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Risk Management and the Problems Associated with the Presence of Pyrite Contained in Sub Floor Infill

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Definition of Pyrite

- The mineral Pyrite or Iron Pyrite is an iron sulphide with the chemical formula FeS_2 .
- The name Pyrite is derived from the Greek word (Purites) meaning “of fire”.
- In ancient Roman times this name was applied to several types of stone that would create sparks when struck against steel.



Where it is found

- Pyrite is usually found associated with other sulphides or oxides in quartz veins, sedimentary rock and metamorphic rock as well as in coal beds.
- Despite been nicknamed “fools gold” it is sometimes found with small quantities of gold.



Uses

- Pyrite enjoyed brief popularity in the 16th and 17th centuries as a source of ignition in early fire arms.
- Pyrite remains in commercial use with the production of sulphur dioxide for use in such applications as the paper industry and in the manufacture of sulphuric acid.
- It is also used in making certain types of jewellery.

Weathering and Release of Sulphate

- Pyrite exposed to the atmosphere during mining and excavation reacts with oxygen and water to form sulphate resulting in acid mine drainage.
- Iron Pyrite oxidation is sufficiently exothermic that underground coal mines in high sulphur coals seams have occasionally had serious problems with spontaneous combustion in the mined out areas of the mine.
- The solution was to seal the mined out areas to exclude oxygen.
- In modern coal mines limestone dust is sprayed onto the exposed coal surfaces to reduce the hazard of dust explosions.

Weathering and Release of Sulphate

- This has the secondary benefit of neutralising the acid released by Pyrite oxidation and therefore slowing the oxidation cycle thus reducing the likelihood of spontaneous combustion.
- In the long-term however, oxidation continues and the hydrated sulphates formed may exert crystallisation pressure that can expand cracks in the rock and lead eventually to roof collapse.



The Mineral Pyrite



The Mineral Pyrite



The Mineral Pyrite



What is Hardcore?

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



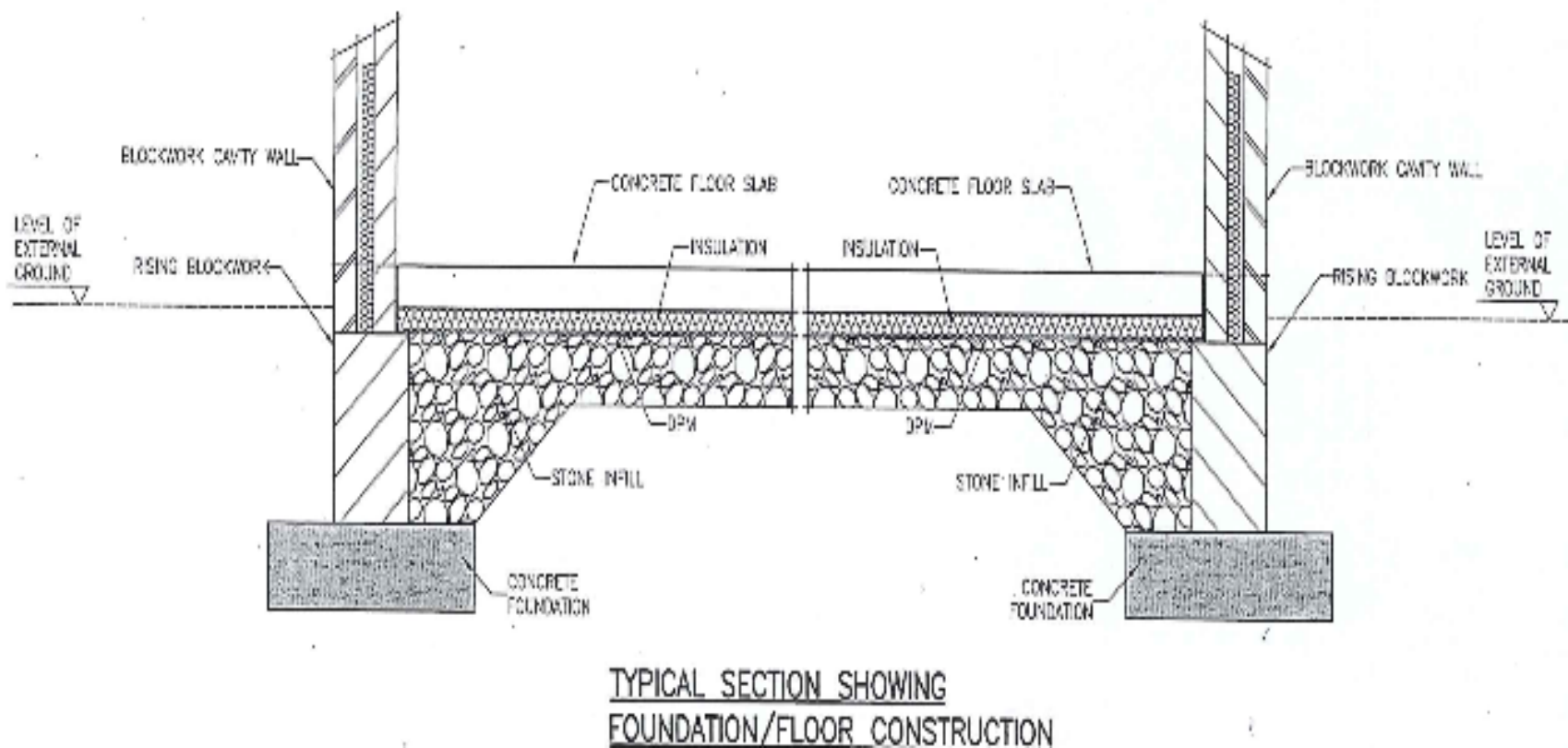
What is Hardcore?

