
**REPORT OF
THE EXPERT
PANEL ON
CONCRETE
BLOCKS**

June 2017

DISCLAIMER

The Expert Panel did not commission or carry out any tests on buildings or building materials itself and was dependent on technical information supplied directly to it by homeowners and concerned parties. The Panel have no responsibility for the accuracy of the technical reports and information received by it and the Report should be read in that light. It was not part of the Panel's remit to apportion responsibility for any building defects drawn to its attention and it has not done so.

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Letter to the Minister

June 2017

Mr. Damien English, T.D,
Minister of Housing and Urban Renewal,
Department of Housing, Planning, Community and Local Government,
Custom House,
Dublin 1,
D01 W6X0.

Report of Expert Panel on concrete blocks in counties Donegal and Mayo.

Dear Minister,

I submit herewith for you and your Government's consideration the report of the Expert Panel established by your predecessor Mr. Paudie Coffey, T.D. in April 2016.

The Expert Panel was established in the light of problems that emerged with concrete blocks used in certain dwellings in Counties Donegal and Mayo for the purpose of assisting the parties directly involved in their efforts to reach a satisfactory resolution to these matters. The Terms of Reference required the Expert Panel to identify the number of private dwellings affected, to establish the nature of the problem, to outline technical solutions and to submit a report to you as Minister. The full Terms of Reference of the Expert Panel are shown in Chapter 1 of this report.

My colleagues on the Expert Panel were: -

- Mr. Noel Kane, BE,Dip Comp Eng, Eurlng, CEng, FIEI, FIStructE, MIEAust, MACI, RconEI, member of the National Standards Authority Of Ireland's Concrete and Eurocodes Consultative Committees and chair of their Masonry Panel and Eurocodes Masonry Subcommittee;

-
- Mr. Frank Lee, BE, FIEI, FConsEI and nominated by the Association of Consulting Engineers of Ireland; and
 - Mr. Dave Blaney, PGeo, EurGeol, BSc, MSc and Board member of the Institute of Geologists of Ireland.

The Panel was assisted by the following staff from your Department, Mr Paris Beausang, Assistant Principal, Housing Advisers & Building Standards Section, who also acted as secretary to the Panel and by Mr. John Wickham, Technical Advisor, Housing Advisers & Building Standards Section.

The Panel met on several occasions since their appointment and visited both Donegal and Mayo where they inspected a representative sample of the affected dwellings. In both counties, the Panel met with the elected members and with the executive staff of the respective local authorities. The Panel also facilitated meetings with TDs and Senators.

As part of the consultation process, the Panel met with several stakeholders and groups who were in a position to contribute to the final report. In particular, the Panel met with representatives from the Mica Action Group in Donegal and the Mayo Pyrite Group in Mayo.

During our visits to Counties Donegal and Mayo, the Panel had the opportunity to see at first hand the difficulties being experienced by the affected home owners in these counties. Unfortunately, there are many families affected. These persons are devastated by the manner in which their family homes have deteriorated since they were constructed. The frustrations, trauma and distress of these people were clearly visible during our visits to their homes. They have homes in which they made significant financial investments on behalf of their families but now find that their investments may be worthless. The lives of these people have been seriously impacted both emotionally and financially and they find themselves in an unfortunate and difficult position and are seeking assistance from wherever possible to rectify their situations.

While there are many dwellings affected, the problems appear to be largely confined to the Inishowen and Letterkenny areas in County Donegal and the north western area of County Mayo. The dwellings impacted are within estates, one off rural types and a mix of contract and self-build.

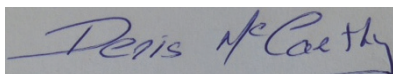
On behalf of the Panel, I wish to thank most sincerely the individuals and families who allowed us access to their homes to see at first hand the problems. They extended the greatest respect and hospitality to us. I also wish to thank the elected members and officials of both local authorities and the TDs and Senators for their support and information gathering for the assistance of the Panel. Additionally, I wish to thank the members of the Mica Action group in County Donegal and the Mayo Pyrite Group in County Mayo for meeting with us and assisting us in our travels to the various affected homes. Finally, I wish to thank the various stakeholders who met with, and assisted the, Panel in the provision of appropriate information to formulate this report.

I wish to acknowledge the input and work of my fellow members of the Expert Panel for their time and expert advice and cooperation at all times and for making themselves available at short notice for many meetings. I also wish to acknowledge the assistance of the staff of your Department, particularly Mr. Paris Beausang and Mr. John Wickham who were a constant support to the Panel.

This report has put forward a number of technical solutions for the problems encountered in Donegal and Mayo. I trust that you will find the report helpful and that it will assist the Government in dealing with an issue that is hugely difficult for the homeowners affected.

The affected homeowners in both Donegal and Mayo have endured a harrowing experience with their respective issues. It is imperative that the relevant standards, controls and procedures are followed to ensure that there is not a recurrence of this or similar issues in house construction. In this context, the Panel recommend that existing building controls are fully enforced for all house building to give confidence to individual homeowners that their significant investment is not wasted.

Yours sincerely,

A handwritten signature in blue ink that reads "Denis McCarthy". The signature is written in a cursive style and is positioned above a horizontal line.

Denis McCarthy,
Chairperson of the Expert Panel

Chapter 1 Introduction and Background

1.0 Introduction

The emergence of dwellings exhibiting structural distress manifesting as a particular pattern of external wall cracks first became public knowledge in 2013 and was subsequently raised with the Department of the Environment, Community and Local Government shortly before the end of 2013. In the case of Donegal, media reports and political representations suggested that the nature of the problem related to the crumbling of the concrete blockwork in the external walls thereby compromising the structural integrity of the affected dwellings and giving rise to considerable personal upset and worry among the many homeowners involved. At that time, several hundred homes were suspected to be exhibiting structural distress in north Donegal. The presence of muscovite mica in abundant quantities in the aggregate constituent of the concrete blocks was suggested as being one of the main factors contributing to the deterioration of the concrete blocks.

In late 2013, similar problems also came to light in both public and private dwellings located in west Mayo. Mayo County Council submitted a report to the Department on problems that had been identified with the concrete blockwork in two of their social housing estates comprising of some 9 dwellings and 6 dwellings respectively. In this instance, the presence of pyrite in the aggregate constituent of the concrete block was suggested as being one of the main factors contributing to the deterioration of the concrete blocks. In addition, a political representation on behalf of the owners of 10 private homes was also received in the Department which reported the emergence of similar problems among private households located on the Belmullet peninsula. In mid-2014, the Council further advised the Department that a third social housing estate comprising a pair of semi-detached dwellings was similarly affected.

Over the course of 2014 and 2015, political representations, parliamentary questions, media reports and letters from affected homeowners continued to be received in the Department illustrating the increasing scale of the problems emerging in the two counties, the progressive nature of the external wall cracking and the resultant structural distress in the affected properties. Meetings were held with representatives from both the Mayo Pyrite Group and with representatives from the Mica Action Group in Donegal during 2014.

In early 2015, Mr. Paudie Coffey, T.D., then Minister of State at the Department of the Environment, Community and Local Government, visited a number of affected homeowners

in County Donegal to acknowledge the extremely difficult and distressing situations they were facing and to witness first-hand the damage to their homes. Following the Minister of State's visit, a number of technical reports, from consulting engineers and testing laboratories respectively, were provided by representatives from the Mica Action Group to better inform the Department's understanding of the problems facing their members and many other homeowners in the county with regard to the symptoms of structural distress manifesting as a particular pattern of external wall cracks in their homes.

Against this background and from the information available at that time, an internal report was prepared within the Department to provide an overview of the problems in Counties Donegal and Mayo together with a number of options for the Minister of State's consideration.

1.1 The regions affected

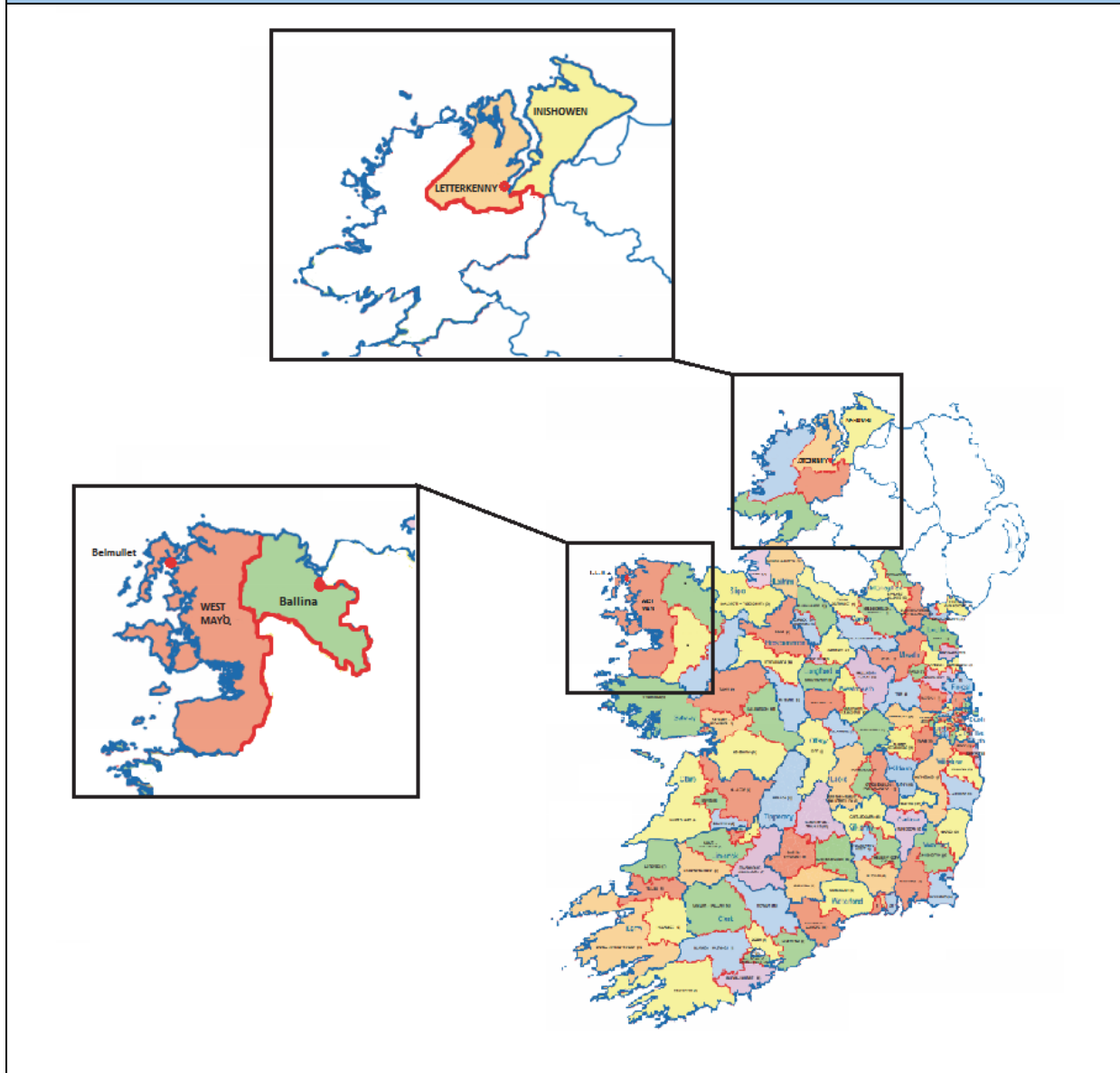
The problems that have emerged in the affected properties appear to be largely confined to specific regions within each of the two counties concerned. In the case of County Donegal, the affected dwellings appear to be located principally in the Inishowen Municipal District although a smaller number of properties are similarly affected in the Letterkenny Municipal District. It is reported that problems have manifested in dwellings built as far back as 1984 and in buildings constructed up to 2011 although the period between 1999 and 2008 appears to be when most of the affected properties were completed.

In County Mayo, the problems appear to be largely concentrated in the northern parts of the Ballina and the West Mayo Municipal Districts. The affected dwellings are reported to have been constructed between 1998 and 2008 although the largest concentrations appear to have been completed within the 2000 to 2006 period.

The problems do not appear to be confined to particular property types, as dwellings in both large and small-scale housing developments located in towns and villages across the two counties seem to have been affected. A large number of one-off rural dwellings also appear to be affected in the locations specified in both counties. There is also evidence to suggest that an extension to a school in County Donegal may be exhibiting structural distress manifesting as a particular pattern of external wall cracks similar to affected homes.

Figure 1.1 illustrates the affected Municipal Districts in Counties Donegal and Mayo.

Figure 1.1 Affected Municipal Districts in Counties Donegal and Mayo



1.2 Expert Panel on Concrete Blocks

1.2.1 Terms of Reference

In late November 2015, the Minister of State announced his intention to establish an Expert Panel to investigate the problems emerging in the concrete blockwork of certain dwellings in Counties Donegal and Mayo with a view to providing some assistance to the parties directly

involved in their efforts to reach a satisfactory resolution to their difficulties. Accompanying the Minister of State's announcement were the terms of reference and an outline structure of the Expert Panel.

In light of the highly technical nature of the emerging problems in Counties Donegal and Mayo, a range of specific technical skillsets were considered to be essential to the membership of the Expert Panel. In this context, the Expert Panel would comprise a chartered engineer with a particular expertise in building defects analysis, a geologist with an expertise in the practical assessment of geological resources, aggregates and their suitability for particular end-use applications, an expert on the current standards applicable in the manufacture of aggregates, concrete products, cements and masonry products and a chairperson with a senior public sector experience and a strong technical background.

The Terms of Reference announced by the Minister of State were: -

In light of the problems that have emerged with the concrete blocks used in certain dwellings in Donegal and in Mayo and for the purpose of assisting the parties directly involved in reaching a satisfactory resolution to these matters, it is proposed to establish an expert group with the following terms of reference: -

- (i) to identify, insofar as it is possible, the numbers of private dwellings which appear to be affected by defects in the blockwork in the Counties of Donegal and Mayo;*
- (ii) to carry out a desktop study, which would include a consultation process with affected homeowners, public representatives, local authorities, product manufacturers, building professionals, testing laboratories, industry stakeholders and other relevant parties, to establish the nature of the problem in the affected dwellings;*
- (iii) to outline a range of technical options for remediation and the means by which those technical options could be applied by the affected homeowners in a manner that delivers cost effective and satisfactory outcomes for those homeowners; and*
- (iv) To submit a report to the Minister of State by 31 May 2016¹.*

¹ The formal arrangements to establish the Expert Panel did not conclude until April 2016 and, having regard to the complexities of the problems in the two counties, the deadline for submission of the report to the Minister of State was revised to end January 2017.

Arrangements were put in place to identify and appoint a chairperson with the necessary mix of skills and experience required to direct and manage the work of the Expert Panel over the duration of its investigations and to facilitate the delivery of a comprehensive report to the Minister of State on completion of their research.

1.2.2 Membership of the Panel

The chairperson of the Expert Panel was announced in late January 2016; nominations to participate on the Expert Panel were sought thereafter from Engineers Ireland, the National Standards Authority of Ireland and the Institute of Geologists of Ireland. The full composition of the Expert Panel is: -

- Mr. Denis McCarthy, a civil engineer and former Director of Services and Acting County Manager with Waterford County Council. Chairperson of the Expert Panel;
- Mr. Noel Kane, BE, Dip Comp Eng, Eurlng, CEng, FIEI, FStructE, MIEAust, MACI, RconEI, member of the National Standards Authority of Ireland's Concrete and Eurocodes Consultative Committees and the chair of their Masonry Panel and Eurocodes Masonry Subcommittee;
- Mr. Frank Lee, BE, CEng, FIEI, FConSEI nominated by the Association of Consulting Engineers of Ireland; and
- Mr. Dave Blaney, P.Geo, EurGeol, B.Sc., M.Sc. and Board member of the Institute of Geologists of Ireland.

Technical and administrative support was provided to the Expert Panel by officials from the Department of Housing, Planning, Community and Local Government (formerly the Department of the Environment, Community and Local Government).

The Expert Panel was formally announced in early April 2016 and held its inaugural meeting on 15 April 2016.

Chapter 2 Consultation, Investigation and Nature of the Problem

2.0 Introduction

In response to the Terms of Reference: -

“(ii) *To carry out a desktop study, which would include a consultation process with affected homeowners, public representatives, local authorities, product manufacturers, building professionals, testing laboratories, industry stakeholders and other relevant parties, to establish the nature of the problem in the affected dwellings*”,

this chapter discusses the findings of the Panel’s desktop study and consultation with stakeholders.

While the Panel endeavoured to determine the nature of the problem, it should be noted that it was not within the Panel’s remit to apportion blame for the cause of the building defects and the determination of civil liability is ultimately a matter for the courts.

2.1 Consultation

The Panel undertook an extensive stakeholder consultation exercise.

Over the course of the consultation process, the Panel met on twelve separate occasions and a similar number of meetings took place with key stakeholders, including affected homeowners, the elected members of Donegal and Mayo County Councils, local authority officials, industry bodies, academics, public representatives and other interested parties. In addition, the Panel visited 9 private households across different locations within the Letterkenny and Inishowen areas of County Donegal to view first-hand the damage to their homes and to hear of their experience of how the problems emerged and progressed over the years. Equally, the Panel visited 14 homes within the Ballina and Belmullet regions in Mayo in order to gain an important insight into the similar-type problems facing many homeowners in County Mayo.

A substantial volume of information was provided by affected homeowners in both counties, as well as from Donegal and Mayo County Councils; additional information was also provided through the extensive consultation process undertaken by the Panel. In this

regard, information on dwellings exhibiting structural distress manifesting primarily as a particular pattern of external wall cracks were collated from various sources including: -

- home owners/ home owner representatives;
- public representatives;
- local authorities;
- house guarantee providers;
- builders; and
- stakeholders.

Appendix 1 lists the persons / organisations who met with the Panel over the course of its investigations and consultations.

2.2 Investigation

For the purposes of establishing the nature of the problem, the consultations outlined in paragraph 2.1 enabled the Panel to form a general profile of the: -

- local geological setting;
- local climatic and exposure conditions;
- type of construction;
- builder type;
- year(s) of construction;
- manifest nature of the defect; and

-
- timeframe for problems to be first noticed.

The Panel accepted at face value the identification of private houses exhibiting structural distress primarily manifesting as a particular pattern of external wall cracks from the affected homeowners and other informed sources.

In addition, the Panel conducted an evaluation of all associated technical reports and other supporting information received. It should be noted that it was not in the Panel's remit to commission testing to verify the cause of the defects claimed in these reports.

2.2.1 Geological setting

For the purposes of this report, the geology has been simplified and can be described as three principal rock types: -

- the metamorphic rocks, which are dominated by phylites, psammities, quartzites, marbles and metadolerites of the Dalradian Supergroup aged between 700 - 600 million years old;
- large igneous bodies (dominantly granites and granodiorites) that were intruded during the Caledonian Orogeny and are approximately 415 million years old; and
- the younger sedimentary rocks, dominated by limestones and sandstones that unconformably overly the Dalradian to the south of the county and are Carboniferous aged, approximately 359 - 343 million years old.

2.2.1.1 The geological setting of County Donegal

Due to a complex structural history, involving at least three orogenic events, the geology of County Donegal is extremely complicated and is a world renowned destination for structural geologists. The complexity is due to the repeated deformation and metamorphism by the orogenic, mountain building, events - namely the Grampian, Caledonian and Variscan Orogeny's.

