Engineers Report in Accordance with IS 465 :2018

K2 Design

Consulting Structural
& Civil Engineers

Dundrain, Burnfoot, Donegal,
F93 CK74

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1.0 Introduction

IS:465:2018+A1:2020 Assessment, Testing and categorisation of damaged buildings incorporating concrete blocks containing certain deleterious materials.

This is the current standard on which the testing is based upon. The protocol of the standards recommends a building condition assessment by the Engineer to categorise the level of damage and group the property within
groups 1-4. There was no damage attributable to defective blockwork evident.

The protocol in IS:465 states that no core extraction or coring should take place unless any damage to the property places the property in at least Group 2.(table 1) Group 1 properties are outside the scope of IS:465. If the property is undamaged, then no testing would be recommended.

The testing in this dwelling has been requested to check if the blockwork contains deleterious materials. We have extracted 6no. cores from the dwelling.

Supplementary Test Suite A+ has been carried out. The testing consists of the following:

The Suite A+ report provides an interpretative summary of concrete block classification risk for mica and sulphide degradation based on the following fixed package of testing:
· Test Suite A – Simplified petrography carried out as per I.S. 465 standard procedure.
· Mica testing – Free mica quantification by SEM phase mapping (Test Suite C).
· Sulphide testing – Examination of sulphides by reflected light optical microscopy.
· Sulphur/sulphate chemical testing – Laboratory analysis of a representative bulk sample for TS, AS and WSS and two further samples for total sulphur only.

2.0 Brief

On the instructions of our client [redacted], we have been asked to confirm the presence of defective blockwork at the above project.

3.0 Observations

In association with Anytime Coring, we have extracted cores as follows:

Core 001	Front Elevation (outer leaf)
Core 002	Front Elevation (inner leaf)
Core 003	LHS Gable Elevation (outer leaf)
Core 004	Rear Elevation (inner leaf)
Core 005	Rear Elevation (outer leaf)
Core 006	RHS Gable Elevation (substructure)

Suite A simplified petrography analysis, Suite B examination and classification requirements, estimation of free muscovite mica and sulphides.

4.0 Results

4.1 Suite A Analysis.

Suite A has identified one type of concrete.

Cores 1, 2, 3, 5 & 6 have been classified by Suite A examination as displaying a LOW/MEDIUM susceptibility to deterioration due to the common (trace/minor) presence of potentially problematic mica bearing lithologies / minerals.

4.2 Compressive Testing

The compressive test results have indicated strengths of

Core 4 , 13.80 N/mm^2

Core 4 is ABOVE the minimum recommended strength of 7.5N/mm2 specified with the Building Regulations Technical Guidance Booklet A ;2012.

4.3 SEM Petrographic Analysis.

Core 1 (Concrete Type 1) was submitted for Supplementary Test Suite A+

The aggregate in concrete type 1 is composed of a 0/20 mm heterogenous river gravel and a 0/1 mm beach/dune sand (~90:10).

SEM analysis of the binder of sample 1 quantifies the average content of free muscovite mica at 4% by volume of cement paste. This is considered to be an underestimate as discrimination of free mica by SEM analysis is not absolute. There is also evidence of free chlorite, which is also a phyllosilicate and could behave similarly to muscovite in cement. While there are no published limits for free mica content of aggregates in European or American standards, it has been reported that in most cases of poor concrete block durability due to micaceous aggregates that the free mica content of the binder is typically >5% by volume of the paste. The free mica content is below this proposed threshold and associated with aggregate components that typically perform well during freeze-thaw testing.

The presence and abundance of free mica in the binder, as determined by the supplementary testing, confirms the Suite A classification of concrete type 1 as displaying Low/Medium susceptibility to potential free mica degradation
(RISK LEVEL 2) Risk (of mica degradation) levels subjectively take into account both amount and context: 1 – Negligible; 2 – Low/Medium; 3 – High; 4 – Very High/Critical.