- The Hardcore should be well compacted in layers of appropriate thickness.
- Materials should also be chemically inert and not physically affected by water.
- Unfortunately some of the materials and placing procedures used in the past have not met these requirements and there has been consequent damage to buildings.

What is Hardcore?

- The principal problems have been
 - Chemical attack by hardcore materials on concrete.
 - Settlement due to poor compaction.
 - Consolidation or Swelling resulting from changes in the moisture content and/or chemical instability.

What is Hardcore?



International Experience

- In the early 1980s Canada saw an upsurge in the construction of new residential units which peaked at nearly 75,000 in 1987, a proportionally higher number of problems were recorded from that period.
- Traces of Pyrite (FeS_2) was found in the sedimentary rock used to make crushed stone, the backfill material used in the construction of private houses in this period.
- Cases have been reported in some sites on the island of Montreal.
- Most cases were recorded as occurring in buildings from 8 to 20 years old.



International Experience

- Affected areas in the UK are the English Midlands from Coventry to Birmingham.
- Also reported are areas in the North East of England from Doncaster northwards to Newcastle-upon-Tyne and the midland valley of Scotland between Glasgow and Edinburgh.



International Experience



Map showing Coalfield areas of the UK. In and adjacent to these areas there has been widespread use of sulfate-bearing hardcore derived from burnt colliery spoil, furnace bottom ash and mineral processing slags.

International Experience

- For residential buildings constructed before 1970 the layer of crushed stone used as infill at foundation level was found to be either non-existent or quite thin.
- This would tend to explain why there have been very few problems reported with buildings constructed up to this time.