The oldest rocks found in mainland Donegal are the Dalradian aged sequence of metamorphic rocks that were deposited in a marine environment and consist of limestones, sandstones and mudstones. Metamorphism, due to deep burial with associated crustal

stresses, led to extremes of pressure and temperature resulting in the alteration of the sedimentary rocks to form schists, pelites, psammites, quartzites and marbles. The individual geological formations of the Dalradian are sequences of sedimentary beds that have been formed over a discrete period of time in similar depositional conditions. They are often locally heterogeneous and can consist of interdigitating beds of schist, pelite, psammite and marble in varying proportions. The variability in associated (but lithologically different) sediment types impacts upon their physical characteristics, e.g. grain size, strength, mineralogy, resistance to chemical / physical weathering etc.

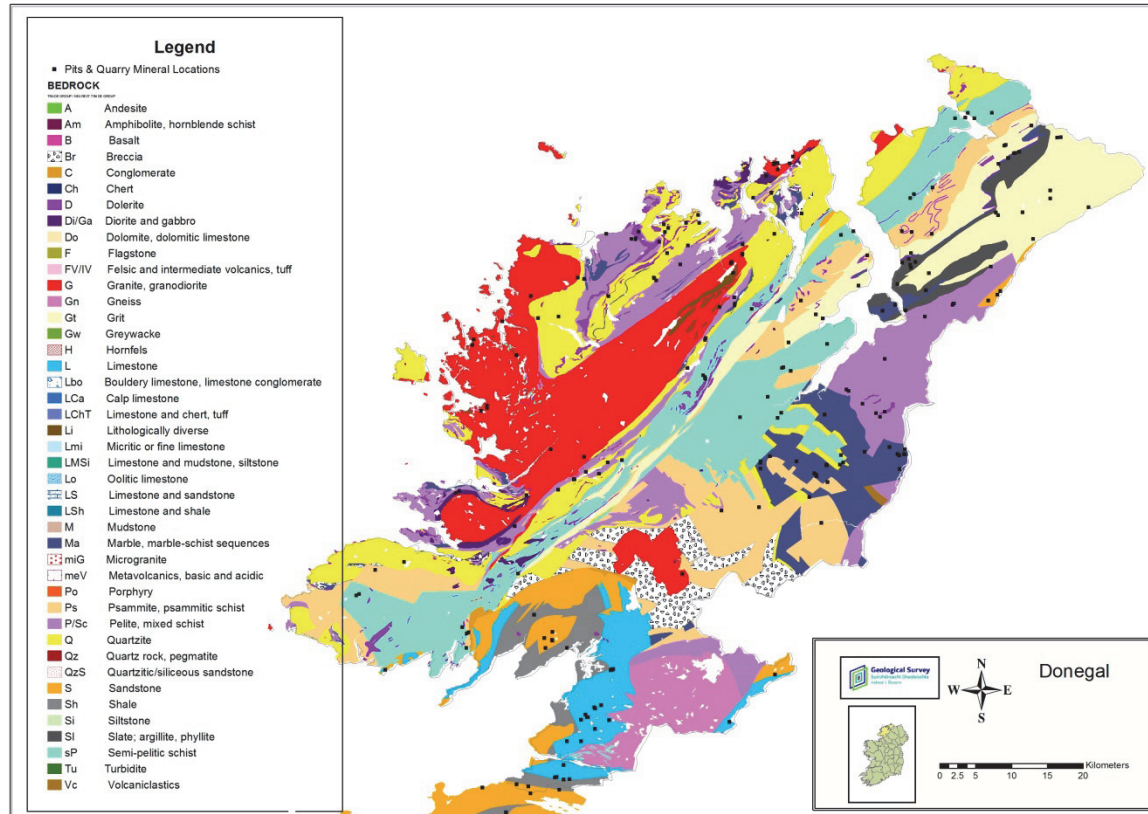
A period of volcanism occurred during the late Precambrian / Cambrian, which resulted in the intrusion of mafic sills and dykes across Donegal. These intrusives were metamorphosed, folded and faulted and are now dominantly metadolerite with minor basalt and gabbro. Some of these intrusive bodies are extremely thick (i.e. greater than 200 metres) and have been historically quarried for aggregates.

The granitic intrusive bodies formed deep within the earth's crust and differences in rock type reflect the varied composition of the magma melts. They are dominantly located in the west and north west of the county, with minor intrusions found to the north of the Fanad and Rosgill peninsulas.

The younger Carboniferous rocks are concentrated to the south of the county in the region around Donegal Bay, centred on Donegal Town. The Carboniferous rocks are dominated by limestones and sandstones that unconformably overlay the Dalradian metasediments and are un-metamorphosed.

A simplified geological map for County Donegal is presented in Figure 2.1 overleaf.

Figure 2.1 Simplified Geology of County Donegal



Courtesy: Geological Survey of Ireland, 2017

2.2.1.2 The geological setting of County Mayo

The geology of north Mayo has many similarities to Donegal. There are very old, basement rocks with a complex deformational and metamorphic history, unconformably overlain by much younger relatively undeformed Carboniferous limestones and sandstones.

The oldest rocks in Mayo are granitic gneiss and psammitic to semi-pelitic schists of the Erris Complex that outcrop to the west and northwest of the county. The Erris Complex is faulted against the younger rocks of the Dalradian Supergroup. The Dalradian rocks of north Mayo are very similar to Donegal, consisting of an interdigitating sequence of quartzite, psammities, mica schists, phyllites, pelites, semi-pelites and carbonates (limestones and marbles).

Devonian aged Old Red Sandstone (ORS) facies unconformably overlie or are faulted against the Dalradian. They consist of conglomerates, coarse sandstones and siltstones that were deposited in a continental environment and are dominated by fluvial and lacustrine sediments.

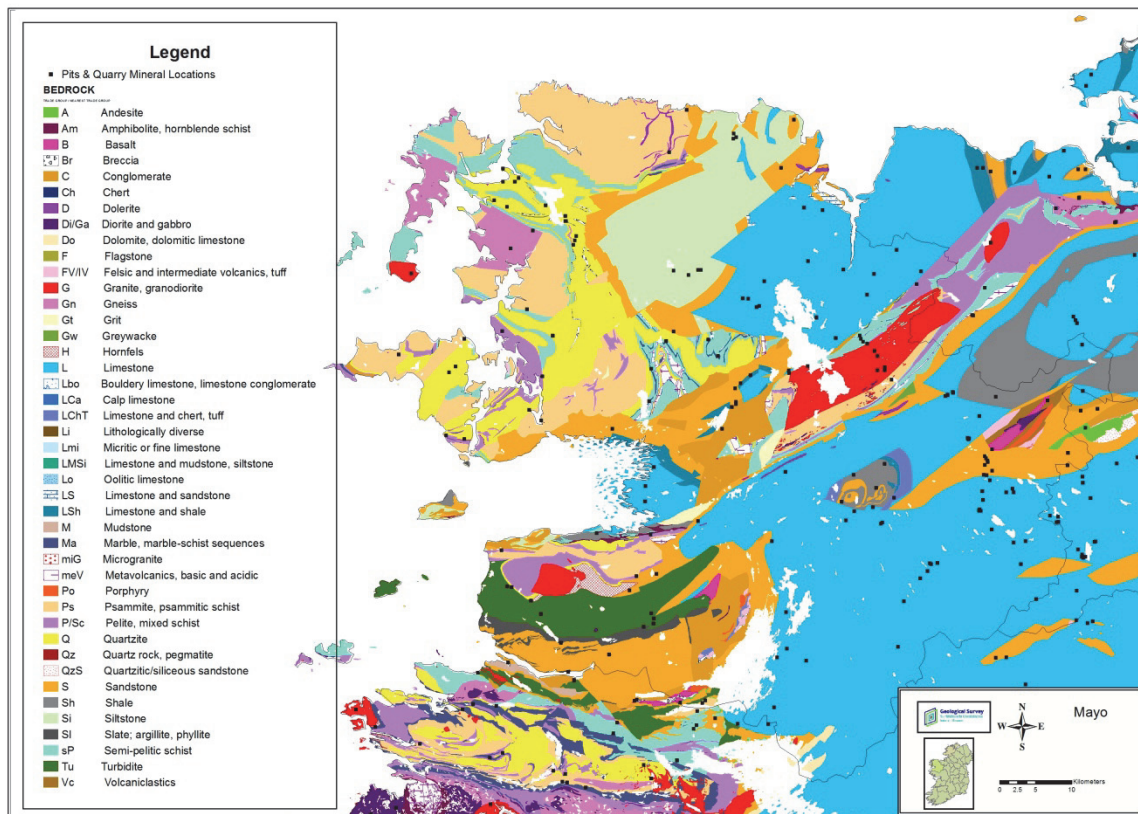
The oldest Carboniferous formation is dominated by sandstones that unconformably overlie the Dalradian and Devonian ORS. They are dominated by pale grey medium to fine grained, sandstones with a calcareous matrix and minor limestone interbeds. The Carboniferous Limestone conformably overlies the sandstones and outcrops in northeast of the county. This formation, the Ballina Limestone Formation, can be subdivided into lower and upper successions based upon that mapping of coastal exposures.

The Lower Ballina Limestone is 130 – 200 metres thick and consists of a fine grained, black, homogenous, argillaceous limestone, with dark grey / black shale bands, fine bioclastic debris and scattered blebs of pyrite.

The Upper Ballina Limestone Formation is estimated to be greater than 600 metres thick and consists of dark grey, fossiliferous limestones with shaley partings (up to 10 cm thick), it is recorded as having significantly less shale than the Lower succession.

A simplified geological map is presented as Figure 2.2 overleaf.

Figure 2.2 Simplified Geology of County Mayo



Courtesy: Geological Survey of Ireland, 2017

2.2.2 Quarrying Activity in County Donegal

The Donegal County Council Quarry Register lists 186 quarries, of which 111 are registered and 75 are unregistered. Many of these quarries are historic and are no longer in operation. The Geological Survey of Ireland published a report on Aggregate Potential Mapping (APM) in Donegal that listed quarries actively producing aggregates in the county in 2002. This period would be particularly applicable to the subject matter of this report.

The 2002 report on Aggregate Potential Mapping lists a total of twenty quarries operating in the county, of these six were producing from young Carboniferous aged limestones located in the extreme south around Donegal Town, Ballyshannon and Bundoran. A total of fourteen quarries were listed as producing from Dalradian aged metasediments, of which three were working quartzites; three were working altered carbonates (i.e. limestones and marbles with minor shale / schist); two were producing from basic intrusive bodies that consist of

metadolerite, basalt, dolerite and gabbro and six were producing from altered / metamorphosed, fine grained sedimentary rocks, pelite, semi-pelite, slate, schist, phyllite and psammite. The mineralogy of the metamorphosed sedimentary rocks is likely to consist of varying proportions of quartz / feldspar / mica with a minor component including ferromagnesian minerals (e.g. olivine, pyroxene), clay minerals, amphibole and hornblende. The Geological Survey of Ireland database lists just five active quarries producing crushed rock aggregates in Donegal in 2014.

2.2.3 Quarrying Activity in County Mayo

A detailed study on Aggregate Potential Mapping and report has not been carried out for County Mayo. However, the 2014 update of the Geological Survey of Ireland's quarry database lists six operating quarries in County Mayo. Of these, one is a sand and gravel operation and the remaining five are producing crushed rock aggregates, all from limestone formations. The Geological Survey of Ireland state that the Quarry Database is compiled using data volunteered by the quarries who have responded to a request for information and there is the possibility of active quarrying operations that are not recorded on this database.

2.2.4 Aggregate Potential Mapping

The Geological Survey of Ireland has carried out a programme of Aggregate Potential Mapping for the entire country. The methodology, designed by the Geological Survey of Ireland in consultation with industry and experts from the quarrying sector, has produced a system for classifying crushed rock aggregate resources. A Geographical Information System (GIS) mapping system has been produced and is based upon scores related to geological, geographical, market and social factors. A score from 1 to 10 was assigned to each of seven factors: -

- Rock Type Suitability (2.8)
- Deleterious Substances (0.7)
- Number of Quarries (1.2)
- Area (0.5)
- Overburden Thickness (2.0)

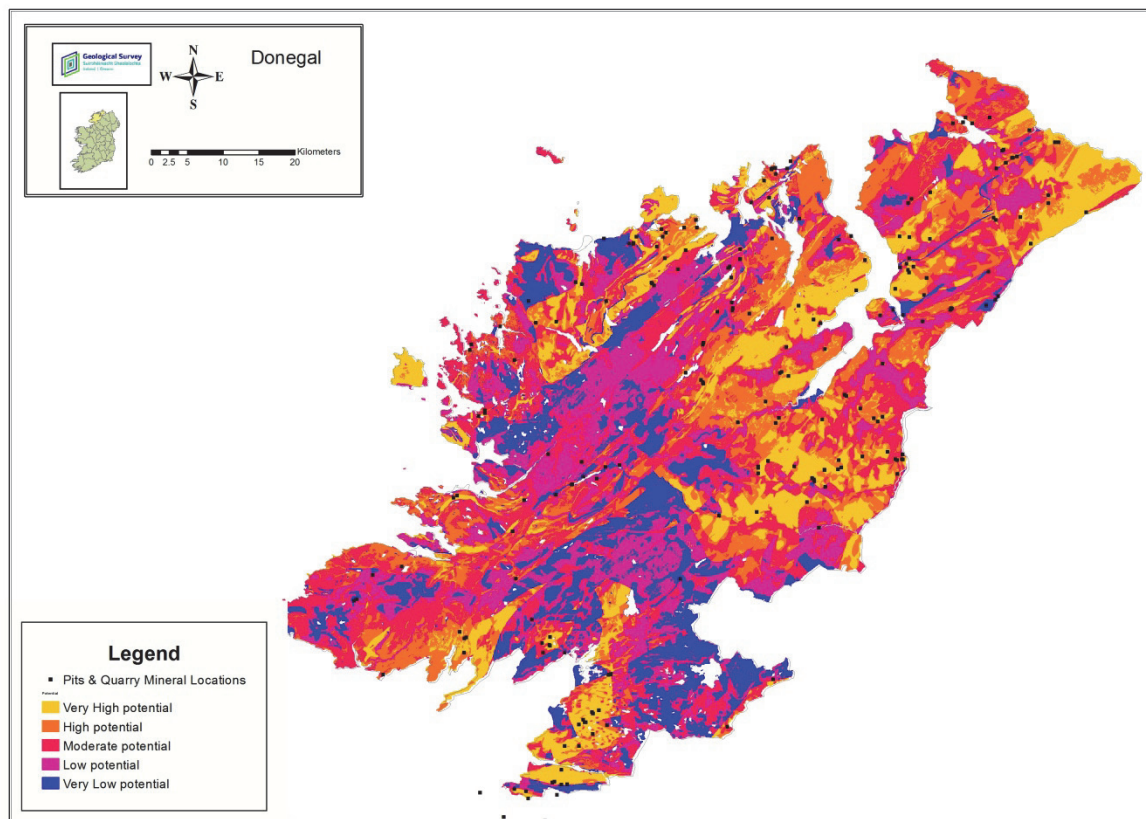
-
- Elevation (0.8)
 - Markets (1.2)

The seven factors were then weighted by a multiplication factor (in brackets) and a final score was obtained giving a score ranging from 5 to 100. A series of maps have been produced on county-by-county basis and these are merged to form a country-wide dataset.

2.2.4.1 Aggregate Potential Mapping – County Donegal

The County Donegal Aggregate Potential Map for crushed rock aggregate production (Figure 2.3 refers) shows a number of interesting features. The map can be simplified into areas that are purple / blue = low / very low potential and oranges and yellows = high / very high potential. This scoring system has rated two rock formations as having the highest potential for crushed rock aggregates. In the east / northeast (Inishowen, Fanad, Raphoe) and northwest (Rosgill, Gweedore) two coherent regions of high to very high potential are defined, located in areas underlain by Dalradian Metasediments. In the south (Donegal Town, Bundoran), a coherent area of generally very high potential is in a region underlain by Carboniferous limestones.

Figure 2.3 Crushed Rock Aggregate Potential Map of County Donegal



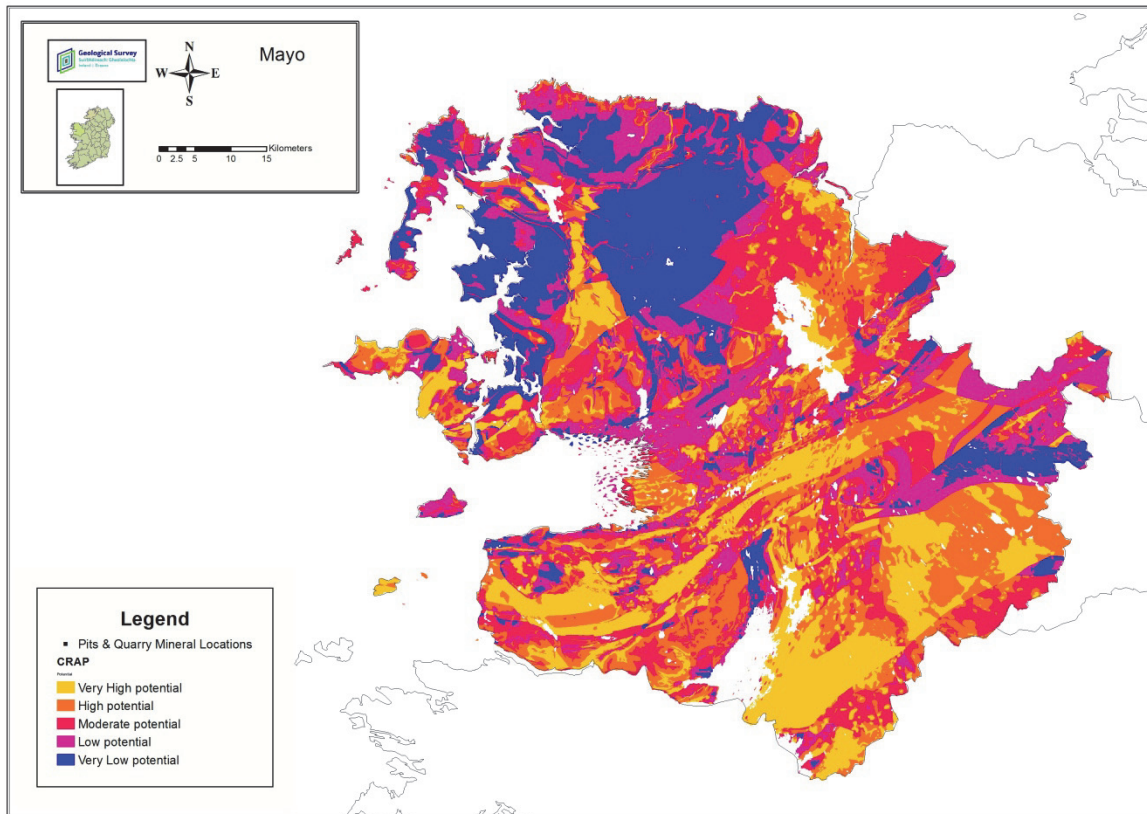
Courtesy: Geological Survey of Ireland, 2017

2.2.4.2 Aggregate Potential Mapping – County Mayo

From the County Mayo Crushed Rock Aggregate Potential Map (Figure 2.4 refers), it can be clearly seen that the highest potential regions are located to the south of the county. This is dominated by areas underlain by Carboniferous Limestones to the east and northeast of Lough Mask and a region of weakly metamorphosed Ordovician sediments to the west of Lough Mask and south of Clew Bay. The north of the county is not so well endowed with potential high quality aggregate resources. The large region of very low potential to the northwest is mainly underlain by Carboniferous sandstones that grade into Dalradian metasediments to the west. Interestingly, the Dalradian in this area is rated as having a low to very low potential, this may be due in part to the lack infrastructure and remoteness from market, rather than unsuitability of the rock types. In the north of the county a spotty area of high to very high potential is located in the Ballina / Killala / east Lough Conn region. This is the approximate subcrop of the Upper Ballina Limestone, it should be noted that the

potential decreases to the west and east where the Lower Ballina Limestone is outcropping and makes much less attractive target.

