is visually identified, and its depth is determined.

Samples are taken, then the findings - including any anomalies, presence or otherwise of a damp-proof membrane etc. are recorded.

Once all this has been done, the hole is backfilled with arisings from the borehole (and inert gravel if more fill is needed).

The hole is “concreted up” and the floorboards reinstated.

A solid concrete floor is treated much the same. Quite often, concrete floors have "thermoplastic" tiles - designed to stop "cold bridging", or a screed of one description or another.

In the case of the tiles, we attempt to take each one up without breaking it, so it can be glued back down after the test.

If we do severely break a tile, (some are glued down so well, they have to be broken to be removed), we either cover the concrete with polythene or if there is a spare tile on the van we may use that – though we cannot guarantee this, nor can we guarantee to provide a matching tile.

If screed is present instead of tiles, we will concrete the hole up to finished floor level. In this case the area of the test can be clearly seen, but this isn't

generally an issue as the floor is usually covered in some way, with a carpet for example.

Polythene is placed over the hole, in order to protect carpet and underlay until the concrete cures.

The in-fill under an attached or integral garage is also often investigated.

The same procedure applies, but in this case, the area of test is often unlikely to be hidden under carpet, and you will see a small round area of different coloured concrete to the rest of the floor.

IS IT MESSY AND NOISY

It is certainly noisy.

You can imagine, we are chiselling through concrete, and that's not quiet.

The actual noise only lasts about 30 minutes generally, but it could be much longer (or shorter).

We always advise people with pets to make arrangements for them to be elsewhere - even if this is just in another room.

This is especially important with small animals.

Messy?

Well, that is a subjective opinion.

There is certainly a lot of dust kicked up (we are after all chiselling through concrete).

But we do our utmost to contain it.

For example, we use an industrial vacuum cleaner, and the nozzle is pointed at the chisel tip while we are drilling through the concrete.

This way, over 95% of the dust is removed at source; However, we cannot guarantee there will be no dust whatsoever.

We can provide dust sheets (on request) in the area in which we work, although many people prefer to cover their furniture with their own dust sheets prior to our arrival.

As a quick guide, to date, (touch wood) we have never had anyone complain about the mess (that is because we are honest with them from the start).

What we have had on many occasions is people tell us how pleasantly surprised at the LACK of mess the shale test has caused.

HOW LONG WILL IT TAKE

In general, the on-site test takes about an hour and a half.

The duration depends on a number of factors Including access, density, depth and hardness of concrete, density and depth of In-fill.

The time taken It may be as little as 45 minutes, or as much as 3.5 hours, but the typical duration is 1.5 hours.

HOW DO YOU KNOW WHETHER SAMPLES NEED TO BE SENT OFF?

From the moment we walk into a property, we are looking for potential problems.

Even just walking across a floor can reveal important information.

We take note of the way the concrete behaves as we drill through it, any anomalies that are present and a host of other things.

If we find any problems, or anything other than materials that are automatically accepted as being "stable", we will need to send samples off to the labs.

Materials that are accepted as being stable include Dolomite, Clean gravels and natural clays. ***If there are anomalies in the floor, even these may have to be sent off.***

Materials that are routinely sent off include, but are not limited to; Cleveland shale, colliery spoil, slag, certain sands and gravels, ash, burnt red shale and brick rubble.

HOW CAN DAMAGE OCCUR?

There are a number of different mechanisms that cause damage, depending on the material type.

Let's first look at Cleveland shale.

Cleveland shale is a "mud-rock". Millions of years ago it was clay.

Over time and subjected to temperature and pressure changes (a little bit like a mild metamorphosis - a process called diagenesis), it changed to a rock.

When the clay was deposited, some of it was deposited in layers - laminations - and in some of these laminations other chemicals were laid down with the clay.

Even though the clay is now a rock, the laminations and the chemicals are still present.

These chemicals have an ability to react with water and grow crystals.

As the crystals grow, they start to force the laminations apart, causing expansion of the rock itself.

As the rock expands, the "extra volume" needs to go somewhere, and it can either "go up or out" and usually does both.

The result is that floor slabs can be pushed up, and supporting walls can be pushed off underlying foundations.

