

Sampling Potentially Pyritiferous Materials

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Introduction

Since 2006 it has become apparent that a number of properties in the Dublin area are suffering distress as a consequence of expansion of pyritiferous fill placed beneath ground bearing floor slabs. The location and method of sampling and the appropriate storage of the material are important in order to reliably determine whether such expansion has taken place and/or may take place in the future.

In many instances the distress is very obvious, with large cracks developing in dry-lined walls, doors jamming, floors and window cills arching etc. In others, the evidence is more limited, such that it could potentially be related to other causes. A further concern is for the structural integrity of concrete/concrete blocks which may be attacked by sulphates, although this is probably more problematic with larger structures than estate houses.

In the current climate, in order to put forward an insurance claim it is generally necessary not only to confirm evidence of damage to a property but also to demonstrate the cause. This is usually done by providing evidence that sulphates have developed in the underfloor fill and there is a potential for the associated chemical reactions to continue. Similarly, in order to obtain finance/insurance, a purchaser is commonly required to demonstrate that the property is “pyrite-free”. Sampling may also be required when purchasers wish to establish the suitability of a potential aggregate material, particularly if a new quarry is to be opened, or if a new face/stratum in an existing quarry is to be worked.

This chapter discusses the sampling required to obtain appropriate material on which the necessary chemical testing and petrographic analyses can be undertaken, as described by Eden (2013). It draws attention to the ways in which important evidence can be missed or destroyed and how, without proper care, the samples acquired can result in misleading data.

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Sampling Locations

In order to allow a proper analysis of the nature of the fill beneath house floors, it is necessary to obtain samples which are representative of the fill mass, such that all the relevant characteristics can be assessed. It is desirable to obtain samples from areas where the distress has been greatest. Unfortunately this is invariably in the middle part of a floor and, in an occupied home, this may cause the owners some distress even if every attempt is made to minimise the disturbance to the finishes. In this case, a judgment will need to be made as to the most appropriate and practical location for the test pit/s. However, as seen in Fig. 1, it is clearly not appropriate to sample adjacent to or through the rising walls (external or internal) where the samples may be dominated by coarser (less mudstone-rich) material and the aggregate is likely to be less dense.

In most cases, one or two sampling locations will be sufficient to confirm a pyrite problem when distress associated with heave is evident in the property. However, as the pyrite will be present at random locations within the host material and will vary in its susceptibility to oxidation (and associated expansion), it is likely the Engineer will require at least two samples to confirm that the fill will not give rise to problems in the foreseeable future.

A number of different factors affect sampling locations in a greenfield site when the in situ ground is being assessed for potential sulphate problems. This is considered in Hawkins (2013) and hence is not discussed further here.

Where a new quarry is being assessed, it is important that the advice of an experienced geologist/engineering geologist is sought at the outset; they will be responsible for specifying the sampling regime. Subsequently, it will normally be recommended that visits are made to the quarry at regular intervals in order to confirm that the material being extracted has not changed significantly as different levels are reached and/or faces opened up. This will depend on the nature of the strata being exploited.

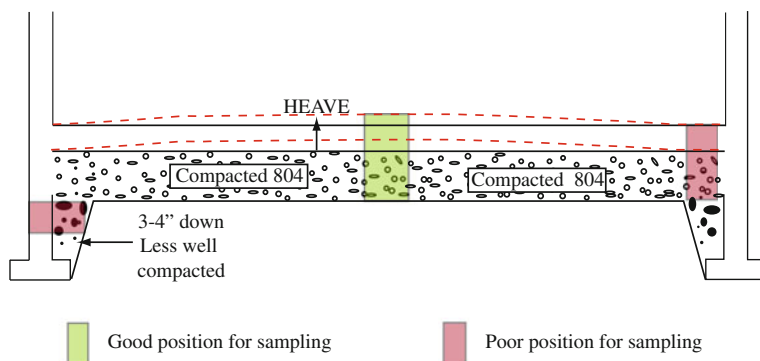


Fig. 1 Significance of locations for taking fill samples from below floor slabs

Sampling Methods

Wherever possible, in order to observe the nature of the fill, a small, approximately 0.5 m square, inspection pit is opened. If the property is empty, this can be undertaken using a kango hammer. When the property is occupied, it is generally better to break through the concrete floor slab using a series of c. 150 mm diameter perimeter holes to allow the central plug to be lifted out (Fig. 2). It is important that during the break-through and drilling the minimum of water is used, both to avoid any effect on the fill material and to reduce the disturbance to the home owners. The uncut membrane should be photographed and the date recorded.