Figure 2.4 Crushed Rock Aggregate Potential Map of County Mayo



Courtesy: Geological Survey of Ireland, 2017

2.2.5 Deleterious materials

Deleterious materials, chemicals and characteristics related to aggregate type and sources have an effect on concrete strength and durability. Reference should be made to the harmonised European product standards (commonly referred to as hENs) for the assessment of aggregates and the associated Standard Recommendations and relevant Codes of Practice which provide national guidance for their use in construction products and works in Ireland. The following not exhaustive list describes the most common deleterious materials and their effect on concrete, which include: -

2.2.5.1 Sulfates

Interaction between sulfate and cement paste causes the generation of the mineral ettringite through the interaction of tricalcium aluminate and gypsum. This causes extensive cracking, expansion, loss of bond integrity between the cement paste / aggregate particles and the alteration of the cement paste composition. In wet / saturated, low temperature conditions (<15°C) a carbonate / sulfate interaction known as thaumasite attack occurs. Thaumasite replaces the cement paste causing the concrete surface to soften and eventually disintegrate;

2.2.5.2 Sulfides

Sulfide minerals, in particular iron sulfides such as pyrite and the much more reactive marcasite or pyrrhotite, can have a considerable effect upon concrete strength. In-situ oxidation, disintegration and dissolution of iron sulfides weakens the aggregate strength. The chemical reaction between oxidising pyrite and calcite causes the formation of secondary gypsum with an associated volume increase (greater than twice the volume of the original iron sulfide mineral). In addition, the oxidation of iron sulfide can produce sulfuric acid, which attacks the cement paste (i.e. Mundic Decay);

2.2.5.3 Chlorides

The presence of chloride ions have the effect of increasing shrinkage and reducing sulfate resistance;

2.2.5.4 Organic Matter

Organic material such as humus or humic fluvo acids causes delays to the setting and hardening of concrete. Coal and wood are also undesirable components;

2.2.5.5 Clays / Aggregate Coatings

The presence of clay and very fine grained material can form an adherent coating that is cemented strongly or weakly to the surfaces of the aggregate particles, interfering with the cement paste / aggregate bond and weakening concrete strength;

2.2.5.6 Expanding Clays

Clay minerals from the montmorillonite group (e.g. nontronite, saponite etc...), which expand in the presence of water, are undesirable. Volumetric instability associated with expansion and contraction can cause a rapid deterioration of concrete strength. Montmorillonite can

affect water absorption and concrete flow rates and also causes accelerated setting times by preventing the decomposition of gypsum in the cement paste due to the release of calcium ions;

2.2.5.7 Flaky or Elongate Particles

Phyllite, shale, slate and micas have been found to decrease workability due to their high specific surface area and flake like structure. This increases the water demand of the concrete mix resulting in decreased compressive strengths. Mica particles resist the natural flow of a plastic or liquid material like fresh concrete and increased mica content has also been found to reduce freeze-thaw resistance. Mica crystals have a low compressive and flexural strength, absorptive characteristics and bond poorly with cement paste. Mica also has a tendency to split along cleavage planes, fan out along particle edges and act in a hydrophilic manner;

2.2.5.8 Reactive Silica

Silica in the form of opal, chalcedony or obsidian can react with alkali hydroxide in the cement paste to form a gel. The gel collects in voids within the concrete and swells in contact with water. This is known as the *Alkali Silica Reaction (ASR)*²;

2.2.5.9 Reactive Dolomite

Certain dolomitic rocks facilitate the breakdown of dolomite crystals. The dolomite subsequently recrystallises to form brucite causing considerable expansion. This is a relatively rare phenomenon.

2.3 Climatic and exposure conditions

Some homeowners to whom the Panel spoke indicated that cracking had started or become more pronounced after the prolonged cold winter spells of 2009 / 2010 and late 2010 but others advised that their homes had started to crack years before this. The Panel consulted with Met Éireann with regard to extreme weather events during the period under consideration, which may have contributed to the deterioration of the external walls in the affected dwellings. The Panel also consulted the relevant standards with regards to guidance on exposure conditions for the regions affected.

² Alkali Silica Reaction in Concrete – General Recommendation and Guidance in the Specification of Building and Civil Engineering Works - The Institution of Engineers of Ireland and Irish Concrete Society 2003.

2.3.1 Climatic conditions

Met Éireann gave the Panel an overview of the significance of the severe weather events of winter 2009 / 2010 and late winter 2010 having particular regard to the affected region.

Key factors noted for winter 2009 / 2010 included: -

- Rainfall was 1½ to 2 times the national average in November with driving rain continuing into early December;
- The exceptional rainfall in November 2009 was followed by a prolonged cold spell (i.e. 30 days) in December;
- Daily variation temperature with temperatures ranging by up to 10°C on certain days;
- There were no ice days³ in Malin Head, County Donegal (excluding shading); and
- The conditions prevailing in the winter of 2009 / 2010 occur every 25 to 30 years.

Key factors noted for winter in late 2010 included: -

- There was less rainfall than the previous year. The level of rainfall was considered to be average with some 20 days of rain in November 2010;
- There were colder temperatures in winter 2010 than in winter 2009 / 2010 with some 30 days of low temperatures (i.e. from 24th November to 26th December);
- There were 3 to 5 consecutive “ice days” excluding shading in Malin Head, County Donegal;
- There were 7 consecutive days in Staide, County Mayo where the temperature did not rise above freezing;
- The prolonged cold spell was followed by a rapid rise in temperature over a short period of time (i.e. from -10°C to +10°C in 24 hours); and

³ An “ice day” refers to a day where both the maximum and minimum temperatures do not exceed 0° Celcius.

-
- The depth of cold in the winter of late 2010 occurs every 50 years.

Refer to Appendix 2 for Met Éireann Reports.

2.3.2 Exposure conditions

An assessment of the local wind-driven rain index should be made to inform design, detailing, workmanship and selection of materials suitable for the local exposure conditions if the incidence of rain penetration is to be minimised.

The quantity of rain falling on a vertical surface, such as a wall, at any point depends on both the intensity of the rainfall and the wind speed. The BRE Report *Driving Rain Index*⁴ postulated that the quantity of rain falling on a vertical surface, such as a wall, was proportional to the quantity falling on a horizontal surface and to the local wind speed, and incorporated maps of an annual wind driven rain index, which is the product of the annual local rainfall and the annual average airfield wind speed. The current driving rain index for Ireland, prepared by Met Éireann⁵, is set out in Figure 2.5 overleaf.

Rainfall varies considerably across the country but is largely unaffected by local features. Conversely, the general wind speed does not change so much across the country but is very much affected by local features, such as the spacing and height of surrounding trees and buildings and whether the ground is flat or steeply rising.

Table 2.1 overleaf describes three simple exposure categories and should be read in conjunction with Figure 2.5.

⁴ Building Research Establishment Report - Driving Rain Index, 1976.

⁵ Met Éireann Climatological Report No.13 - Distribution of Driving Rain in Ireland (November 2010).

Table 2.1 Driving Rain Index	
Simple exposure category	Driving Rain Index
Severe	Severe category obtains in districts where the driving rain index is 7 or more
Moderate	Moderate category obtains in districts where the driving rain index is between 3 and 7 except in areas which have an index of 5 or more and which are within 8 km of the sea or large estuaries where the exposure should be regarded as severe ¹
Sheltered	Sheltered category obtains districts where the driving rain index is 3 or less, excluding areas that are within 8 km of the sea or large estuaries the exposure should be regarded as moderate ¹
Notes: In districts of sheltered or moderate exposure, high buildings which stand above their surroundings, or buildings of any height on hill slopes or hill tops, should be regarded as having an exposure one grade more severe than indicated by the map.	

These simple categories cannot take account of all local circumstances. For example, if a building lies on high ground on the windward side, or on the windward slope of even a slight hill, or in a valley facing into the strongest rain-bearing winds, it may be more severely exposed than the average for the district. Such details can be studied in large scale maps and taken into account, while the Met Éireann may be able to advise in cases of doubt.

The Panel noted that both of the affected areas in Counties Donegal and Mayo are mainly located in Severe Exposure zones, see Figure 2.5 overleaf.

Figure 2.5 Driving Rain Index map of Ireland



Note: I.S. 325: Part 2 1995 Code of Practice for the use of masonry contained a similar map.

2.4 Type of construction

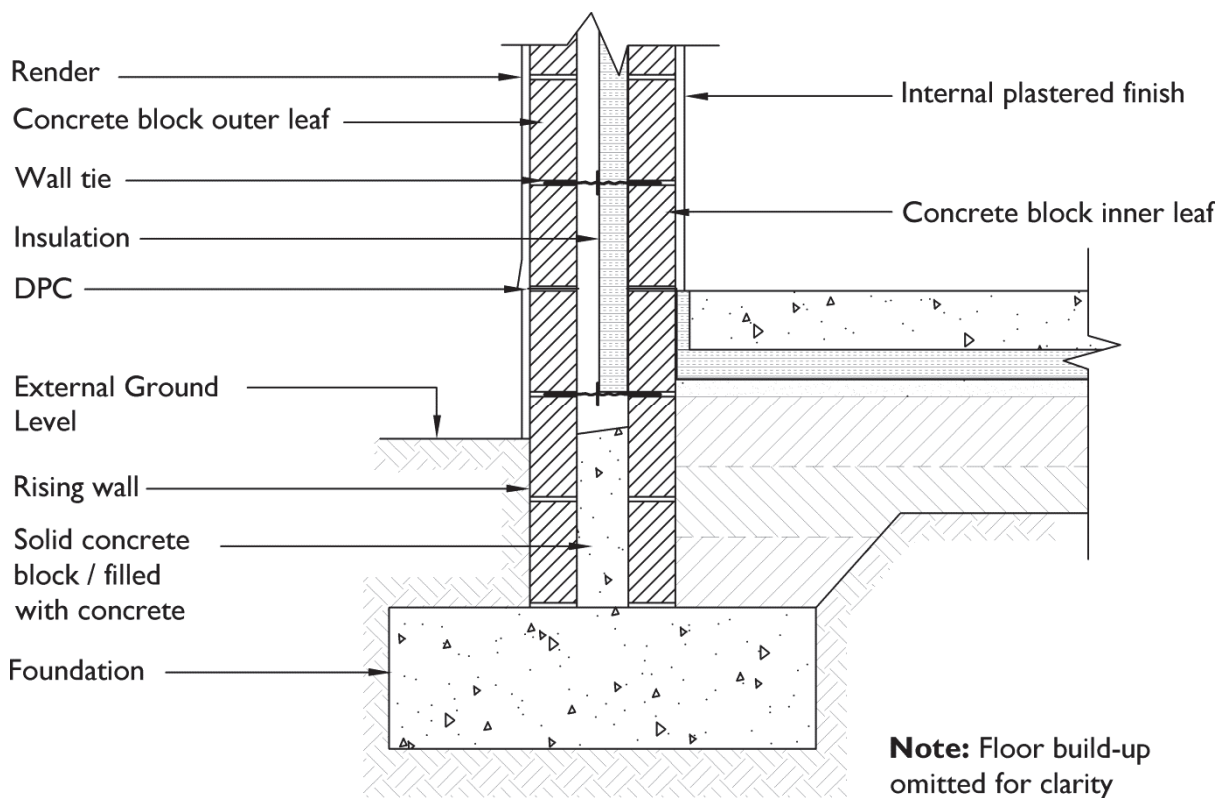
The dwellings affected in both Counties Donegal and Mayo consisted of a mixture of traditional build, single storey, dormer, two storey detached and semi-detached houses. The Panel made the following observations: -

- the external walls of the dwellings consisted of cavity wall construction. Both the inner and outer leafs consisted of 100 mm concrete blockwork, separated by a 100 mm cavity;
- the external wall faces were rendered in sand / cement render generally applied as a single finish coat over a scud coat. The render finish was generally smooth and generally left unpainted;
- insulation was provided in the cavities and in general⁶ and ranged from partial (board) fill to full fill (blown fibre, or beads).

See Figure 2.6 overleaf for typical cavity wall construction terminology.

⁶ One dwelling visited by the Panel in the Inishowen Municipal District consisted of cavity wall construction but insulation was applied as a dry-lining to the inner leaf.

Figure 2.6 Typical cavity wall construction



2.5 Year(s) of construction

From the information provided, the years of construction of the affected dwellings reported ranges from 1984 to 2011, see Table 2.2 for breakdown.

Table 2.2 Years of construction of affected dwellings (as advised to the Panel)

County	Earliest Year	Latest Year
County Donegal	1984	2011
County Mayo	1998	2006

Notes: Chapter 4 provides a detailed analysis of years of construction and geographical distribution for the purposes of estimating the scale of the problem.

2.6 Builder type

Following a survey conducted, the Mica Action Group advised the Panel that the majority of houses affected within their membership were direct labour / self-build. At the same time, many builders of scheme houses, e.g. HomeBond registered builders have also been involved with the construction of affected dwellings.

2.7 Manifest Nature of the Defect – County Donegal

The following section outlines the Panel's findings and observations arising from their site visits to the affected areas, consultation with stakeholders and evaluation of reports received.

2.7.1 Site Visits to Inishowen and Letterkenny Municipal Districts

From the sites visited and the photographic evidence provided, the Panel noted that the following observations repeat as a common theme: -

- the display of the structural distress expresses itself in a particular pattern which generally involves horizontal and vertical cracks, with vertical cracking being most severe near corners;
- in certain cases the concrete block outer leaf had moved away from window frames set into the wall thus restricting their operational use;
- in general, the worst structural distress observed on gables and/or wall elevations most directly exposed to prevailing wind and rain. These wall elevations were where homeowners generally noticed the problems initially appearing;
- exposed outer leaf concrete blocks were observed where render had fallen off. These concrete blocks could be easily fragmented by hand;
- the inner concrete block leaf was generally unaffected;

-
- some homeowners indicated that cracking had started or become more obvious after the particularly prolonged cold winter spells of 2009 / 2010 and 2010; others advised that their houses had started to crack years preceding these events;
 - in one instance, surplus blocks from the construction of a dwelling and left exposed to the elements were readily breakable by hand.

The Panel viewed one house where the homeowner had removed and replaced the outer leaf of the gable wall. The homeowner showed the Panel a video of the demolition process of a portion of the gable outer leaf. Behind the render the concrete blocks (dark grey in colour) were saturated. The outer leaf was taken down by hand with minimal effort using a claw hammer. The concrete blocks appeared to disintegrate into gravelly fragments during the process. The inner leaf concrete blocks, (light grey in colour), were dry, and appeared intact.

The Panel was anecdotally informed that in some instances cavity walls had been fully filled with blown fibre insulation. These dwellings were severely cracked; apparently some homeowners have removed the fibre and found it saturated.

See Figures 2.7 and 2.8 for a selection of photographs.

Figure 2.7 Examples of affected dwellings – County Donegal



a) Typical horizontal and vertical cracking to gable



b) Characteristic horizontal and vertical cracks



c) Rear wall cracking



d) Gable cracking

Figure 2.8 **Examples of affected dwellings – County Donegal**



a) Filled cracks, characteristic corner crack



b) Cracking on exposed gable



c) Corner crack



d) Pattern Cracking

2.7.2 Engineering and Laboratory Reports

The Panel received via the Mica Action Group and other stakeholders, a total of 63 technical reports which had been commissioned by affected homeowners relating to approximately 50 dwellings in addition to other supplementary information relevant to the problems their members are facing. In broad terms, the information provided largely consisted of a mixture of reports from consulting engineers (some with and some without laboratory reports) as well as a number of isolated laboratory reports.

The laboratory reports received were conducted by at least 6 different laboratory test houses. The scope and type of laboratory testing undertaken and recounted in reports made available to the Panel varied from case to case. Some covered petrographic, XRD, and chemical tests, though not all covered each test type.

Among recurring conclusions from the laboratory reports are: -

- the crushing strength of the blocks was less than would be expected (by the testing laboratory) given their positions in the sub and superstructure of the house;
- there was a variable but generally high content of muscovite mica in the fine and coarse aggregate makeup of the concrete blocks;
- in some cases there appeared to be a high water / cement ratio and less cement in the blocks than would be expected (by the testing laboratory);
- there was proportionately higher voids in the concrete blocks than would be expected (by the testing laboratory);
- one laboratory report described the poor behaviour of a concrete block sample when subject to repeated freezing and thawing by comparison with a control concrete block sample.

The engineers' reports drew attention to published technical references setting out the adverse effects on strength and workability for concrete made with aggregate containing high levels of muscovite mica. The reports ascribe the structural distress in the houses to those adverse effects manifesting in the concrete block outer leaf.

2.7.3 Timeframe for problems to be first noticed

Based on the engineers' reports received by the Panel, a minority of homeowners noticed cracks appearing during or shortly after construction. Others ranged from 5 to 10 years post construction before defects became noticeably apparent.

The Mica Action Group advised the Panel that, based on a survey they conducted, the average time homeowners reported cracking becoming evident to their home was 5.3 years after construction.

HomeBond advised the Panel that time taken from dwelling registration to a complaint / claim of a defect being made ranged from between 4 to 12⁷ years.

2.8 Discussion

In general, the forensic analysis of the construction defect should address the following three key areas: -

- (i) Design
- (ii) Product
- (iii) Workmanship

Construction defects may be caused by any one of these or a combination of more than one. To enable the most appropriate solution to be applied, correct diagnosis regarding the cause of the structural defect is paramount. In this regard, the Panel have set out their opinions under these headings below based on their review of engineering reports, photographic evidence and on-site observations.

2.8.1 Design related observations

Although few reports gave information on the wall types, the dwellings affected all appear to be non-complex traditional concrete block construction. The particular pattern of external wall cracks on affected dwellings suggests that the cracks are unlikely to be attributable to

⁷ Complaints / claims made to HomeBond outside the 10 Year Warranty cover period were automatically rejected.

foundation settlement⁸ or shrinkage.⁹ At the same time, the Panel observed some deviations from the codified recommendations for masonry use in Ireland, e.g. movement joints, weep holes, render specification.

With regard to the use of full fill fibre insulation, unless the site exposure conditions and the insulation's suitability are carefully considered, the Panel note that the inclusion of full fill fibre insulation can lead to the passage of moisture across the cavity to the inner leaf and may cause internal dampness problems¹⁰.

2.8.2 Product related observations

Most of the engineering reports submitted to the Panel, though not all supported by laboratory tests, concluded that the cause of the structural distress / cracking was attributable to harmful impurities, in particular excessive levels of muscovite mica present in the constituent aggregate of the concrete blocks.

2.8.2.1 What are the potential implications for excessive muscovite mica in the manufacture of concrete blocks?

The presence of significant concentrations of muscovite mica have been documented by researchers worldwide to cause issues during the manufacture of concrete. In summary, muscovite mica is a very common rock forming mineral that is found in granitic, metamorphic and fine grained and immature sedimentary rocks. It is a potassium aluminium silicate that can sometimes have chromium or manganese replacing the aluminium.

Muscovite mica which is found in mica schist, see Figure 2.9, has a pearly lustre and can range in colour from colourless to white, yellow, brown, grey, green, pink, purple or red and can be translucent or transparent. It is relatively soft, with a hardness of 2 - 2.5 on the Mohs hardness scale and has a monoclinic crystallinity. The crystal aspect tends to be flat, tabular, foliated, flaky and scaly, one dimensional flakes that have the ability to flex or bend and have a very well-developed cleavage. While muscovite mica is relatively chemically inert, it can be altered under certain conditions to form kaolinite. Mica has hydrophilic properties with the ability to absorb and store water along cleavage planes.