The aggregate contains only traces of pyrite (visual estimate<0.1%), with common iron oxides likely formed from the oxidation of the sulphides. No pyrrhotite was seen. The sulphides are generally encapsulated in stable lithologies. The presence of sulphides can be a cause for concern due to the potential for oxidation and subsequent production of expansive cracking and associated secondary sulphate minerals. However, in this sample the pyrite is generally well encapsulated, or already converted to iron oxides, and only trace sulphides are visible.

4.4. Sulphide Chemical Analysis.

Results of a sulphide risk assessment are detailed below.

Test	Core 1
Total sulphur content (as S) by HTC	0.18%
Acid soluble sulphate content (as SO_4)	0.50%
Water soluble sulphate content (as SO_4)	10 mg/l
pyrite equivalent value	<0.1%

The chemically determined residual sulphide mineral content (pyrite equivalent value) was calculated as <0.1% for sample 1. Acid soluble sulphate (AS) content was reported as 0.50% SO4 and water-soluble sulphate (WSS) content was reported as 10 mg/l SO4. The AS value is at the guidance value of 0.5% SO4 mentioned in Annex E of IS 465:2018+A1:2020 as a value of sulphate that would not be considered abnormal in a standard concrete block. (RISK LEVEL 2) Risk (of pyrite or other sulphide degradation) levels subjectively take into account both amount and context: 1 –Negligible; 2 – Low/Medium; 3 – High; 4 – Very High/Critical.

Total sulphur (TS, 0.18%) only slightly exceeds the 0.1% value mentioned in Annex E as a typical contribution to total sulphur from the cement for a standard block. Irish Standard EN 12620:2002 and Irish national guidance S.R. 16:2016 limit total sulphur in aggregate for use in concrete to ≤1.0%TS, provided there is no pyrrhotite present. In sample 1, after sulphur in the cement has been accounted for, the TS remains significantly below this limit.
(RISK LEVEL 1) Risk (of pyrite or other sulphide degradation) levels subjectively take into account both amount and context: 1 –Negligible; 2 – Low/Medium; 3 – High; 4 – Very High/Critical.

EN12620 and guidance document SR16 limit total sulphur in aggregates to 1.0 %. However, if Pyrrhotite or other reactive pyrites are present this limit is reduced to 0.1%. An allowance of 0.1% is given for the sulphur contribution from the cement.
In this instance when the allowance for cement has been considered the Total Sulphur level is well below the 1.0% allowable.

The chemical results for sample 1, taken together with the textural encapsulation of the majority of the pyrite, means the risk of concrete degradation from sulphide oxidation is considered Negligible.

5.0 Conclusions

The concrete should be considered as displaying LOW/MEDIUM Risk to deterioration from potential freeze-thaw damage.

The concrete should be considered as displaying NEGLIGIBLE Risk to deterioration from sulphide degradation.

In my opinion the blockwork is suitable for construction if all blockwork is characteristic of these test samples.

Following more recently published peer reviewed research (The Mica Crisis in Donegal, Ireland – A case of Internal Sulfate Attack?, A Leeman, B Lothenbach, B Munch, T Campbell, P Dunlop) it has become apparent that the cause of damage to properties in County Donegal is due to excessive levels of Iron Sulfide (Pyrite and Pyrrhotite) in the aggregate used for the manufacture of concrete blocks, and that Muscovite Mica played only an enabling role.

The oxidation of iron sulfides, primarily pyrite (FeS_2) and pyrrhotite (Fe1-x S), as the cause of the most severe examples of poor durability in Donegal. The initial oxidation of iron sulfides leads to the formation of iron oxides and hydroxides, along with the release of sulfuric acid. The continuation of chemical reactions within the cement paste then lead to the formation of ettringite, causing a pronounced volume change, followed by thaumasite and gypsum under certain conditions. Sulphur deterioration is not a concern based upon these test results.

Signed____________________

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