Additionally, any walls built off the slab can be moved in such a way to give them eccentric loading that they weren't designed for, not to mention problems with sub-floor service pipes.

Now, the amount of chemicals that can grow crystals within the body of the rock, will determine how much expansion can take place.

A lot of chemicals can lead to large volume expansion; if none of these chemicals are in the laminations, then you can expect no expansion. Our job is to determine what is present and if it poses a threat.

Slags are another problematic material.

They are a by-product of the steelworks industry, and some slags have a twofold problem.

One is that they contain substances collectively known as water soluble sulphates (also spelt sulphates).

This problem will be addressed in a short while, but first let's look at the other problem associated with some metalliferous slags.

They have an ability to expand, which can cause the same expansion type problems as shale expansion.

They also tend to then totally collapse into a powder.

Thus, they have caused an expansion problem and damaged the concrete, and then they collapse leaving a void.

Clearly, the presence of a void can give lack of support to an already significantly damaged concrete.

The next problem is *THE* most common problem we encounter.

Sulphate attack is the most common factor regarding problems associated with deleterious In-fill.

In our region, Cleveland shale is the “big name on the streets”, but in fact even in this region, a property is more likely to fail from high sulphate concentrations in the in-fill, than it is from potential shale heave.

It is such a major problem country-wide, literally dozens of papers have been written on the problem. (Compare that with two or three written on Cleveland shale expansion).

WHAT ARE SULPHATES AND WHAT IS SULPHATE ATTACK?

Sulphates are salts in which the negatively charged ion (anion) $SO4^{2-}$ forms a compound with a metal positively charged ion (cation) such as Ca^{2+}.

In hardcore, we are concerned primarily with sulphates that are readily soluble in water and which can therefore be readily transported to react with concrete.

Such sulphates include gypsum (calcium sulphate, CaSO4), epsomite (magnesium sulphate, MgSO4), and Glauber’s salt (sodium sulphate, Na2SO4).

Sulphate-bearing materials which have been used in the past as hardcore in domestic properties include burnt colliery spoil, (red ash or red shale), furnace bottom ash (black ash or just ash), blast-furnace slag, oxidised pyritic shales, and demolition debris including brick rubble, containing gypsum plaster or contaminants of chimney soot etc.

The amount of soluble sulphates present in the material is a vital factor in determining the potential for sulphate attack on concrete.

Where a concrete slab overlies moist sulphate-bearing hardcore, the sulphates in the hardcore may migrate into the concrete where they react with constituents in the cement matrix.

Two sulphate attack mechanisms have been identified as affecting concrete slabs and oversite concrete:

(i) Conventional or ettringite form of sulphate attack.

In this type of attack, sulphates and water react with the tricalcium aluminate found in Portland cement to form a calcium sulphoaluminate hydrate known as ettringite.

This type of sulphate reaction has long been known and most published guidance on sulphate attack has addressed this mode.

The formation of ettringite can be destructively expansive since it has a solid volume greater than the original constituents and typically grows as myriad acicular (needle-shaped) crystals that can collectively generate high internal stresses in the concrete.

(ii) The thaumasite form of sulphate attack (TSA).

This form of sulphate attack was first recognised in the UK in the 1990s and has since been found in several floor slabs and in over-site concrete.

The reaction product is the mineral thaumasite which is a calcium silicate carbonate sulphate hydrate.

Since the calcium silicate hydrates provide the main binding agent in Portland cement, this form of attack weakens the concrete as well as causing some expansion and, in advanced cases, the cement paste matrix is eventually reduced to a mushy, incohesive mass.

Whilst several chemically different types of concrete have been used in construction over the years, the type used for floor slabs has invariably been one based on the use of Portland cement, and of these the majority have employed the commonly available ordinary Portland cement (OPC).

This type of cement is the most vulnerable to sulphate attack as it imparts to concrete, abundant amounts of both calcium aluminate hydrates and calcium silicate hydrates that are readily attacked by sulphates.

SOME COMMON MISTAKES AND QUESTIONS

"This house has stood for forty years with no problems. Surely if there was going to be a problem it would have shown itself by now".

The answer is "not necessarily”

Firstly, these reactions can be very slow, so you may not have noticed them yet.