⁸ Two engineers' reports submitted attributed the cause of some of the cracking to foundation settlement.

⁹ One engineer's report does make reference to cracking caused by a design problem unrelated to defective blockwork.

¹⁰ Case Study: Remedial works to external cavity walls, social housing scheme, Letterkenny - John McCarron of Donegal County Council 05 April 2016, See link: <http://www.engineersjournal.ie/2016/04/05/remedial-works-to-external-cavity-walls-letterkenny/>.

The Panel consulted the National Standards Authority of Ireland seeking a clarification on the historic limitations regarding the use of harmful impurities in concrete blocks as set out in S.I. No. 288 of 1949 of 1949¹¹. A copy of the National Standards Authority of Ireland's response to the Panel is provided in Appendix 4.

¹¹ Standard Specification (Solid Concrete Building Blocks Made With Natural Aggregate) Order 1949 (S.I. No. 288/1949).

Figure 2.9 **Examples of Mica Schist from County Donegal**



a) Mica Schist (hand specimen)



b) Mica Schist Outcrop

Courtesy: Geological Survey Ireland, 2017

Muscovite mica is particularly susceptible to the production of monomineralic grains, as the crystals are flaky and fracture relatively easily along cleavage planes. Large particles of schist will preferentially break along mica rich cleavage planes exposing the mica coating in the exposed cleavage surface, allowing spalling and liberation of mica and also creating a mica rich surface on the coarse aggregate particle.

The undesirable effect of muscovite mica, in particular free mica¹², has been documented in a number of studies from around the globe. During the concrete manufacturing process the loose flakes and high specific surface area of mica particles increases water demand, has a negative effect on the rheology, decreasing workability and reducing the compressive strength of the finished concrete. Estimates suggest that the presence of 1% muscovite mica in the aggregate causes a reduction of the concrete strength by approximately 5%¹³.

Other problematic properties of mica include its low compressive and flexural strength and absorptive characteristics. It has relatively poor bond strength with cement paste due to disbonding focused along cleavage planes. Its tendency to split and fracture along cleavage planes, fan out at particle edges is also undesirable. Micro-fractures can focus along weak cleavage within the mica particle and migrate across the particle / paste boundary propagating into the concrete.

2.8.2.2 Possible failure mechanism in concrete blocks

The predictable consequences of high mica content in the blockwork concrete can provide a plausible mechanism for many of the particular cracking patterns observed. Technical references published in the UK^{12,14}, Sweden¹⁵, USA¹⁶ and South Africa¹⁷ describe the implications for concrete made from aggregates containing high levels of mica based on

¹² Fine mono-mineralic mica grains.

¹³ Technical Report 370. Cement and Concrete Association, 1963. J. Dewar.

¹⁴

- (i) Impurities in Concreting Aggregates". 1987, T. P. Lees, Cement and Concrete Association Guide.
- (ii) Lea's Chemistry of Cement and Concrete (Fourth Edition) - Peter C. Hewlett ISBN: 978-0-7506-6256-7.
- (iii) Zografou, Heath, Walker – China Clay waste as aggregate in Alkali- activated cement mortars – University of Bath.

¹⁵

- (i) Lagerblad, Gram, Westerholm - Quality of fine materials from crushed rocks in sustainable concrete production – Swedish Cement and Concrete Research Institute.
- (ii) Novikova and others – The behavior of mica rich base course aggregates under freezing – thawing conditions – Lulea University of Technology.

¹⁶ Effects of Mica, Aggregate Coatings, and Water-Soluble Impurities on Concrete - James W. Schmitt. Concrete International Volume: 12, Issue Number: 12 publisher: American Concrete Institute ISSN: 0162-4075.

¹⁷ Some Aspects of the Effect of Micaceous Sand on Concrete" 1971, O. H. Muller, THE CIVIL ENGINEER in South Africa.

laboratory tests. Those effects would be expected to manifest in concrete blocks since the constituents are essentially the same.

The references above describe how a high level of mica in the concrete aggregate when it is batched attracts a disproportionate amount of water by comparison with the rest of the aggregate. This effect is exacerbated if the high mica levels are also present in the fine aggregate, i.e. if both coarse and fine are from the same geological source. Workability and strength are reduced in those circumstances.

Susceptibility to loss of integrity in freeze thaw conditions also results¹⁸. On the information provided, the Panel is of the opinion that if concrete blocks become saturated in the outer leaf and are subsequently subjected to repeated freezing and thawing, the contained water would expand in the blocks as it froze and thus tend to disaggregate the blocks. An explanation could be that the flat nature of the mica crystals in the blocks provided planes of weakness allowing the blocks to crack along the mica crystal planes. Repeated freeze thaw cycles such as might occur during a cold spell with fluctuating night / day time temperature levels could be expected to result in concrete blocks deteriorating.

Significant wet and subsequently freezing cold weather pertained; in particular, in County Donegal during the 2009 / 2010 and late 2010 winters (see paragraph 2.3.1). In each of those instances a prolonged number of rainy days - which would have saturated the outer block leaves - preceded an unusually long freezing cold spell. Day time sunshine could have raised the wall temperatures above freezing for south / west walls which would then cool below freezing overnight. This would accord with reports from some homeowners that the cracking in their homes had become significantly worse after those winters.

At the same time, information from house owners and their engineers' reports is that cracking in the characteristic horizontal / vertical pattern had in many cases commenced before those winters.

2.8.3 Workmanship related observations

At the time the affected houses were built, standards existed for both the constituent materials and the manufacture of concrete blocks. There were also Codes of Practice in place for structural design, construction, and rendering of concrete block walls.

¹⁸ Deterioration of Concrete Due to Specific Minerals". 2001, Y. Wakizaka, K Ichikawa, Y Nakamura and S Anan. Environment and Economy.

Under the Building Regulations, compliance with those standards and codes as referenced in the relevant Technical Guidance Documents would have been considered *"prima facie"* evidence of compliance with the Regulations for "Structure", "Resistance to Moisture" and "Materials and Workmanship".

On some houses viewed by the Panel, deviations were noted from the recommendations of those standards including render makeup / thickness, absence of cavity weep holes and of control joints on long walls.

However, given the geographical spread of affected dwelling locations, the wide variety and number of builders involved, there is little reason to believe that construction practice and details on the affected dwellings were significantly different to those on nearby similarly exposed houses. Those nearby houses did not exhibit the pattern cracking seen by the Panel.

2.9 Conclusions – County Donegal

Based on information received, the Panel is of the opinion that the reason for the widespread pattern cracking in private dwellings in County Donegal is primarily due to the excessive amount of deleterious material (in the form of muscovite mica) in the aggregate used to manufacture the concrete blocks. This was a more significant deviation from the Standards of the time than the workmanship deviations mentioned above, see paragraph 2.8. The consequence was the concrete blocks had poor freeze / thaw resistance. Given that no traditional render is totally waterproof, inevitably damp outer leaf blocks cracked, leading to render cracking and further water ingress and structural distress.

As it turned out the severe cold weather in parts of the 2009 / 2010 and late 2010 winters reportedly exacerbated the cracking in many instances.

Finally, it is not normal for concrete blocks to fail in the manner observed. It is the Panel's opinion, which was supported by the laboratory reports provided, that the concrete blocks which deteriorated in the manner observed were not fit for purpose.

2.10 Manifest Nature of the Defect – County Mayo

The following section outlines the Panel's findings and observations arising from their site visits to the affected areas, consultation with stakeholders and evaluation of reports received.

2.10.1 Site Visits to Ballina and West Mayo Municipal Districts

From the sites visited by the Panel and the photographic evidence provided, the following observations repeated as a common theme, similar to those observed in County Donegal: -

- the display of the structural distress expresses itself in a particular pattern which generally involves horizontal and vertical cracks, with vertical cracking being most severe near corners. Many cracks are of significant width (> 10 mm);
- in certain cases, the concrete block outer leaf had moved away from window frames set into the wall thus restricting their operational use;
- in general, the worst structural distress was on gables and/or wall elevations most directly exposed to prevailing wind and rain. These wall elevations were where homeowners generally noticed the problems initially appearing. One gable inspected had been almost totally stripped of render by the owner (with a view to re-rendering) exposing soft underlying concrete blockwork.
- the inner concrete block leaf was generally unaffected.

See Figures 2.10 and 2.11 overleaf for a selection of photographs.

Figure 2.10 Examples of affected dwellings – County Mayo



e) Typical vertical cracking at gable corner



f) Typical pattern cracking



c) Cracking on sheltered wall



d) Pattern cracking, sealant filled

Figure 2.11 Examples of affected dwellings – County Mayo



a) Front wall corner crack



b) Horizontal and vertical cracking



c) Corner and pattern cracks



d) Corner of house fallen away.

2.10.2 Evaluation of Engineering and Laboratory reports

Homeowners provided the Panel with technical reports in respect to 17 dwellings.

Laboratory reports received were commissioned by 8 homeowners and were conducted by at least 5 different laboratory test houses. Similar to the Donegal experience, the scope and type of laboratory testing undertaken and recounted in reports made available to the Panel varied from case to case. Some covered petrographic, XRD, and chemical tests, though not all covered each test type. Parameters such as equivalent pyrite content, total sulfur by mass, sulfate content by mass, acid soluble sulfate content, and water soluble sulfate content were the subject of testing – though not all in any individual report.

Among recurring conclusions in the laboratory test reports are: -

- the presence of pyrite (including reactive “framboidal” pyrite¹⁹) is consistently reported, and
- reference to high sulfate content in the concrete blocks (emanating from within the block).

The reports generally conclude that the aggregate used in the manufacture of the concrete blocks tested was unsound and was not suitable for that use because of its potential to cause further deterioration of the blocks.

2.10.3 Timeframe for problems to be first noticed

Based on the engineering reports received by the Panel, a minority of homeowners noticed cracks appearing shortly after construction. Others ranged from 5 to 10 years post construction before the defects became apparent.

From the Panel’s own site visit to a selection of houses in County Mayo, homeowners described how cracks initially developed in the external render ranging from 4 to 13 years after construction. These initial cracks became progressively more frequent and larger over time.

¹⁹ Pyrite structure that affords a large surface area which facilitates the oxidising reactions. Reactive pyrite generally has a framboidal texture i.e. resembling raspberries.

HomeBond advised the Panel that time taken from dwelling registration to a complaint / claim of a defect being made ranged from between 4 to 9 years.

2.11 Discussion

Again, similar to Donegal the Panel considered the following three key areas: -

- (i) Design
- (ii) Product
- (iii) Workmanship

The Panel provides their opinion under these headings below based on their review of the engineers' and laboratory reports, photographic evidence and on-site observations.

2.11.1 Design related observations

Similar to County Donegal, the dwellings affected are all non-complex buildings of traditional construction. The high degree of consistency as to the characteristics of the damage and the particular crack patterns observed also make them unlikely to be attributable to foundation settlement or shrinkage. The Panel observed some deviations from the codified recommendations for masonry use in Ireland, e.g. movement joints, weep holes, render specification.

2.11.2 Product related observations

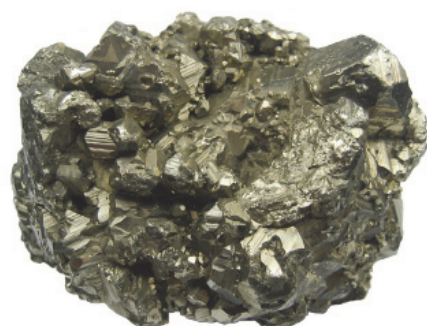
Most of the engineers' reports submitted to the Panel, though not all supported by laboratory tests, concluded that the cause of the structural distress / cracking was attributable to harmful impurities, in particular excessive levels of reactive pyrite present in the constituent aggregate of the concrete block.

2.11.1.1 What are the potential effects of pyrite on concrete blocks?

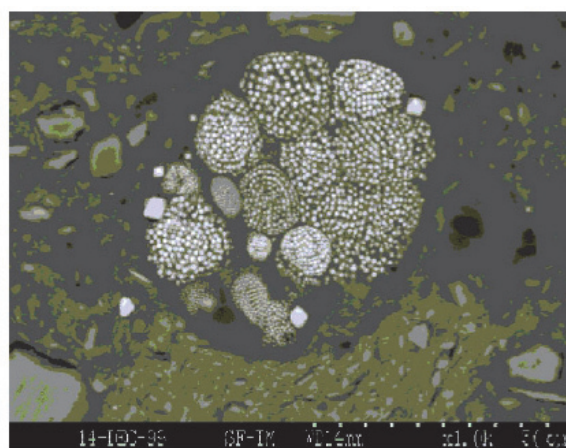
Pyrite is a naturally occurring mineral comprised of the elements iron and sulfur (see Figure 2.12 overleaf). In general, pyrite may be described as being either reactive or non-

reactive²⁰. When reactive pyrite in aggregate material is exposed to moisture and oxygen under certain conditions, the pyrite will oxidise to form sulfuric acid which may, in turn, react further with other minerals found in the aggregate to form calcium sulfate in the form of gypsum. Gypsum, formed under these conditions, will have a significantly greater volume than that of the pyrite, expanding to approximately twice that of the original pyritic material. Where this expansion occurs in the aggregate constituent of concrete blocks, it may result in cracking in individual concrete blocks.

Figure 2.12 Examples of Pyrite



a. Crystalline pyrite



b. Framboidal pyrite
(Electron microscope photo image)

Courtesy: Report of the Pyrite Panel, 2012

2.11.3 Workmanship related observations

Similar to County Donegal, at the time the affected houses were built, standards existed for both the constituent materials and the manufacture of concrete blocks. There were also codes of practice in place for structural design, construction, and rendering of concrete block walls.

Under the Building Regulations, compliance with those standards and codes as referenced in the relevant Technical Guidance Documents would have been considered "*prima facie*"

²⁰ Report of the Pyrite Panel (June 2012).

evidence of compliance with the Regulations for “Structure”, “Resistance to Moisture” and “Materials and Workmanship”.

On some houses viewed by the Panel, deviations were noted from the recommendations of those standards including render makeup / thickness, absence of cavity weep holes and of control joints on long walls.

However, given the geographical spread of affected dwelling locations, the wide variety and number of builders involved, there is little reason to believe that construction practice and details on the affected dwellings were significantly different to those on nearby similarly exposed houses. Those nearby houses did not exhibit the pattern cracking seen by the Panel.

2.12 Conclusions – County Mayo

Based on information received, the Panel is of the opinion that the reason for the widespread pattern cracking in private dwellings in County Mayo is primarily due to the excessive amount of deleterious material (in the form of reactive pyrite) in the aggregate used to manufacture the concrete blocks. This was the most significant factor causing the distress rather than the design / workmanship deviations mentioned above, see paragraph 2.11. The severe cold weather in parts of the 2009 / 2010 and the late 2010 winters reportedly exacerbated the cracking in many instances.

Although the inner and outer leaf concrete block most likely came from the same source, there are in general minor signs of damage to the inner leaf. While this is probably due to the dryer conditions which the inner leaf is normally subject to, it does not remove the risk of a chemical reaction occurring at a later stage.

Finally, it is not normal for concrete blocks to fail in the manner observed. It is the Panel’s opinion, which was supported by the laboratory reports provided, that the concrete blocks which deteriorated in the manner observed were not fit for purpose.

Chapter 3 Regulatory Requirements and Technical Specifications

3.0 Introduction

This chapter gives a brief overview of the regulatory requirements and well established technical specifications in place during the period under consideration namely: -

- (a) the building control system in place in Ireland;
- (b) the requirements of the Building Regulations and the technical guidance provided therein, in relation to masonry construction and use;
- (c) specifications that were commonly used in practice on construction sites; and
- (d) the regulatory requirements for the marketing of construction products.

3.1 Building Control System

The design and construction of buildings is regulated under the *Building Control Acts 1990 to 2014*, in order to ensure the safety of people within the built environment. The Acts provide for the making of Building Regulations and also set out the legislative basis for the system of enforcement.

3.1.1 Building Regulations

The *Building Control Act 1990* provides, inter alia for the making of Building Regulations in respect of the construction of buildings. The aim of the Building Regulations is to provide for the safety and welfare of people in and about buildings. The Building Regulations apply to the design and construction of a new building (including a dwelling) or an extension to an existing building. The minimum performance requirements that a building must achieve are set out in the Second Schedule to the Building Regulations. These requirements are set out in 12 parts (classified as Parts A to M). Technical Guidance Documents (TGDs) are published to accompany each part indicating how the requirements of that part can be achieved in practice. Adherence to the approach outlined in a Technical Guidance Document is regarded, *prima facie*, as evidence of compliance with the requirements of the relevant part of the Building Regulations.

3.1.2 Building Control Regulations

The Building Control Regulations set out the system of administrative controls to support compliance with the Building Regulations by requiring, inter alia, the submission of Commencement Notices, Fire Safety Certificates, Disability Access Certificates and the more recent Certificates of Compliance on Completion (introduced under S.I. No. 9 of 2014 which came into effect on 1 March 2014).

The primary responsibility for compliance with the requirements of the Building Regulations rests at all times with the owner of the proposed building or works, and with any builder or designer engaged by the owner.

Responsibility for enforcement is delegated under the *Building Control Acts 1990 to 2014* to local building control authorities who are independent in the exercise of their statutory powers. Building control authorities have strong powers of inspection and enforcement under the Acts.

Authorised officers of each local building control authority have delegated powers to: -

- scrutinise proposals and inspect works in progress;
- serve enforcement notices on owners and builders for non-compliance;
- institute proceedings for breaches of any requirements outlined in the Acts, or any regulations made thereunder; and
- seek High Court orders to mitigate danger to the public where serious non-compliance poses risks to public safety.

Failure by an owner or a builder, at the request of a building control authority, to demonstrate compliance with the Building Regulations or the Building Control Regulations, or to rectify any such non-compliance, may be an offence under the *Building Control Acts 1990 to 2014*. If successfully prosecuted in court, such offences may lead to a fine and/or a term of imprisonment.

The use of these powers is, however, subject to a statute of limitations of five years from the date of completion of the buildings concerned.

The *Building Control (Amendment) Regulations 2014* (S.I. No. 9 of 2014) were introduced with effect from 1 March 2014 in order to strengthen the arrangements in place for the control of building activity in response to the widespread failures that had occurred in all sectors of the industry in the period leading to the recent economic collapse. S.I. No. 9 of 2014 has required that the design and construction of buildings is verified during construction through the execution of an inspection plan overseen by a registered construction professional (the assigned certifier) that enables the builder and the assigned certifier to sign a statutory certificate of compliance on completion.

This statutory certificate of completion effectively represents a badge of approval reassuring owners of homes and buildings that their home or building is a quality, compliant one that is:

- safe and healthy to live in;
- structurally sound and resistant to fire;
- energy efficient, therefore warm and comfortable, and requiring relatively low spending on fuel;
- durable, having used properly certified materials combined with good construction practice.

Following a review of Building Control Regulations²¹ following 12 months of operating under S.I. No. 9 of 2014, it was decided that a relaxation of the new rules should be afforded the owner of works involving the construction of a new single dwelling, on a single unit development, or of a domestic extension, the facility to opt out²² of the requirement to obtain statutory certificates of compliance signed by a registered construction professional.

²¹ Review of Building Control Regulations following 12 months of operating under S.I. No. 9 of 2014 Report on Consultation Process (30 June 2015).