It is essential that the sampling engineer is in attendance before the radon barrier is cut diagonally and carefully bent back such that it can be replaced and securely taped when the hole is reinstated (Fig. 3). The thickness of the concrete should be noted, and whether there is any reinforcement. The thickness of any sand (blinding) present should be recorded and very carefully scraped away as crystals of gypsum and/or calcite may be present directly below the membrane. Should any evidence of crystallisation be seen, samples will be taken for laboratory study. A photograph should then be taken of the exposed fill.

Fig. 2 Cored inspection pit with exposed membrane



Fig. 3 Membrane cut such that it can be securely taped back during reinstatement



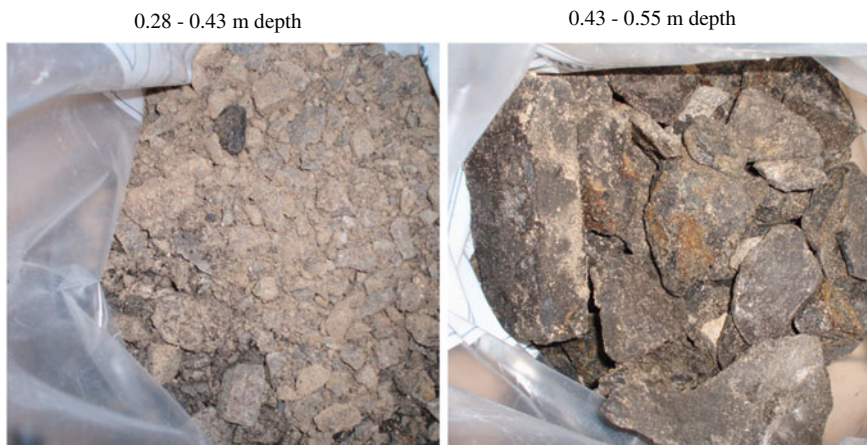


Fig. 4 Variation in fill taken from two different depths in the same inspection pit

The exact depth of the hole and extent of the sampling will depend on the nature of the material exposed. In general, coarser material (3–4" down) is put into the trenches dug for the strip footings while the finer (Clause 804) material is commonly placed beneath the slab (Fig. 1). It is likely that the finer material will contain a greater proportion of mudstone and hence is likely to be the most problematic.

Any layering related to a difference in the placed material should be photographed and samples taken from each horizon (Fig. 4). The size and density of the fill should be visually determined as an assessment may need to be made as to whether the material was appropriately compacted at placement stage; a loose fill may result in settlement.

At all stages it is important to ensure that the individual fragments of the fill are not damaged or allowed to disintegrate during the sampling process as this will affect subsequent particle size distribution analysis. It is also extremely important to obtain the fine fraction as this will affect the liquid limit and plasticity results. If samples are collected by hand through a cored borehole, it is likely the “grabbed” sample will contain dominantly the coarser material in preference to the weaker/finer material. This will influence the Los Angeles and water absorption results.

Whenever possible, the pit should be extended to the underlying in situ strata and a sample taken from this material. However, this is often not practical during this investigation stage when the house is occupied. In this case, the approximate depth of fill can be determined using a hand held drill.

Size of Samples

Various Codes and Standards indicate the size of the sample required for various grades of material. Clearly, if a borehole is undertaken rather than a test pit it will be difficult to obtain a representative sample, particularly at depth. If coarse material is present it may be impractical to obtain a sample of the recommended volume/weight from an occupied home. In this case, it is essential that the photographs realistically indicate the nature of the fill such that an approximation can be made of the relative proportions of the gravel/cobble and smaller sized clasts. It should be noted that British Standards Institute (2002) recommends a 17 kg sample for coarse grained material (37.5 mm).

An appreciation of the recommended sample sizes is important if the testing may form part of the evidence in legal proceedings.

Number of Samples Required

In some instances the commissioning engineer will specify the number of samples required. This is most often the case when there is a dispute and in this situation the size of the samples and how they should be distributed between the various parties will also be a consideration. More frequently, however, the number and size of the samples will be determined on site in the light of the conditions encountered.

Although the blinding sand is not generally tested, unless there is some evidence that crystals are present, it is good practice to take a small (c. 200 g) sample in the event of subsequent information suggesting testing would be appropriate (Fig. 5).

Fig. 5 Blinding sand is carefully removed and a small sample taken immediately after the membrane has been cut and bent back



In general, two large (c. 15–20 kg) samples should be taken of each compacted layer where more than one can be identified, but as noted above, in some situations it may be particularly important to ensure the volume of material taken is appropriate for the size of the aggregate clasts.