Also, the crystals that grow in the shale body and the reaction between sulphate and concrete all rely on one major factor:- The availability of water.

The hardcore doesn't have to be saturated but water must be available.

A common source is groundwater that is drawn up through the finer fraction of the hardcore by capillary action.

Occasionally the source may be surface water floods, or leaking drains and water pipes.

So, if there has been an absence of water, you will not see that anything sinister has manifested itself.

But that does not mean that the *POTENTIAL* for future damage is not there (which is what mortgage lenders want to know).

"This house has a damp-proof membrane below the slab, so sulphate attack won't occur".

Sulphate migration from hardcore into concrete may be impeded by the use of a separating membrane.

Polythene sheets, installed primarily as a damp-proof membrane (DPM), began to serve this purpose from the mid -1960s, and became almost universal for concrete slab construction on sulphate-bearing hardcore by the early 1970s.

DPMs installed in the 1960s were typically only 500 gauge (125 micron) thick, and doubts have been cast by some practitioners on their effectiveness as a barrier to sulphate migration.

Also, membranes have been known to perforate during the construction of the floor, and some have not been overlapped sufficiently.

Also at higher concentrations, the sulphates can start to attack mortar in the sub-floor brickwork

To this end, limits at present are imposed as to the upper allowable sulphate concentrations that can be contained by the presence of a damp-proof membrane.

WHAT DOES DAMAGE LOOK LIKE

The first visible sign of the action of deleterious material is usually some unevenness in the floor. This may be accompanied by appearance of cracks in the concrete screed and floor finish that are at first narrow, but which widen with time.

The unevenness of the floor will typically progress into an obvious heave and there may be increasing difficulty in using internal doors as a result of the lower edge fouling the floor.

However, lifting is generally highest in the centre of the room resulting in a doming in the floor that is detectable with an adequately long straight edge.

The doming is commonly accompanied by a radiating or map pattern of cracking, with some cracks making vertical steps in the floor of the order of several millimetres.

Externally, the pushing out of walls by the sideways expansion initially causes horizontal cracks to appear in mortar courses at or near to DPC level.

With time these typically show a horizontal step in the masonry with the courses above being thrust out (over-sailing or lipping) relative to the courses below.

There may also be irregular displacement of blocks of the wall adjacent to the DPC particularly near to corners.

A further indication of sulphate attack may be efflorescence on the outer face of a wall which has mortar filled cavities below DPC level.

Many load bearing interior walls will be carried down to their own foundations and behave similarly to external walls.

In some cases, however, partition walls will have been constructed using a floor slab as bottom support.

Such walls may be uplifted by doming of the slab, causing deformation and diagonal cracking particularly near to door openings.

Door openings and frames may distort from square, making doors difficult to open or close.

REMEDIAL WORKS

Hopefully, your test will come back favourable.

However, if you are in the unfortunate position of having a house with infill problems, you may be required to carry out remedial works in order to sell it.

The type of remedial works required varies from job to job.

What is important is that you must get a reliable and trustworthy builder who has experience and a very good knowledge of what is required.

Far too many builders assume they know what is required and are quite happy to tell you things like they can "save you money by leaving the kitchen in, and just digging under the slab".

So, make sure you check out your prospective builders carefully.

Make sure they are going to remove the kitchen, downstairs bathroom etc and not just leave them in and excavate under them.

Ask them what they are going to do if the interior supporting walls are built off the slab.

They should be telling you that the walls will be supported by other means, and the slab and all underlying material will be removed.

Don’t let them tell you that that the slab and material has to be left intact in these areas – unless signed off by a suitably qualified structural engineer.

If a builder gives a quote without wanting to see the report or knowing the depth of fill, alarm bells should start ringing; a builder needs to know the depth of the fill so he can work out what volumes need to be removed.

Then he can estimate things like how long it will take, how many skips he will need, how much inert material to put back etc.

Some builders in the past have not taken out all the deleterious material.

You need to make sure they are going to remove all the in-fill down to the natural material – again, unless determined otherwise by a suitably qualified professional.

Ask them if they get the local building inspector involved; in order to ensure compliance with current local building regulations.

I hope that this report has been of some use to you.

I have tried to ensure that it is accurate at the time of writing.

If you have any questions at all, please don't hesitate to contact me.

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