²² Information Note for Owners of new dwellings and extensions who opt out of Statutory Certification for building control purposes.

3.2 Construction Products Legislation

3.2.1 Construction Products Directive (89/106/EEC²³)

Council Directive 89/106/EEC of 21 December 1988 on the approximation of laws, regulations and administrative provisions of the Member States relating to construction products (known as the Construction Products Directive) was adopted by the European institutions to address the problem of technical barriers to international trade caused by varying national standards in the construction sector and came into effect on 27 June 1991.

Persons placing construction products on the market had specific legal responsibilities under the *European Communities (Construction Products) Regulations 1992* (S.I. No. 198 of 1992), as amended by the *European Communities (Construction Products) (Amendment) Regulations 1994* (S.I. No. 210 of 1994), which transposed the Construction Products Directive into Irish law. Under these legislative instruments a “product” is defined as “*any construction product to which these Regulations apply which is produced for incorporation in a permanent manner in works*”. In addition, suppliers of construction products “... *shall not place a product, other than a minor product, on the market unless it has such characteristics that the works in which it is to be incorporated, assembled, applied or installed can, if properly designed and built, satisfy the essential requirements when, where and to the extent that such works are subject to regulations containing such requirements*”²⁴. The Building Regulations are an example of regulations containing such requirements.

Building control authorities are the principal enforcement agencies for these Regulations. Separate to their powers under the *Building Control Acts 1990 to 2014*, building control officers have been appointed as authorised officers under these Regulations by their local building control authorities. The Regulations set out the specific powers of an authorised officer. However, in brief, where an authorised officer is of the opinion that a product (that was covered by these Regulations) was placed on the market in contravention of the Regulations, s/he had the following powers: -

- to access, examine, test, inspect, seek documentation / information etc. about products to establish if the product complies;

²³ Regulation (EU) No 305/2011 (known as the Construction Products Regulation or “the CPR”) was adopted on 9 March 2011 and repeals the Construction Products Directive (89/106/EEC – CPD).

²⁴ Extract from *European Communities (Construction Products) Regulations 1992* (S.I. No. 198 of 1992) and *European Communities (Construction Products) (Amendment) Regulations 1994* (S.I. No. 210 of 1994).

-
- to seek a warrant, from the courts, to enter and search a premises;
 - to request the Minister to prohibit (or apply conditions to) a product being placed on the market; and
 - to prosecute an offence.

Although these Regulations did not come into effect until 1993, existing national provisions i.e. Irish Standards, British Standards etc. continued to apply where European technical specifications were not available. In such cases, products may have been placed on the market in accordance with these national provisions.

Given the limited resources available and their application over the then 37 separate local building control authorities, enforcement action relating to the Construction Products Directive was generally carried out on a reactive basis. Typically, market surveillance activity was triggered on foot of acting on information received from complaints, e.g. from the public, public bodies, contractors, designers, customs or other market surveillance authorities etc.

3.2.2 Construction Products Regulation (Regulation (EU) No. 305/2011)

Although outside the scope of the legacy period under consideration, since 1 July 2013, *Regulation (EU) No 305/2011 of the European Parliament and of the Council laying down harmonised conditions for the marketing of construction products and repealing Council Directive 89/106/EEC* (commonly known as the Construction Products Regulation) requires any construction product placed on the market that is covered by a harmonised standard to be accompanied by a *Declaration of Performance* and to have the CE marking affixed. There is a suite of harmonised standards covering most construction products including aggregates, concrete blocks etc.

The primary purpose of the Construction Products Regulation (and its predecessor the Construction Products Directive) is to break down technical barriers to trade in order to ensure the free movement of construction products across Member States within the European Union. In this regard, the Construction Products Regulation provides for: -

-
- a system of harmonised technical specifications (i.e. harmonised European product standards and European Assessment Documents);
 - an agreed system of assessment and verification of constancy of performance for each product family (as set out in the harmonised technical specifications);
 - a framework of notified bodies, who are third party bodies involved in the assessment of products, or their production, to varying degrees as set out in the harmonised technical specifications; and
 - the mandatory CE marking of construction products as a passport to the internal market, along with the requirement for *Declarations of Performance* to accompany such construction products.

The Construction Products Regulation came directly into force across the entire European Union on 1 July 2013 with the result that each construction product for which a harmonised European product standard is in force, or for which a European Technical Assessment has been issued, will need a *Declaration of Performance* from the manufacturer and be affixed with the CE marking before it can be placed on the internal market.

In addition, the Construction Products Regulation has introduced a ‘chain of custody’ approach for construction products being placed on the market which will result in greater legal responsibility for compliance not only on manufacturers but also with agents, importers and distributors (i.e. retailers) who must, amongst other things, take appropriate steps to ensure that these requirements have been fulfilled by the manufacturer.

In the context of construction products, market surveillance refers to the activities carried out and the measures taken by market surveillance authorities (i.e. enforcement authorities) to ensure that construction products comply with the requirements set out in the Construction Products Regulation and therefore do not endanger the health, safety or any other aspect of public interest protection. In real terms, market surveillance under the Construction Products Regulation will include any necessary actions to: –

-
- stop the circulation of construction products that do not comply with all the requirements set out in the Construction Products Regulation (e.g. bans, withdrawals, recalls);
 - require economic operators to bring their construction products into compliance; and/or
 - apply sanctions to non-compliant economic operators.

However, it should be noted that primary responsibility for demonstrating a construction product's compliance with the requirements of the Construction Products Regulation rests with the manufacturer of the product. It is not the responsibility of a market surveillance authority to certify products.

Under the *European Union (Construction Products) Regulations 2013* (S.I. No. 225 of 2013), building control authorities have been designated as the principal market surveillance authorities for construction products that fall within the scope of the Construction Products Regulation although the Minister for Housing, Planning, Community and Local Government may also appoint other bodies and/or persons for specific product areas should the need arise.

Enforcement action relating to Construction Products Regulation is generally carried out on a reactive basis and is more often triggered on foot of acting on information received from complaints (e.g. from the public, public bodies, contractors, designers, customs, An Garda Síochána or other market surveillance authorities etc.).

3.3 How is masonry construction dealt with in the Building Regulations?

The statutory requirements set out in Part D of the Second Schedule to the Building Regulations in relation to materials and workmanship provides an overarching requirement that *“all works shall be carried out with proper materials and in a workmanlike manner”*. *“Proper materials means materials which are fit for the use for which they are intended and for the conditions in which they are to be used.”*

In addition, Part A of the Second Schedule to the Building Regulations sets out the legal requirements in relation to structure. The accompanying Technical Guidance Document A provides guidance on how compliance can be achieved and, in the context of block work in houses; reference is given to the appropriate masonry design and construction standards. The materials to be used, e.g. concrete blocks, wall ties etc. are required to meet the specified minimum designations, strengths and other qualities, as set out in Technical Guidance Document A and the referenced standards.

Finally, Part C of the Second Schedule to the Building Regulations sets out the legal requirements in relation to site preparation and resistance to moisture. The accompanying Technical Guidance Document C provides guidance on how compliance can be achieved and in the context of masonry construction; reference is again given to the appropriate masonry design and construction standards.

A summary of the particular requirements of Part A – Structure, Part C – Site Preparation and Resistance to Moisture and Part D - Materials and Workmanship of the Second Schedule to the Building Regulations is given in Appendix 3.

3.5 Discussion

3.5.1 Building Control System

The Donegal and Mayo masonry problems adds to the legacy of building failures or severe non-compliance concerns following the downturn in economic and construction activity in 2008, which exposed vulnerabilities in the building control system that was in place at that time. The economic consequences of legacy issues for industry, private building owners and the State continue to be felt in terms of the immediate remediation costs, e.g. the pyrite remediation scheme and the longer term effects on construction-related insurances and consumer confidence in the construction industry.

The Panel regards the strengthening of the regulatory framework by means of the introduction of the *Building Control (Amendment) Regulations 2014* (S.I. No. 9 of 2014), which aims to ensure that a home or building is designed and constructed in compliance with the relevant requirements of the Building Regulations, as a positive intervention. S.I. No. 9 of 2014 requires that the design and construction of buildings is verified during construction through the execution of an inspection plan overseen by a registered construction

professional (the assigned certifier) that enables the builder and the assigned certifier to sign a statutory certificate of compliance on completion.

On the other hand, the Panel disagrees with the more recent relaxation of the provisions of the *Building Control (Amendment) (No. 2) Regulations 2015* (S.I. No. 365 of 2015) which facilitates, amongst other things, a homeowner to opt out of the statutory certification system. It is the Panel's opinion that the introduction of the opt out for new single dwellings, on a single development, as provided for in the S.I. No. 365 of 2015 is a retrograde step that may contribute to repeat building failures such as those experienced in Counties Donegal and Mayo due to an absence of professional involvement.

The Panel is generally satisfied that the Building Regulations were clear with their functional requirements. The Technical Guidance Documents referred to a comprehensive suite of standards, which was reflective of the state of knowledge and experience of concrete block manufacturing and masonry construction at the time and the principles still remain very much current to this day. The Panel notes that Technical Guidance Document C (2004 edition) discontinued some key references but notwithstanding this, Part C itself is very clear in its functional requirement for the resistance of moisture. Regulation C4 states: *"The floors, walls and roof of a building shall be so designed and constructed as to prevent the passage of moisture to the inside of the building or damage to the fabric of the building."*

The Panel noted that both affected areas of Counties Mayo and Donegal are located in an exposure zone classified as severe category, see paragraph 2.3.2. In this regard, the specification of the concrete block, mortar and render etc. should have been a key consideration to ensure the exclusion of moisture. The Panel observed some deviations from the codified recommendations for masonry use in Ireland, e.g. movement joints, weep holes, render specification.

3.5.2 Enforcement of Construction Products Legislation

During the period under consideration, building control authorities did not have the technical resources in-house to test construction products which may have been non-compliant with the requirements of the Construction Products Directive. In this regard, all enforcement activity was (and remains the same today²⁵) performed within existing local authority budgets

²⁵ IRELAND Regulation (EC) No. 765/2008 National Sector Specific Market Surveillance Programme 2014-15 (February 2014).

and remained subject to national restrictions on Government spending following the downturn in the economy in 2008.

Given the limited resources available and their application over 31 separate local building control authorities, enforcement action relating to construction products is generally carried out on a reactive basis. Typically, market surveillance activity is triggered on foot of acting on information received from complaints (e.g. from the public, public bodies, contractors, designers, customs, An Garda Síochána or other market surveillance authorities etc.).

3.6 Conclusions

The many incidences of building failures or severe non-compliance concerns which followed the 2008 collapse in economic and construction activity ultimately led to a strengthening of the building control system. The Panel regards the strengthening of the regulatory framework by means of the introduction of the *Building Control (Amendment) Regulations 2014*, which requires the design and construction of buildings to be verified during construction through the execution of an inspection plan overseen by a registered construction professional (i.e. an assigned certifier) that enables the builder and the assigned certifier jointly to sign a statutory certificate of compliance on completion, as a positive intervention to support compliance with the requirements of the Building Regulations. The new regime, in place over 3 years, has improved adherence to the Building Regulations and associated Technical Guidance Documents and referenced standards. However, it is the Panel's opinion that the introduction of an opt out for new single dwellings, on a single development, as provided for in S.I. No. 365 of 2015 is a retrograde step that through lack of professional supervision of works could contribute to a repeat building failures such as those experienced in Counties Donegal and Mayo and should be amended.

The Panel advocate that more meaningful on-site inspections and enforcement by building control personnel is required to ensure that standards are maintained as a necessary check and balance to requirements under the current building control system. However, the Panel does not consider it was reasonable to expect that the Building Control Authorities could have prevented the problem from occurring.

With regards to the Building Regulations, given that Part C – Site Preparation and Resistance to Moisture and the current edition of Technical Guidance Document C dates back to 2004, the Panel considers that it is timely that a full review be undertaken to ensure that the latest standards and subsequent changes to construction practice and technology are reflected into the Building Regulations.

The Panel considers that the risk of failure of a construction product is significantly reduced when the manufacturer, who takes full responsibility for placing his product on the market, has full knowledge of their raw material (as is legally required by the Construction Products Regulation via the relevant harmonised European Standards) and has assessed the end product's suitability for use in construction works in accordance with the relevant Standard Recommendations. In Ireland, since the publication of S.R. 325: 2013²⁶ manufacturers of concrete blocks are recommended to have third party oversight by a Factory Production Control Certification body. The recently published version of S.R. 16: 2016²⁷ endorses the benefits of third party oversight and recommends that manufacturers of aggregates for concrete have factory production control certification in place by December 2017.

Compliance with the mandatory harmonised standards for construction products needs to be adequately enforced. In this regard, the Panel advocates that market surveillance authorities be sufficiently resourced with dedicated units which would have, among other things, available expertise in the quarrying sector to provide effective enforcement nationwide. In tandem with enhanced market surveillance, manufacturers and their representative bodies will have a lead role to play in ensuring that they have the knowledge and expertise necessary to ensure they meet their legal requirements under the Construction Products Regulation and their products will be fit for the purpose.

²⁶ S.R. 325:2013+A1:2014 Recommendations for the design of masonry structures in Ireland to Eurocode 6.

²⁷ S.R. 16:2016 Guidance on the use of I.S. EN 12620:2002 +A1:2008 - Aggregates for concrete.

Chapter 4 Scale of the Problem

4.0 Introduction

In response to the terms of reference: -

“(i) To identify, insofar as it is possible, the numbers of private dwellings which appear to be affected by defects in the blockwork in the Counties of Donegal and Mayo”,

this chapter discusses the findings of the Panel’s desktop study and consultation with stakeholders.

The Panel endeavoured, in so far as is practicable, to quantify the known scale of the problem to date based on information presented to the Panel by affected stakeholders. The Panel also estimated the number of private dwellings that potentially may be affected.

4.1 Information gathering

The Panel undertook an extensive stakeholder consultation exercise (see Chapter 2). Information on dwellings exhibiting structural distress manifesting primarily as a particular pattern of external wall cracks were collated from various sources²⁸ including: -

- home owners/ home owner representatives;
- public representatives;
- local authorities;
- house guarantee providers;
- builders; and
- stakeholders.

²⁸ See Appendix 1 for full list of individuals / companies who met with the panel.

For the purposes of establishing the scale of the problem, this enabled the Panel to form a general profile of: -

- the general locations of affected dwellings;
- whether affected dwellings were one-off or scheme houses; and
- the year(s) of construction.

4.2 Evaluation of information received

The Panel evaluated the information received, taking the following into consideration: -

- a) it is not within the Panel's remit to apportion blame for the cause of the building defects as the determination of civil liability is ultimately a matter for the courts;
- b) for the purposes of estimating the scale of the problem, the Panel accepted at face value, from the informed sources, the identification of private houses exhibiting structural distress primarily manifesting as a particular pattern of external wall cracks. The Panel conducted an appraisal of any associated technical reports supporting the information received. It was not in the Panel's remit to commission testing to verify the cause of the defects claimed in these reports;
- c) the Panel acknowledges that there has been reluctance by some key stakeholders to share information due to commercial sensitivities and for reasons of litigation. Therefore, the figures presented in this chapter are reflective of the level of knowledge available up to 31 December 2016 and does not rule out the possibility of additional knowledge becoming available in the future;
- d) where private dwellings which formed part of a housing estate were brought to the attention of the Panel, the Panel counted the total number of private houses in those estates as being potentially affected;
- e) to establish the upper limit of the number of private dwellings that could conceivably be at risk to the problem in the affected Municipal Districts, the Panel mainly referred to

Commencement Notices²⁹ submitted for building control purposes to quantify the amount of new build private dwellings built in the same locality where complaints of masonry defects were made over the same period. The Panel satisfied themselves that the Commencement Notice data of potential dwellings reflected a real contribution to the building stock by cross referencing the Commencement Notice data with the Central Statistics Office, census data for the Municipal Districts (where possible) which responded to question H.2 *“When was your house, flat or apartment first built?”*

- f) the experience of Donegal County Council’s assessment of the proportion within their own social housing stock exhibiting masonry defects primarily manifesting as a particular pattern of external wall cracks was taken into account and this ratio was applied as a proxy indicator to the private housing stock to estimate the proportion of private dwellings that may be affected.

4.3 Key Findings – County Donegal

The following summarises the key findings of the Panel arising from their extensive consultation process with various key stakeholders.

4.3.1 Feedback from homeowners and their representatives

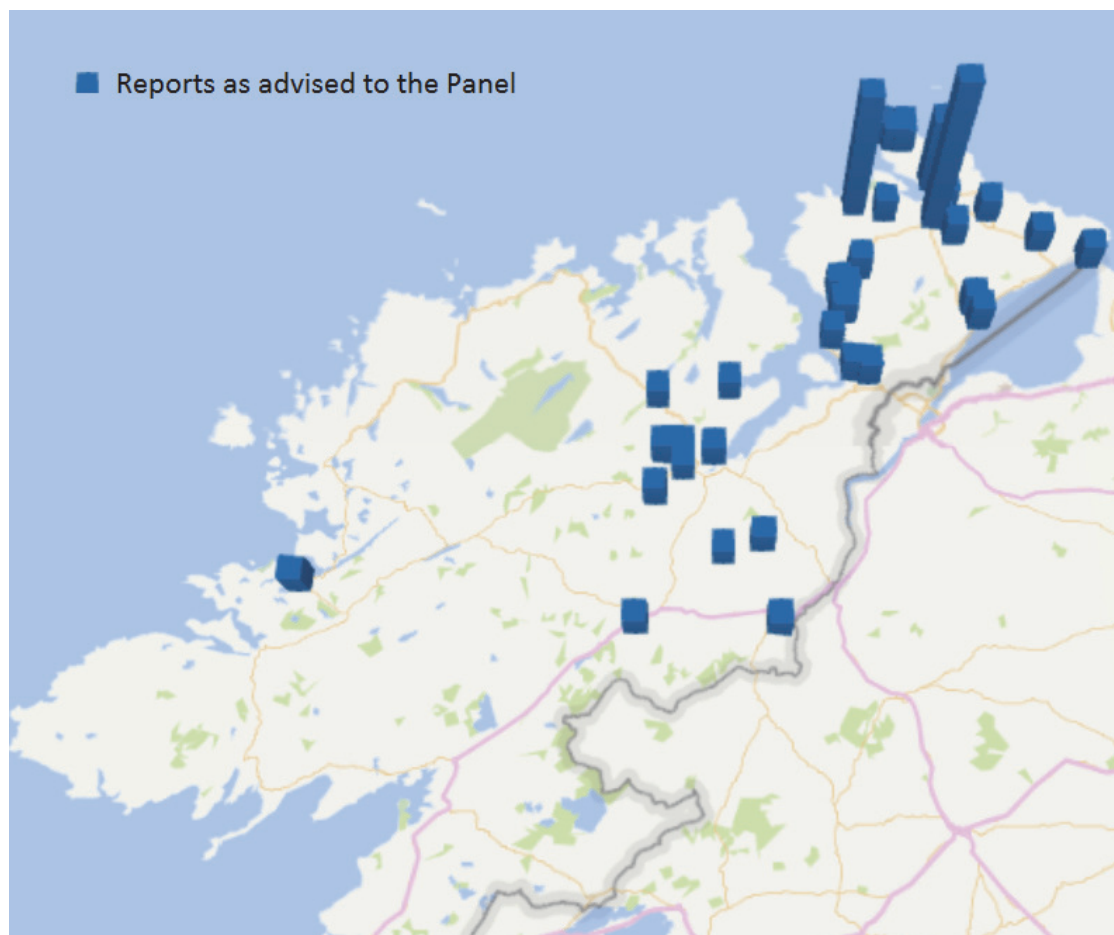
The Mica Action Group advised the Panel that, to the best of their knowledge, there were 471 individual homeowners who had registered with their group in the belief that their dwellings were exhibiting structural distress.