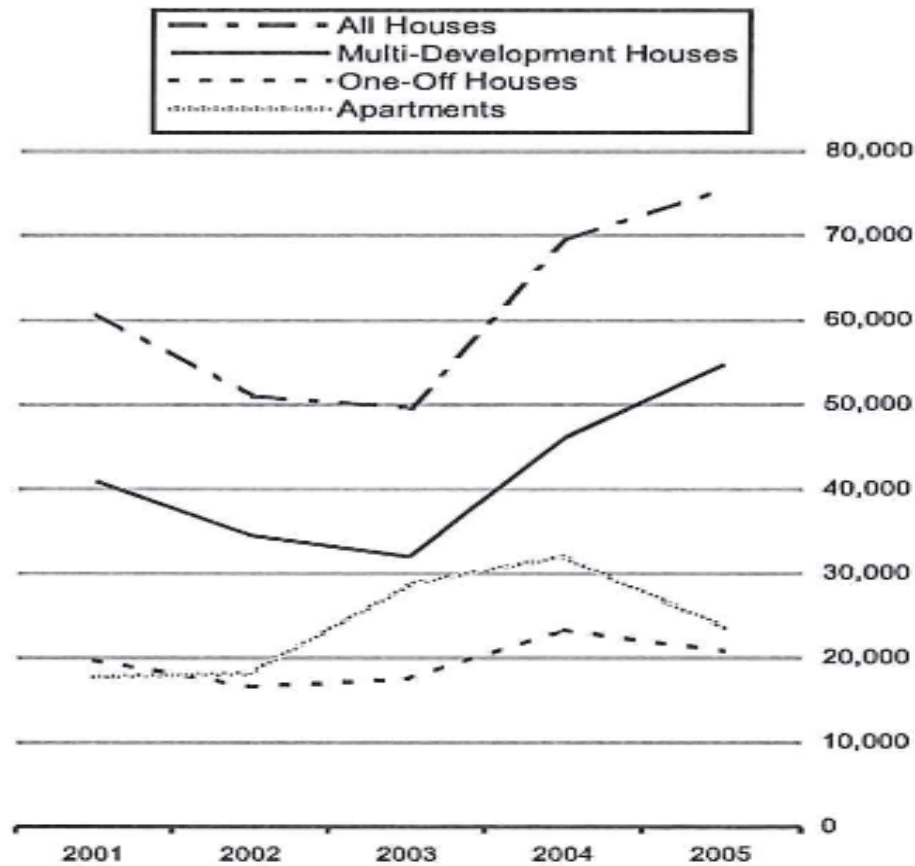
The Irish Experience

- Celtic Tiger 1995 – 2007.
- Construction Industry Boom.
- Increased demand for building materials, building products.
- Particular demand for infill for residential, commercial and infrastructural projects.



The Irish Experience

Number of Dwelling Units approved
classified by type of unit, 2001-2005



“Pyrite caused 2 new homes to explode”

Wednesday 7th of April 2010

- Fine Gael's Sean McIntee has told the Oireachtas Transport Committee that 2 homes had exploded because of the inappropriate use of Pyrite in their construction.
- Mr McIntee said that this happened in Kentstown, Co Meath to houses worth €500,000 each.



“Devastating Pyrite Epidemic Hits 20,000 Newly Built Houses”

Monday 22nd of February 2010

- Up to 20,000 homeowners are facing the devastating Pyrite problem which is destroying recently built houses.
- The average cost of removing Pyrite from a house and repairing the damage is between €50,000 and €70,000.
- According to an Irish Independent investigation there are 20 building firms which have used material which contains Pyrite from at least 4 suspected quarries which are located in Dublin and Meath.



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Irish Geology

- Approximately 40% of the Island of Ireland, and 50% of the Republic, is underlain by limestone bedrock.
- The most common form of limestone comes from the carboniferous age and is over 300 million years old.
- This limestone is generally hard and grey or black in colour.
- Limestone is a rock type that is almost entirely composed of calcite (calcium carbonate).
- Some limestones are almost pure carbonates but many contain thin layers or pockets of other softer materials, such as clay or shale.

Cause

- A chemical reaction causes the hardcore infill to swell and expand.
- Where the infill contains Pyrite this metal oxidises and produces sulphuric acid in the presence of humidity and oxygen.
- This acid reacts with calcium carbonates found in the crushed stone.
- The chemical reaction results in the formulation of sulphate and gypsum.

Cause

- This gypsum crystallises and causes the infill to swell.
- This swelling may heave the internal concrete slab and interior structural supports resting on it.
- In cases where the aggregate fill is of small chips which have not been heavily packed there may be space where the gypsum can form without causing expansion of the sub floor unit.

Cause

- The amount of heave will depend on the percentage of Pyrite, the depth of the fill, the size and orientation of the aggregate and various factors which affect the Pyrite oxidation process.
- Where the Pyrite content is 2%+ evidence has been found of damage caused by the swelling of the infill heave.

Cause

- Pyrite content has been found to be higher when compared to the problematic aggregates in Quebec.
- Gypsum percentage has been found to be higher than that experienced in Canada.
- Rapid oxidation has occurred because of the presence of fine strands of Pyrite found in the aggregate.
- The aggregate infill in Ireland has shown a higher rate of absorption which favours Pyrite coming into contact with water.
- The climate in Ireland has significant levels of rainfall leading to greater moisture levels.