Prior to reinstatement, the test pit should be photographed and logged.

Sampling Concrete

It is often necessary to take samples to establish the strength/quality of the concrete used in the floor slab and whether there is any reinforcement, as this will affect how heave is manifested in the property.

One cored sample will be required to assess the strength and composition of the concrete, including the proportion of cement and whether there is any evidence of pyrite in the contained aggregate. This sample may be one of the cores removed when the test pit was opened.

If cracks are present in the floor slab, it is valuable to take a sample including the crack. It can then be examined to determine whether it extends through the full depth of the concrete and/or is more open near the upper surface, which would indicate heave. A core containing a crack may also be requested in order to determine if there are sulphate minerals growing in the crack, which would indicate an unsatisfactory membrane between the fill and the concrete.

Testing of structural concrete in the foundations/rising walls may also be required. However, as this is normally specified during the remedial works, it is not discussed here.

Post-sampling

A drawing should be prepared detailing the property, room and location where each sample was taken and the date.

A test schedule will be drawn up reflecting both the site conditions and the requirements for the particular project. This may involve splitting samples between interested parties. After the samples have been logged, as much air as possible should be removed from the sample bags and they should be securely sealed and labelled. If they cannot be tested immediately, they should be stored in a cool environment (say 5–10 °C), away from direct sunlight.

Samples for immediate testing should be dispatched as quickly as possible and the laboratory notified, such that preparation for testing can be undertaken as soon as possible. This is extremely important as changes in the environment will affect the chemical reactions which take place in the material. Where additional samples are to be held for future use, the conditions in which they are to be kept should be agreed and recorded. At a minimum a cool environment away from direct sunlight

is required, but instructions may be given for the material to be kept at a lower temperature and/or for the moisture content to be obtained and the sample then dried in an oven at in the order of 40 °C or air dried under a lamp.

Summary and Conclusions

This chapter has drawn attention to some important considerations when sampling potentially pyritiferous material, with particular reference to fill beneath structures which are showing evidence of distress. In order to ensure that the appropriate testing can be carried out and to minimise the likelihood of misleading results, a number of factors must be taken into account.

1. The location of the sampling points can directly influence the results obtained. Samples taken in warmer areas (near fire places, radiators, underfloor hot water pipes etc.) are likely to show enhanced gypsum growth compared with areas near rising walls where it is likely the temperature will be cooler and the fill less compacted. This information must be recorded.
2. Sampling should be undertaken from a carefully excavated inspection pit in order that:
 - a. The nature of the concrete slab and whether it is reinforced can be determined;
 - b. The full nature of the material can be visually assessed, including the thickness and density of the various fill layers;
 - c. A suitably sized sample of material can be taken which is representative of the fill, including the coarse and fine fractions;
 - d. The depth of the fill and where necessary the nature of the underlying in situ material can be determined.
3. Care should be taken to minimise any disturbance suffered by the sample as this will affect both the assessment of the material in its current condition and potentially accelerate further oxidation.
4. When samples of concrete are required to assess its quality, it is valuable if one of the cores can extend across a crack, if present. This not only allows information to be obtained on the strength/composition of the concrete but, if the crack can be seen to widen upwards, provides useful evidence that heave is taking place.

The positions of the inspection pits should be recorded and a log and photographs obtained. Samples should also be photographed and dated prior to the air being excluded and the bags sealed. Storage should be kept to a minimum as any changes in environmental conditions can affect the chemical reactions which may be taking place. When necessary, samples should be kept in a cool environment, away from direct sunlight, prior to transportation to the laboratory.

If additional samples are to be kept for future use, the conditions in which they are kept should be agreed and recorded. In most cases a low temperature will be required, or it may be decided that the moisture content should be obtained and the sample oven/air dried.

References

- British Standards Institute (BSI). BS 1377 (1990 amended 2002). 1999 *Methods of test for soils for civil engineering purposes*. London: British Standards Institution.
- Eden, M. (2013). Testing of Potentially Pyritiferous Material. In A. B. Hawkins (ed.), *Implications of pyrite oxidation for engineering works*, 1–25.
- Hawkins, A.B. (2013). Engineering Implications of the Oxidation of Pyrite: An Overview, with Particular Reference to Ireland. In A. B. Hawkins (ed.), *Implications of pyrite oxidation for engineering works*, 1–97.

Implications of Pyrite Oxidation for Engineering Works

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