In support of the issue, the Panel received via the Mica Action Group and other stakeholders, a total of 63 technical reports (dated 2011 to 2016), which had been commissioned by affected homeowners in addition to other supplementary information relevant to the problems their members are facing. In broad terms, the information provided largely consisted of a mixture of reports from consulting engineers (some with and some without laboratory reports) as well as a number of isolated laboratory reports.

Figure 4.1 below, shows the general locations (where known) that these reports related to.

²⁹ A Commencement Notice is a notification to a building control authority that a person intends to carry out works to which the Building Regulations apply.

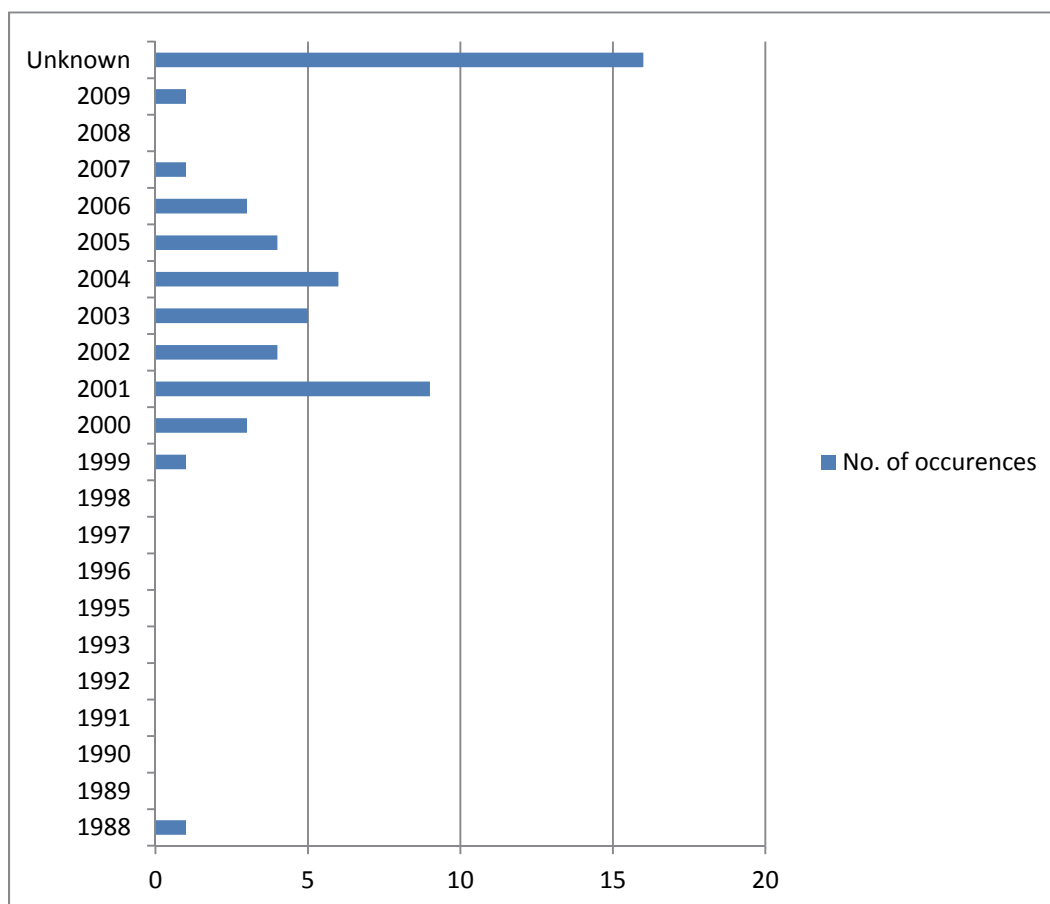
Figure 4.1 General location of affected dwellings (as advised to the Panel)



From review of the reports received, the Panel noted that the affected dwellings were largely constructed in the Inishowen / Letterkenny Municipal Districts during the period between 2000 and 2007³⁰, although a significant number of reports did not indicate any year of construction. See Figure 4.2 for the distribution of reports on affected dwellings per stated year of construction.

³⁰ Two reports indicated that the commencement of the dwelling was 1988 and 2009 respectively.

Figure 4.2 Year of construction as referred to in reports received by the Panel



n = 53

4.3.2 Feedback from structural guarantee providers

The Panel made contact with the two main companies, which provided structural warranties on private dwellings, during the period concerned, namely Premier Guarantee and HomeBond.

An agent acting on behalf of Liberty Specialist Markets who are the underwriters of the Premier Guarantee scheme confirmed that they have very limited involvement in relation to claims for dwellings exhibiting structural distress manifesting as a particular pattern of external wall cracks in County Donegal and were not in a position to provide any further

information to the Panel. It is understood that while the guarantee scheme first commenced operations in Ireland in 2002, it is are no longer writing new business in Ireland.

HomeBond advised the Panel that they had received 36 complaints / claims from homeowners across 5 estates where structural distress primarily manifesting itself as a particular pattern of cracking in the external walls. These dwellings were registered in the period from 2002 to 2008 (inclusive). The total number of registered dwellings in these 5 estates amounted to some 327 properties.

4.3.4 Feedback from Donegal County Council

Donegal County Council advised the Panel that on foot of the issues emerging within their social housing stock, their Housing Department undertook an assessment of their total social housing stock for dwellings exhibiting structural distress primarily manifesting as a particular pattern of external wall cracks in both the Inishowen and Letterkenny Municipal Districts.

The total social housing stock within the Inishowen Municipal District consists of 1,117 dwellings. Donegal County Council advised the Panel that some 400 social housing units constructed between 1990 and 2011 were exhibiting structural distress primarily manifesting as a particular pattern of external wall cracks. A total of 777 social housing units from the overall stock were built during this period. While many years displayed singular digit figures for affected dwellings, the majority (334) were constructed between 2000 and 2008 (inclusive). The total number of social housing units built between 2000 and 2008 (inclusive) was 563. Therefore, approximately 60% of social housing stock built in the Inishowen Municipal District between 2000 and 2008 appears to be affected.

The total social housing stock located within the Letterkenny Municipal District amounts to 1,270 dwellings. Donegal County Council advised the Panel that some 141 social housing units constructed between 1998 and 2011 were exhibiting structural distress primarily manifesting as a particular pattern of external wall cracks. A total of 712 social housing units from the overall stock were built during this period. While many years displayed singular figures, the majority (112) were constructed between 2000 and 2008 (inclusive). The total number of social housing units built between 2000 and 2008 (inclusive) was 488 dwellings. Therefore, 23% of social housing stock built in Letterkenny Municipal District between 2000 and 2008 appears to be affected.

4.4 Discussion

While the Panel engaged in an extensive consultation, see Chapter 2, to estimate the scale of the problem in real terms, it was not possible to accurately predict exactly how many concrete block-built private dwellings may be affected by structural distress primarily manifesting as a particular pattern of external wall cracks, beyond those which have already been reported to the Panel. The Panel accept that some homeowners are reluctant to declare an issue due to commercial, insurance or legal sensitivities or even simply just lack of awareness of the defect.

Commencement Notices reflecting a potential 10,600 private dwellings the Inishowen and Letterkenny Municipal Districts were notified to Donegal County Council between 2000 and 2008. The Panel do not believe that all of these dwellings are affected due to the multiple variables such as the utilisation of different builders, block suppliers, variable quality of workmanship employed, local exposure conditions of the dwelling etc.

Mica Action Group advised the Panel that 471 homeowner's dwellings were exhibiting structural distress manifesting primarily as a particular pattern of external wall cracks as at 31 December 2016. The MICA Action Group also identified 28 estates within which dwellings registered by their Members were located. The cumulative total number of dwellings in these 28 estates is approximately 975.

Taking into consideration the geographical distribution of technical reports on affected dwellings throughout the Inishowen and Letterkenny Municipal Districts (see Figure 4.1), the Panel consider that there appears to be a greater probability of affected dwellings being located in the Inishowen Municipal District than the Letterkenny Municipal District.

This distribution of technical reports received by the Panel somewhat correlates with the experience of Donegal County Council, where 60% of social housing stock built between 2000 and 2008 appears likely to be affected in the Inishowen Municipal District as opposed to 23% in Letterkenny Municipal District.

4.5 Conclusions

Table 4.1 summarises the key findings regarding the scale of the problem in County Donegal: -

- the MICA Action group have identified 28 estates in which they advise may have affected dwellings;
- the total number of homes in these estates is approximately 975 dwellings;
- MICA Action Group Membership advise that approximately 50% of their membership relates to one off houses (i.e. 236 dwellings).

On that basis the Panel estimate that the minimum potential number of private homes affected is likely to be approximately 1,200 dwellings, (i.e. 236 + 975).

However, applying the experience of Donegal County Council regarding affected social housing units (60% Inishowen Municipal District and 23% Letterkenny Municipal District), the Panel estimate that there may be as much as 4,800 private dwellings potentially affected.

Based on the information available as of 31 December 2016, the Panel cannot be more definitive in their estimation.

Table 4.1 Summary of Expert Panel's findings for private dwellings in North County Donegal		
Item	Description	Number of Private Dwellings
1.	Number of private dwellings affected as advised by the Mica Action Group (MAG) ¹	471
2.	Total number of private dwellings on 28 housing estates as advised by MAG (31 December 2016)	975
3.	Number of private dwellings with relevant complaints / claims were made to HomeBond ²	36
4.	Total number of private dwellings on estates where a complaint / claim was made to HomeBond ³	327
5.	Number of private dwellings in the Inishowen and Letterkenny Municipal Districts for which a Commencement Notice ⁴ was lodged between 2000 and 2008	10,600 ⁵
6.	Estimate of the minimum potential number of private dwellings likely to be affected (see 4.5)	1,200
7.	Estimate of the potential number of private dwellings that may be affected (using Donegal County Council's experience of affected social housing units as a proxy indicator) ⁶	4,800 ⁶
Notes: <ol style="list-style-type: none"> 1. Based on a survey conducted by the Mica Action Group. 2. HomeBond registrations for County Donegal between 2000 and 2008 (inclusive) averaged 34% of private housing completions in County Donegal for the same period. 3. There were 5 housing estates where a complaint / claim was made regarding structural distress primarily manifesting as a particular pattern of external wall cracks. 4. A Commencement Notice is a notification to a Building Control Authority that a person intends to carry out works to which the Building Regulations apply. 5. There is no evidence to suggest all of these dwellings are affected (See 4.4). 6. [Inishowen Municipal District Commencement Notices x 0.6] + [Letterkenny Municipal District Commencement Notices x 0.23] = approximately 4,800 private dwellings (2000 - 2008). 		

4.6 Key Findings – County Mayo

The following summarises the key findings of the Panel arising from their extensive consultation process with various key stakeholders.

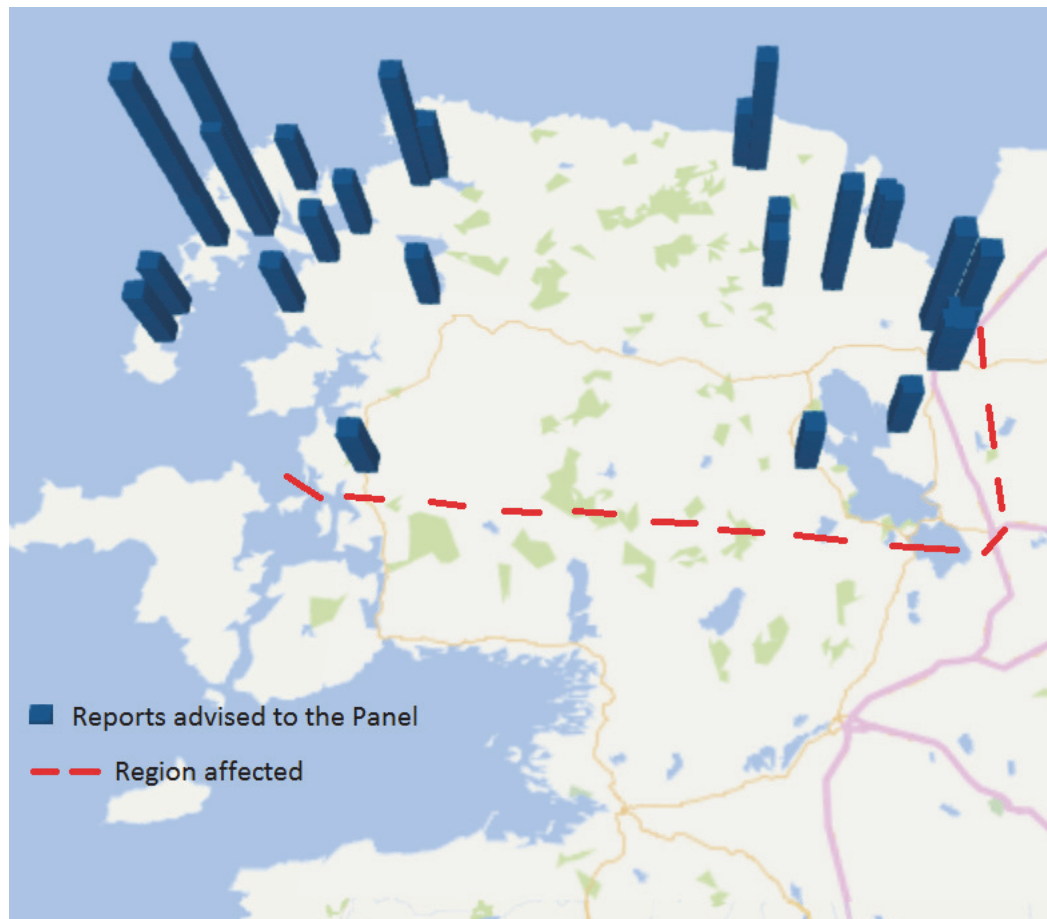
4.6.1 Feedback from homeowners and their representatives

Over the course of the consultation process, a total of 45 homeowners advised the Panel that their dwellings were exhibiting structural distress manifesting as a particular pattern of external wall cracks. This figure represents homeowners of 30 one-off dwellings and 15 homeowners from 9 estates. The total number of dwellings on these 9 estates is 315 dwellings.

Homeowners provided the Panel with technical reports (dated 2010 to 2016), in respect to 17 dwellings. A further 16 homeowners provided supporting evidence by means of photographs.

Figure 4.3 below, shows the general locations (where known) that these reports and photographs related to.

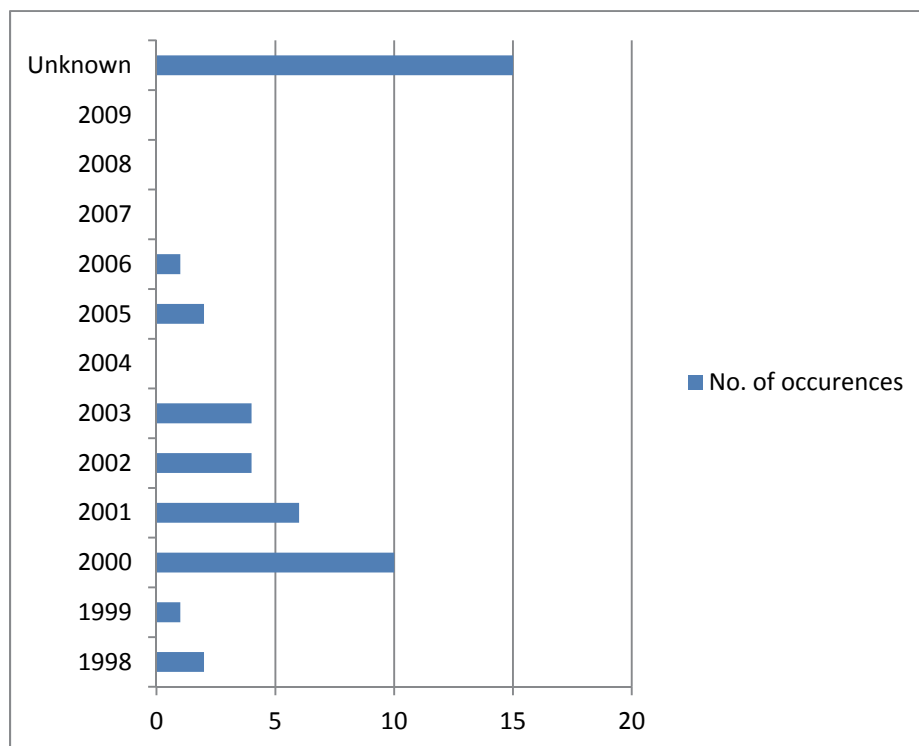
Figure 4.3 General location of affected dwellings (as advised to the Panel)



In general, from review of the reports received, the Panel were advised that the affected dwellings were largely constructed in the period between 2000 and 2006³¹, although a significant number of reports did not indicate any year of construction. See Figure 4.4 overleaf for the distribution of affected private dwellings in County Mayo.

³¹ Two reports indicated that the commencement of the dwelling was 1998 and one report indicated 1999.

Figure 4.4 Year of construction as referred to by homeowners



n = 45

4.6.2 Feedback from guarantee providers

The Panel made contact with the two main companies, which provided structural warranties on private dwellings, during the period concerned, namely Premier Guarantee and HomeBond.

An agent acting on behalf of Liberty Specialist Markets who are the underwriters of the Premier Guarantee scheme confirmed that they have very limited involvement in relation to claims for dwellings in County Mayo and were not in a position to provide any further information to the Panel.

HomeBond advised that they had received 15 claims from homeowners across 6 estates; these dwellings were registered in the period between 2000 and 2006 (inclusive). The total number of registered dwellings in these 5 estates amounted to some 120 properties.

4.6.3 Feedback from Mayo County Council

Mayo County Council advised the Panel that 17 of their social housing units were exhibiting structural distress manifesting as a particular pattern of external wall cracks. These are located on three estates and are located in the north west of the county. These dwellings were constructed between 2000 and 2002.

Mayo County Council advised the Panel that a total of 277 social housing units were built in the period between 2000 and 2006.

4.7 Discussion

Similar to County Donegal, it was not possible to accurately predict exactly how many private dwellings may be affected by structural distress primarily manifesting as a particular pattern of external wall cracks, beyond those already reported to the Panel. The Panel accept some homeowners are reluctant to declare an issue due to commercial, insurance or legal sensitivities or even simply just lack of awareness of the defect.

The geographical distribution of reported private dwellings appears to be confined to the north / north west area of County Mayo, bridging the West Mayo and Ballina Municipal Districts respectively (See Figure 4.2).

Mayo County Council advised the Panel following an assessment of its own social housing stock that their experience of the problem is limited to north-west Mayo. At the time of writing this report, there were no indications of any problems within the Council's social housing stock in the Ballina Municipal District or elsewhere.

From analysis of the locations of reported incidences in County Mayo, the Panel is of the view that the geographical area affected is confined to the north / north-west of the county as indicated by the dashed red line in Figure 4.2. Accordingly, Commencement Notices notified to Mayo County Council between 2000 and 2006 reflects approximately 3,600 private dwellings in this geographical area. The Panel do not believe that all of these dwellings are affected due to multiple variables such as the utilisation of different builders, block suppliers, variable quality of workmanship employed, local exposure conditions etc.

While the information on affected social housing units as provided by Mayo County Council was examined, it was not considered statistically viable to extrapolate a proxy indicator which could be applied to the private dwelling stock due to small sample size, limited timeframe of construction and narrow geographical spread of affected dwellings. In the absence of this and other relevant information, the Panel deem it not possible to be more definitive at this point in time.