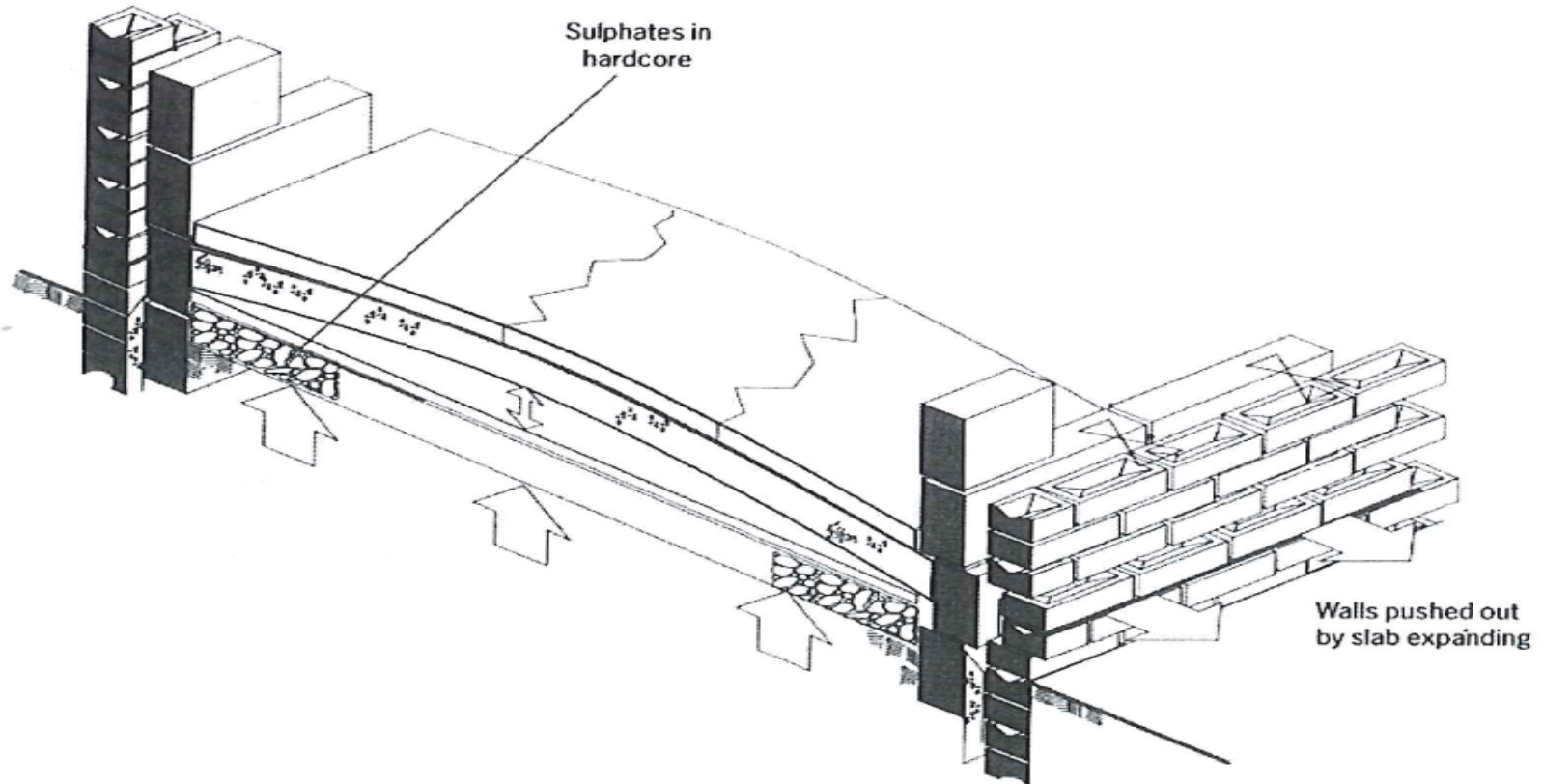


Damage

- As a consequence of the swelling and expansion of the infill damage has been seen mostly to the interior of properties.
- The swelling will take the route of least resistance and generally speaking this is upwards, affecting the concrete floor and internal walls.
- The rising walls can also be affected in some instances.



Damage



Doming and cracking of floor slab and outward displacement of walls

Damage



Distortion and cracking of the concrete floor slab caused by the expanding infill beneath

Damage



Photo shows evidence of concrete floor crack caused by expansion of infill

Damage



Photo shows cracking in tiles caused by swelling beneath

Damage



Photo shows the cracking in the exposed blockwork

Damage



Photo shows example of a trial pit excavated to undertake sampling of the hardcore

Remedial Works

- Survey of internal cracking.
- Plasterboard removed, cracks in exposed block work recorded.
- All services isolated.
- Fixtures and fittings removed and stored.
- Upstairs of properties sealed to minimise dust etc.
- Cut and remove concrete flooring, cut in sections so it can be carried out and placed in skip for disposal.



Remedial Works

- Remove hardcore down to the original subgrade level.
- Ensure all particles of infill inbedded in subsoil are removed.
- New infill delivered and loaded onto conveyor and levelled and compacted.
- Services reconnected.
- New dpm barrier laid.
- New insulation laid.
- Floor reinstated.
- Replaster where required.
- Complete snag list.

Remedial Works



Remedial Works



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Remedial Works



Remedial Works



Remedial Works



Remedial Works



Remedial Works



Remedial Works



Risk Management for the Underwriter

- Knowing the Risk.
- Quality checks at quarry location (metal detectors?)
- Proper analysis of excavated hardcore for specific uses e.g. motorways, residential housing, commercial/infrastructural.
- Quality analysis by contractors using the hardcore.
- Use of different construction methods including suspended floors (timber/concrete). Pre-cast concrete floors with ventilated airspace below.