The indication of a problem comes from the homeowners / home owner representatives who advised the Panel that 93 homeowners on 7 housing estates comprising some 345 dwellings were exhibiting structural distress manifesting primarily as a particular pattern of external wall cracks.

4.8 Conclusions

Table 4.2 summarises the key findings on the estimated scale of the problem in County Mayo: -

- the Mayo Pyrite Group (93 Members) have identified 7 estates in which they advise may have affected dwellings;
- the total number of dwellings in these estates is 315;
- there are an additional 30 one-off houses identified.

On that basis the Panel estimates that the minimum potential number of private dwellings likely to be affected is approximately 345, (i.e. 315 + 30).

Based on the information available as of 31 December 2016, the Panel cannot be more definitive than this in their estimation.

Table 4.2 Summary of Expert Panel's findings for North/ North West County Mayo

Item	Description	Number of Private Dwellings
1.	Number of one-off private dwellings affected as advised to Panel by homeowners	30
2.	Total number private dwellings on estates where an affected dwelling was advised to the Panel ¹	315
3.	Estimate of the minimum potential number of private dwellings likely to be affected (see 4.8)	345
4.	Number of private dwellings where relevant complaints / claims were made to HomeBond ²	15
5.	Total number of private dwellings on estates where a complaint / claim was made to HomeBond ³	120
Notes: 1. 15 homeowners on 9 estates advised the Panel that their dwellings were exhibiting structural distress primarily manifesting as a particular pattern of external wall cracks. 2. HomeBond registrations for County Mayo between 2000 and 2006 (inclusive) averaged 41% of private housing completions in County Mayo for the same period. 3. There were 6 housing estates where a claim was made regarding structural distress primarily manifesting as a particular pattern of external wall cracks.		

Chapter 5 - Technical Solutions

5.0 Introduction

In response to the terms of reference: -

“(iii) to outline a range of technical options for remediation and the means by which those technical options could be applied by the affected homeowners in a manner that delivers cost effective and satisfactory outcomes for those homeowners”,

this chapter discusses the opinion of the Panel with regards to a practical approach to diagnosing the problem and feasibility of application of technical solutions.

5.1 Establishing the cause of the problem

As discussed in Chapter 2, any forensic analysis of the construction defect should address the following three key areas: -

- a) Design;
- b) Product; and
- c) Workmanship.

Construction defects may be caused by any one of these or a combination of more than one. To enable the most appropriate solution to be applied, correct diagnosis by a competent professional regarding the cause of the structural defect is paramount.

5.1 Professional Advice

If homeowners suspect that they may have structural distress exhibiting primarily as cracks in a particular pattern to the external walls, the Panel recommends that homeowners seek the advice of a competent professional.

5.2 Remediation approaches encountered by the Panel

The Panel was advised of several instances where homeowners have conducted or commissioned remediation works to dwellings exhibiting structural distress primarily manifesting as cracks in a particular pattern to the external walls. This section describes the remediation approaches adopted and discusses the varying degrees of success.

5.2.1 Remediation approaches encountered – County Donegal

The following remediation approaches were encountered by the Panel in County Donegal.

5.2.1.1 Remove cracked render and reinstate

This remediation approach was generally applied to an affected external wall of the dwelling rather than the entire dwelling and involved removal of the existing render from the external walls where cracking had expressed itself. Depending on the condition of the concrete blockwork behind, decisions were taken whether (or not) the concrete blocks needed to be removed and replaced³².

In at least one private house, the Panel was made aware that the cracking re-appeared shortly after this remediation approach was applied to a gable end only. The Panel was advised that the homeowner was considering re-rendering for a second time.

5.2.1.2 Replacement of the external leaf only (down to DPC level) and re-render

This remediation solution was applied to a gable external wall of the dwelling (see paragraph 2.7.1).

5.2.2 Remediation approaches – County Mayo

5.2.2.1 Remove cracked render and reinstate

This remediation measure involved removal of the existing render from the external walls and re-rendering incorporating expanded metal mesh for reinforcement. Depending on the condition of the concrete blockwork behind, decisions were taken whether (or not) the concrete blocks needed to be removed and replaced. In instances where this approach had been employed by homeowners, the Panel was made aware that the cracking re-appeared shortly after the remediation solutions were applied.

³² Case Study: Remedial works to external cavity walls, social housing scheme, Letterkenny - John McCarron of Donegal County Council 05 April 2016, See link: <http://www.engineersjournal.ie/2016/04/05/remedial-works-to-external-cavity-walls-letterkenny/>.

5.2.2.2 Replacement of the external leaf only (down to DPC level) and re-render

While the panel did not encounter this remedial approach, they were informed anecdotally that this had been successfully applied to a dwelling affected by pyritic concrete blocks dating back to circa 1998.

5.2.2.3 Replacement of both the inner and external leaf (to top of foundation level)

One homeowner of a two-storey dormer replaced both inner and external leafs (to top of foundation). This was conducted on a phased basis and involved elaborate temporary works.

5.2.2.4 Application of an external wall insulation system

This remediation approach involving the fixing of external wall insulation (EWI) system to a two story detached house was encountered. This remediation option involved the fixing of approximately 25 mm external wall insulation to the external leaf with mechanical fixings and rendering with an impervious certified render system. The Panel was advised that the engineer involved, while satisfied that the solution would minimise the problem recurring, could not guarantee its long-term success.

5.3 Discussion

From an evaluation of the reports received, the Panel noted the differing engineering approaches adopted to diagnose the cause of the problem. Where laboratory testing was carried out, there were often differences with regards to the suite of laboratory tests conducted and the conclusions that can be drawn from these.

Apart from paragraphs 5.2.1.1 and 5.2.2.1, the Panel is not aware that the remediation approaches applied by, or on behalf of, homeowners have resulted in any further structural problems to the remediated works, nor are they aware that specific measures taken have successfully overcome any insurance, future conveyancing issues.

5.4 Conclusions

The Panel considers that each dwelling should be assessed by a competent professional on a case by case basis to establish whether (or not) the structural distress is attributable to harmful impurities in the concrete block. On the basis of this assessment by a competent

professional, the Panel outlines a suite of technical solutions they considered in Tables 5.1 and 5.2 overleaf, along with the pros and cons of each.

Table 5.1 Technical options for remediation of affected dwellings – County Donegal

Option No.	Description	Pros	Cons
1.	Demolish entire dwelling to foundation level and rebuild.	<ul style="list-style-type: none"> Removal of all concrete blocks susceptible to deterioration. Sign off of works by a competent professional, without reservation is possible. 	<ul style="list-style-type: none"> This is the most expensive remediation option. Longest programme duration and may involve making a planning application. Alternative accommodation will be required for duration of works.
2.	Demolish and rebuild external walls (both outer and inner leafs) <u>down to foundation</u> on a phased basis and re-render.	<ul style="list-style-type: none"> 10% to 25% less expensive than Option 1. Sign off of works by a competent professional without reservation is possible. 	<ul style="list-style-type: none"> Elaborate temporary works necessary. Alternative accommodation will be required for duration of works.
3.	Demolish and rebuild external walls (both outer and internal leafs) <u>down to top of rising wall</u> on a phased basis and re-render.	<ul style="list-style-type: none"> 15% to 30% less expensive than Option 1. Sign off of works by a competent professional may be possible. 	<ul style="list-style-type: none"> Detailed assessment of the condition of any retained rising wall (above and below DPC level) required. Elaborate temporary works necessary. Possible reservations to sign-off regarding long term durability of rising walls. Alternative accommodation will be required for duration of works.
4.	Demolish and rebuild external walls (outer leaf only) <u>down to top of rising wall</u> on a phased basis and re-render.	<ul style="list-style-type: none"> 70% to 75% less expensive than Option 1. Occupant relocation may not be necessarily essential. Sign off of works by a competent professional may be possible. 	<ul style="list-style-type: none"> Detailed assessment of the condition of any retained rising wall/ inner leaf (above and below DPC level) required.
5.	Take down and rebuild outer leaf of <u>affected walls only</u> and re-render.	<ul style="list-style-type: none"> Less expensive than Option 4. Occupant relocation not necessary. 	<ul style="list-style-type: none"> Detailed evaluation of the retained rising wall / inner leaf (above and below DPC level) required. Reluctance to sign-off by competent professionals. Problems may emerge in other walls.

Notes:

The cost comparison presented in the Table 5.1 is based on a preliminary costing commissioned by the Panel for: -

- a) a Dormer Bungalow, 3 Bedroom, 2,021 sq.ft, and
- b) a Two Storey, 4 Bedroom, 15,20 sq.ft.

Other technical solutions may exist.

Table 5.2 Technical Options for remediation of affected dwellings – County Mayo

Option No.	Description	Pros	Cons
1.	Demolish entire dwelling and rebuild.	<ul style="list-style-type: none"> Removal of all concrete blocks susceptible to deterioration. Sign off of works by a competent professional, without reservation is possible. 	<ul style="list-style-type: none"> This is the most expensive remediation option. Longest programme duration and may involve making a planning application. Alternative accommodation will be required for duration of works.
2.	Demolish and rebuild external walls (both outer and internal leafs) <u>down to foundation</u> on a phased basis and re-render.	<ul style="list-style-type: none"> 10% to 25% less expensive than Option 1. Sign off of works by a competent professional without reservation may be possible. 	<ul style="list-style-type: none"> Elaborate temporary works necessary. Alternative accommodation will be required for duration of works.
3.	Demolish and rebuild external walls (both outer and internal leafs) <u>down to top of rising wall</u> on a phased basis and re-render.	<ul style="list-style-type: none"> 15% to 30% less expensive than Option 1. Sign off of works by a competent professional may be possible. 	<ul style="list-style-type: none"> Detailed assessment of the condition of any retained rising wall (above and below DPC level) required. Elaborate temporary works necessary. Possible reservations to sign-off regarding long term durability of rising walls. Alternative accommodation will be required for duration of works.
4.	Demolish and rebuild external walls (outer leaf only) <u>down to top of rising wall</u> on a phased basis and re-render.	<ul style="list-style-type: none"> 70% to 75% less expensive than Option 1. Occupant relocation not necessary. 	<ul style="list-style-type: none"> Detailed assessment of the condition of any retained rising wall / inner leaf (above and below DPC level) required. Reluctance to sign-off by competent professionals. Problems may emerge in the future of the inner leaf.

Notes:

The cost comparison presented in the Table 5.1 is based on a preliminary costing commissioned by the Panel for: -

- a) a Dormer Bungalow, 3 Bedroom, 2021 sq.ft, and
- b) a Two Storey, 4 Bedroom, 1520 sq.ft.

Other technical solutions may exist.

Chapter 6 Conclusions and Recommendations

6.0 Introduction

This chapter outlines the conclusions of the Panel and associated recommendations which they consider are necessary to deal with the current problem and to limit any such future problems arising with house construction.

The conclusions and observations of the Panel are based substantially on the information provided to it by affected homeowners and industry representatives and references to published material relevant to the issue.

6.1 Conclusions

The Panel acknowledges the distressing and stressful situations which many affected homeowners in Donegal and Mayo are facing due to the problems that have emerged in the concrete blockwork of their homes. However, as set out in their terms of reference, it is not within the Panel's remit to apportion legal liability for the problems nor was the Panel established under legal statute with powers to compel people to appear before it and to enter into the legal system and matters pertaining to the courts. The determination of civil liability in individual cases is a matter for adjudication of the courts. While the Panel was made aware that a number of legal cases may be pending in the courts, it was not made aware of any cases which had been heard and any judgements made.

The Panel concludes that the nature of the problem is manifested primarily by the disintegration of the concrete blocks used in the construction of the affected dwellings in Counties Donegal and Mayo which in turn results in a pattern of cracking in the external render of these dwellings. The affected dwellings are single storey, dormer and two storey in estates and one-off rural types and were constructed by contract and by self-build.

Based on information received, the Panel is of the opinion that the reason for the widespread pattern cracking in private dwellings in Counties Donegal and Mayo is primarily due to the excessive amount of deleterious materials in the aggregate used to manufacture the concrete blocks. The deleterious material in County Donegal was primarily muscovite mica while in County Mayo it was primarily reactive pyrite.

The problem was exacerbated by the severe exposure of many of these dwellings and the ingress of moisture into the concrete blocks which was possibly accelerated by the extreme weather conditions in winter 2009 / 2010 and late winter 2010.

In County Donegal the ingress of moisture into the concrete blocks, aided by the presence of more than normal amounts of muscovite mica, and the subsequent freeze thaw action which the concrete blocks were unable to withstand is likely to have led to the disintegration of the concrete blocks and the pattern of the associated render cracking.

In County Mayo the ingress of moisture possibly caused a chemical reaction with the reactive pyrite in the concrete blocks resulting in the expansion and disintegration of the blocks and the pattern of cracks in the associated render.

The Panel is satisfied that, while the render may have been less than satisfactory in some situations, no traditional render is 100% impervious, and it is likely that any traditional render would not have prevented the problems occurring.

The Panel is not in a position to accurately quantify the number of affected dwellings due to limited information made available to it. The Panel acknowledges the information provided by the Mica Action Group, the Mayo Pyrite Group, both local authorities and the relevant stakeholders. Chapter 4 of this report and its associated Tables 4.1 and 4.2 give the Panel's best assessment of the potential scale of the problem in both counties.

For County Donegal, the Panel estimates that the minimum potential number of private homes affected is likely to be approximately 1,200 dwellings. However, applying the experience of Donegal County Council regarding affected social housing units, the Panel estimates that there may be as much as 4,800 dwellings potentially affected.

For County Mayo, the Panel estimates that the minimum potential number of private dwellings likely to be affected is approximately 345 dwellings. Based on the information available, the Panel cannot be more definitive than this in their estimation.

The Panel suggests that the extractive and concrete products industry assess their onsite quality control measures to ensure full compliance with their legal obligations, relevant harmonised standards, that their products are always fit for purpose and suitable for the conditions in which they are to be used.

The Panel supports the provisions of S.I. No. 9 of 2014, which requires that the design and construction of buildings is verified during construction through the execution of an inspection plan overseen by a registered construction professional (the assigned certifier) that enables the builder and the assigned certifier to sign a statutory certificate of compliance on completion; this has led to improved compliance with the requirements of the Building Regulations. However, the Panel is concerned regarding the current level of enforcement of the Building Control Regulations and the Construction Products Regulation and recommends that these roles be strengthened significantly. The Panel also advocates that the opt-out provision for a new single dwelling as provided by S.I. No. 365 of 2015 be revoked.

It is clear to the Panel that the affected homeowners, through no fault of their own, are in a difficult position with very few, if any, realistic options available in order to obtain redress. Ultimately, the Panel's terms of reference aim to establish the facts, insofar as it is possible within the timeframe allowed, behind the problems that have emerged in Counties Donegal and Mayo and to outline technical options for addressing the problems identified in order to assist affected homeowners. These matters have been addressed in Chapters 2, 4 and 5 of this report.

In this regard, the Panel would like to thank everyone who provided engineering / laboratory reports to assist the Panel in its deliberations and to all those who met with it over the course of 2016. The Panel hope that this report will provide some assistance to affected homeowners and other interested parties in their efforts to bring a satisfactory resolution for all concerned.

6.2 Recommendations

The Panel's remit is one of a technical nature. In this regard, the recommendations contained below are listed in two broad categories: -

- (i) providing technical guidance to homeowners; and
- (ii) preventing the problem from recurring again.

6.2.1 Providing technical guidance to homeowners

The Panel makes the following recommendations aimed to provide technical guidance to homeowners.

6.2.1.1 Testing and categorisation of damage

The Panel noted from the technical reports provided, that the investigations into the issues was approached by professionals with varying degrees of consistency. Some reports diagnosed the problems based on a visual inspection, while others included various laboratory tests. The Panel is aware of the financial outlay many homeowners in Counties Donegal and Mayo have made to date through commissioning engineering / laboratory tests as they attempt to establish the cause of the defects.

In this regard, the Panel recommends that a simple standardised protocol to assess and categorise the damage and to establish the likely cause should be developed at the earliest opportunity. The protocol should include a suite of the minimum laboratory tests required to facilitate an informed judgement to be made by a competent professional regarding the appropriate remediation works to be applied.

Recommendation 1 – Testing and Categorisation Protocol
<p>The Panel recommends that: -</p> <p>a simple standardised protocol should be developed to -</p> <ul style="list-style-type: none">(a) assess and categorise the damage;(b) establish the extent of the problem;(c) identify the scope of any testing required; and(d) aid selection of an appropriate remedial solution. <p>Action: National Standards Authority of Ireland</p>

6.2.1.2 Competent Professional Oversight

Where homeowners are concerned that due to structural distress in their home there may be a risk to Health and Safety, the Panel recommends that advice be sought from a competent professional.

Where remediation works are proposed to an affected dwelling, the works should be designed and inspected by a competent registered professional. The competent professional should seek to be assured that all specified materials are fit for purpose and that all workmanship complies with relevant standards in order to facilitate certification of works. This will reduce the risk of building defects arising again.

Recommendation 2 - Competent Professional Oversight

The Panel recommends that:

- (a) the homeowners seek the advice of a competent professional where concerns regarding Health and Safety arise, and
- (b) the design and inspection of any proposed remedial works to affected dwellings be monitored by a competent professional.

Action: All affected parties

6.2.2 Preventing the problem from recurring again

While the recommendations contained within the following sections may reduce the number of incidents of defective products that may arise in the future from the extractive and concrete products industry, they do not resolve the current difficulties for the affected homeowners in Counties Donegal and Mayo.

6.2.2.1 Strengthen building control arrangements

The Panel views the introduction of the opt out for new single dwellings, on a single development, as provided for in the *Building Control (Amendment) (No. 2) Regulations 2015* (S.I. No. 365 of 2015) as a retrograde step that may contribute to further building failures such as those experienced in Counties Donegal and Mayo.

Recommendation 3 – Strengthen Building Control Arrangements

The Panel recommends that: -

the opt-out facility afforded to homeowners of a new single dwelling, on a single unit development as provided by the *Building Control (Amendment) (No. 2) Regulations 2015* (S.I. No. 365 of 2015) should be reviewed with a view to removing that provision.

Action: Department of Housing, Planning, Community and Local Government.

The Panel is in support of more independent meaningful on-site risk based inspections and enforcement by building control personnel which is required to ensure that greater compliance with the Building Regulations is secured as a necessary check and balance of the self-certification system. In this regard, building control authorities should be adequately resourced to facilitate increased inspection activity on the ground.

Recommendation 4 – Building Control Inspections

The Panel recommends that: -

the number of inspections by building control be increased to support greater compliance with the Building Regulations.

Action: Local authorities, County and City Management Association.

6.2.2.2 Strengthen market surveillance of construction products

While the manufacturers of construction products remain responsible for the declared performance of the products that they place on the market, the Panel is of the view that reactive market surveillance is not sufficient to guarantee consumer protection. In light of the problems with pyritic heave on the east coast of Ireland and now with the emergence of problems in concrete blocks in Counties Donegal and Mayo, there appears to be a significant amount of building defects arising from quarried materials. In this context, it is recognised that there needs to be a move towards proactive risk based market surveillance.

Recommendation 5 – Strengthen market surveillance of construction products

The Panel recommends that: -

market surveillance authorities be sufficiently resourced with dedicated units which would have, among other things, available expertise in the extractive and manufacturing sectors to provide more effective enforcement nationwide of construction products legislation.

Action: Department of Housing, Planning, Community and Local Government, local authorities.

6.2.2.3 Update relevant Technical Guidance Documents

The Panel notes that Technical Guidance Document C (2004 edition) is now 13 years old and it is considered timely to undertake a full review of requirements in relation to the exclusion of moisture in masonry walls in light of changes in standards, construction technology and practice over the intervening period.

Recommendation 6 – Review Part C of the Building Regulations

The Panel recommends that: -

a full review of Part C (Site Preparation and Resistance to Moisture) of the Building Regulations and the associated Technical Guidance Document C be undertaken.

Action: Department of Housing, Planning, Community and Local Government.

6.2.2.4 Competency scheme for construction skillsets and Industry awareness initiatives

During their site visits to Counties Donegal and Mayo, the Panel observed instances of deviation from standards and good practice in particular relating to external render specification and makeup. Given the critical importance of render in areas of severe exposure, there needs to be a focus on the competency of operatives engaged in the application of render and render systems.

In tandem with the recommended strengthening of market surveillance (see 6.2.2.2), manufacturers and their representative bodies have a lead role to play in ensuring that they have the knowledge and expertise necessary to ensure they meet their legal requirements under the Construction Products Regulation and their products will be fit for the purpose. Enhanced education and the provision of information by industry bodies is required to improve, maintain technical knowledge and awareness of their legal obligations under the Construction Products Regulation and the harmonised European standards thereunder.

Recommendation 7 – Minimum competency scheme for construction skillsets and Industry awareness initiatives

The Panel recommends that: -

- (a) a minimum competency scheme be established by industry to ensure best practice in external render application;
- (b) education and training in the form of detailed industry guidance, seminars etc. be developed in support of good practice in house construction and the correct specification of construction products.

Action: Solas, Construction Industry Federation, Irish Home Builders Association, Irish Concrete Federation.

6.2.2.5 Research

Over the course of the Panel's investigation, it was noted that while there appears to be a significant body of research available on the effects of muscovite mica and pyrite in concrete, further research should be undertaken to learn from legacy failures in the built environment and evaluate whether (or not) the findings from this research could lead to technical advancement of standards.

Recommendation 8 – Further Research

The Panel recommends that: -

due to legacy failures involving construction products, in spite of the current knowledge, further research should be undertaken to gain a greater understanding of the effects of pyrite and excessive amounts of muscovite mica in concrete blocks in order to avoid future adverse effects in buildings.

Action: Irish Centre for Research in Applied Geosciences (iCRAG)

Appendices

Appendix 1

List of persons / organisations who met with the Panel

1. Affected Homeowners (Donegal)
2. Affected Homeowners (Mayo)
3. Banking and Payments Federation Ireland
4. Construction Industry Federation / Irish Home Builders Association
5. Damian McKay, Consulting Engineer
6. Department of Housing, Planning, Community and Local Government
7. Donegal County Council (elected members)
8. Donegal County Council (officials)
9. Dr. Robbie Goodhue
10. Geological Survey of Ireland
11. HomeBond
12. Technical team on the problems in Donegal
13. Insurance Ireland
14. Irish Concrete Federation
15. Mayo County Council (elected members)
16. Mayo County Council (officials)

17. Met Éireann (Seamus Walsh)

18. National Standards Authority of Ireland

19. Public Representatives

20. Representatives from Mica Action Group

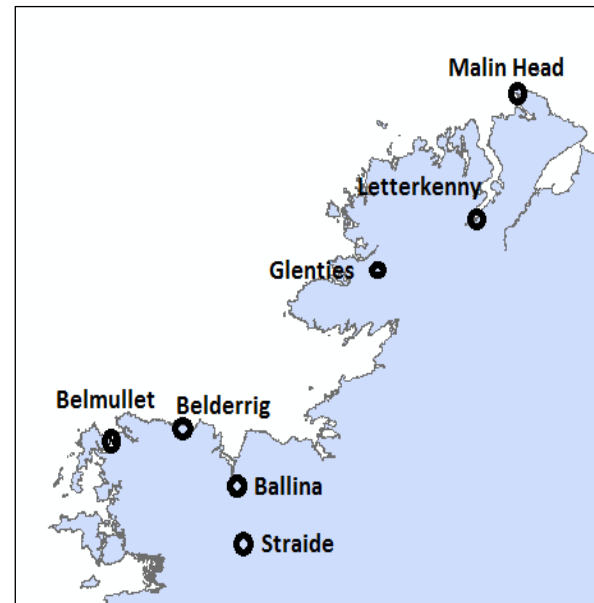
21. Representatives from Mayo Pyrite Group

Appendix 2

Reports from Met Eireann on the exceptional weather events of winter 2009/2010 and winter 2010.

Report on the weather conditions of November and December 2009, and January 2010, in the Inishowen area of north County Donegal and Belmullet are of northwest County Mayo

This report has been compiled using Met Éireann records from synoptic weather stations at Malin Head, Belmullet and Knock Airport, and a selection of climatological stations at Letterkenny and Glenties in County Donegal; and Ballina, Straide and Belderrig in County Mayo. Coastal areas are generally several degrees warmer than inland sites, and the differences can be even greater during severe cold spells, this is mentioned text and illustrated in the selection of station graphs in Appendix I.



1 Nature of Weather event

Atlantic depressions passing close to Ireland brought wet and windy conditions throughout almost all of November, continuing a pattern of very unsettled weather over Ireland that began in mid-October. Persistent and often heavy rain over this period led to unprecedented levels of flooding in parts of the west and south, as ground conditions became saturated. Rainfall totals for November were the highest on record at most stations, including the long-term station at Malin Head.

November and the early part of December was mild, there was a change to much colder conditions after mid-month, bringing severe frost and falls of snow in places. Mean air temperatures for the month were below normal everywhere, by around two degrees generally. The cold spell continued for the first 10 days of January 2010, after which temperature returned to near normal values.

2 Historical Context

Previous cold spells of similar depth and duration had occurred in 1947 and 1963, the return period is approximately 1 in 25-30 years for the cold spell. While nationally the rainfall of November was record breaking, in both the Inishowen and Belmullet areas rainfall was not as exceptional with return periods between 5 and 50 years.

3 Comparison with 2000's

The rainfall of November 2009 was exceptional, however it was exceeded by the rainfall totals of December 2015 which broke long term national records for monthly totals. The temperature in December 2009 and January 2010, with the exception of the months of November and December 2010 were 2-4 degrees below average temperatures in the 2000's

(See appendix I), and both these cold spells were significantly colder and of longer duration than any spell of cold weather since 2000.

4 Weather Diary: No of rain/wet days prior to cold spell, duration of cold spell.

The 2009/2010 cold spell lasted approximately 30 days from 12/13th December 2009 to 10/11th January 2010 (defined by first two consecutive days with minimum air temperature below zero to last two consecutive days with minimum air temperature below zero)

In November the number of raindays (>0.2 mm) was between 28 and 30 (Long term average 22-24 days), while the number of wet days (>1 mm day) was between 23 and 27 (Long term average 18-21 days), while the number of wet days in December prior to the commencement of the cold spell was 9-11 days.

5 Consecutive days with air temperature remained below zero

In the 2009/2010 cold spell there were only one or two isolated ice days at inland stations (days with max & minimum below zero)

6 Average range of daily temperature during the cold spell (see also appendix 1)

During the cold spell maximum temperature ranged 2-5 degrees Celsius (higher at the start, 6-9 degrees), minimum temperatures mostly between -2 and -6 degrees Celsius, but colder between 23 to 27 December and 7 to 10 January (-7 to -11). Inland areas were significantly colder .

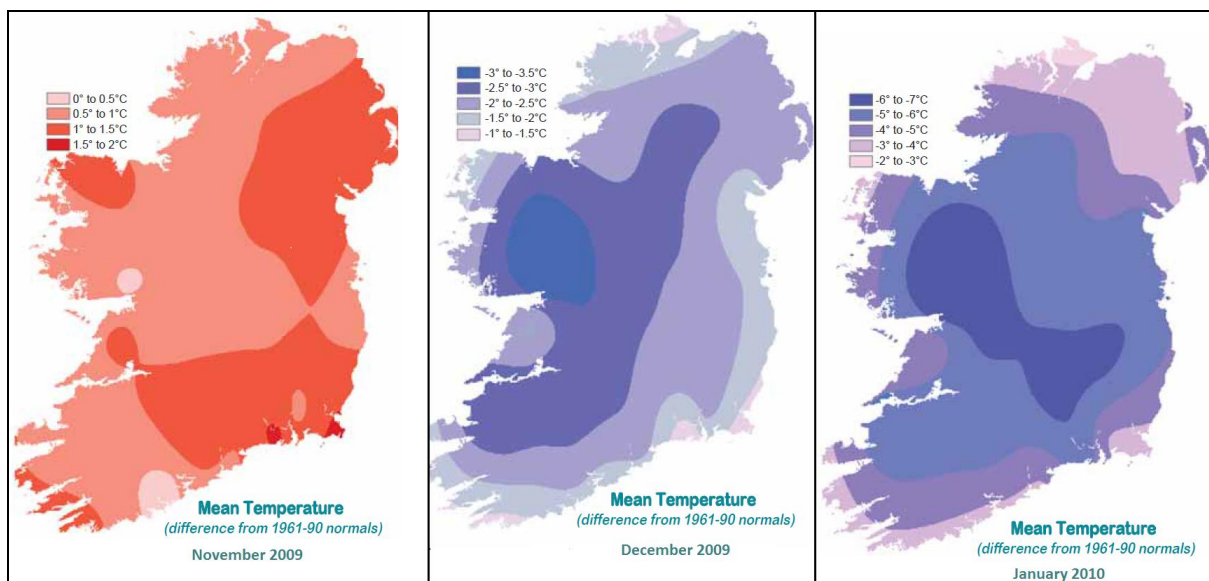
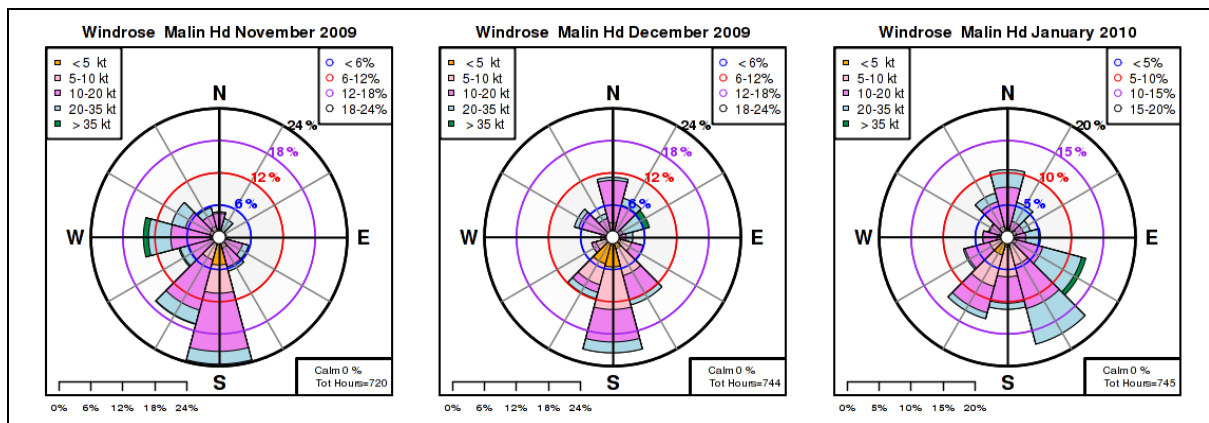
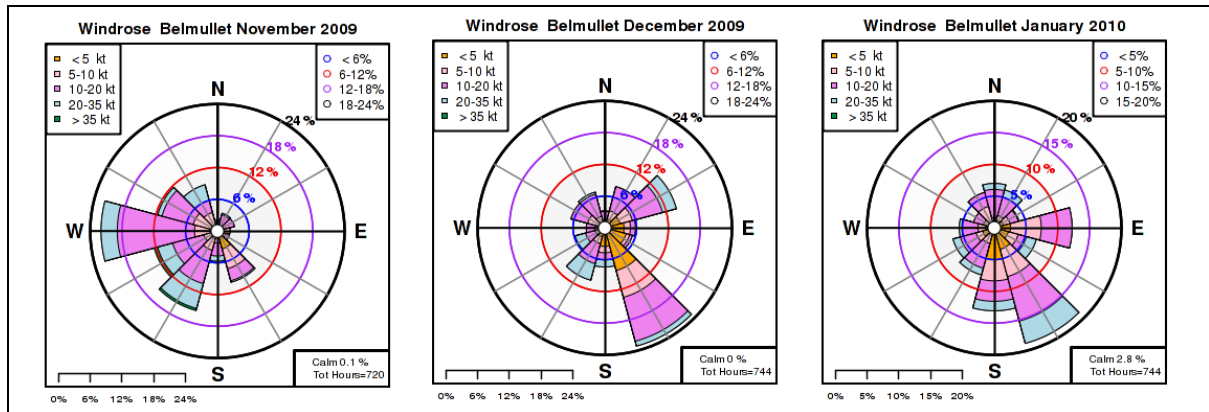
7 Maximum temperature range in one day

The daily range of temperature (maximum minus minimum) ranged between 2 and 12 degrees Celsius, but mostly was between 4 and 8 degrees. The maximum range occurred on 14th December 2009 at 13 or 14 degrees Celsius in both locations.

8 Mean daily temperature departure from average temperatures in the 2000's

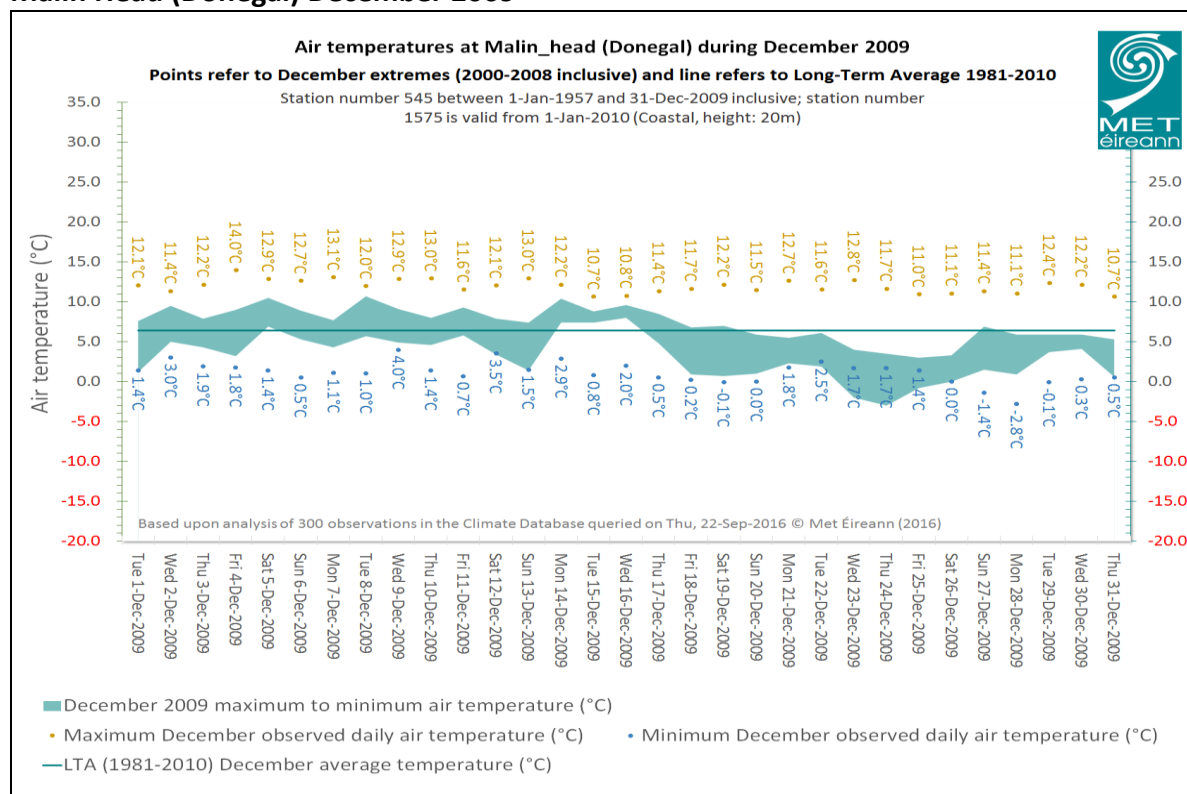
In November the mean daily temperatures were close to average temperatures in the 2000's, in December temperatures inland were 2-3 degrees Celsius below average, in January 2010 temperatures were 2-4 degrees below average temperatures. (See also Appendix I)

9 Wind roses, temperature maps for November and December 2009 and January 2010

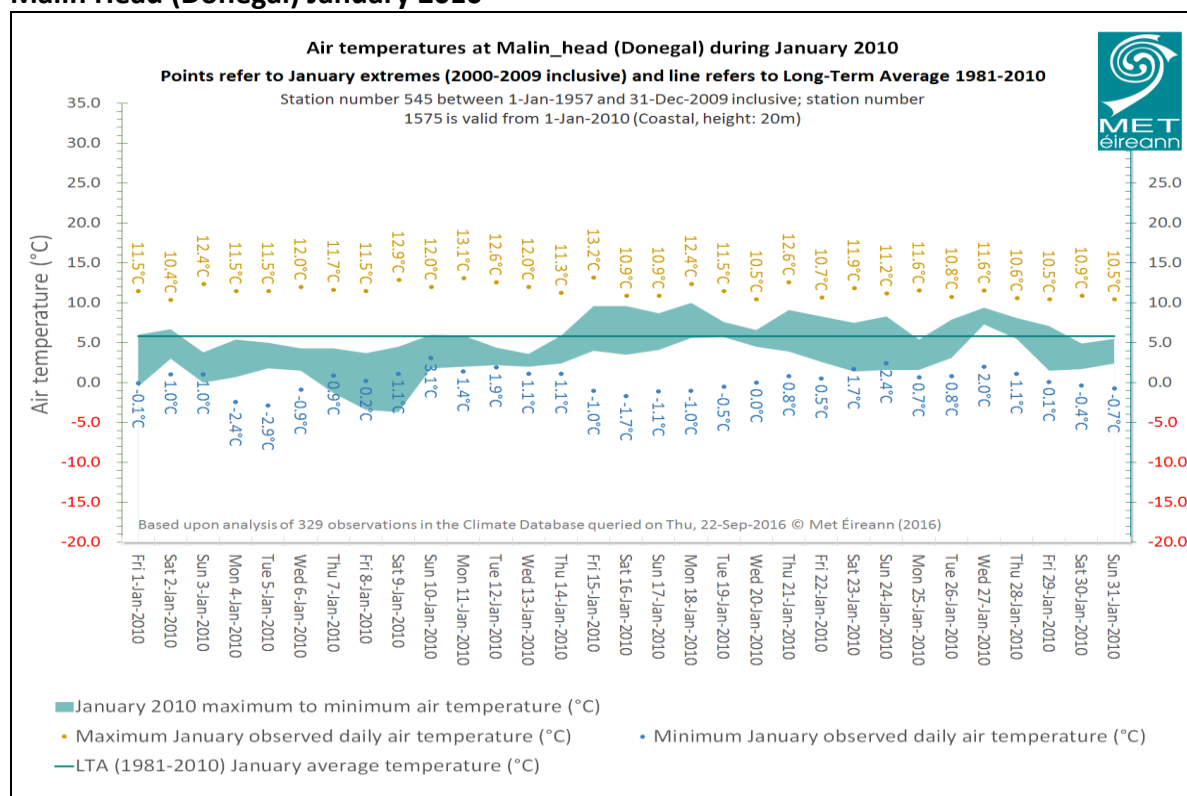


Appendix I Plots of Station Temperature Data December 2009 and January 2010

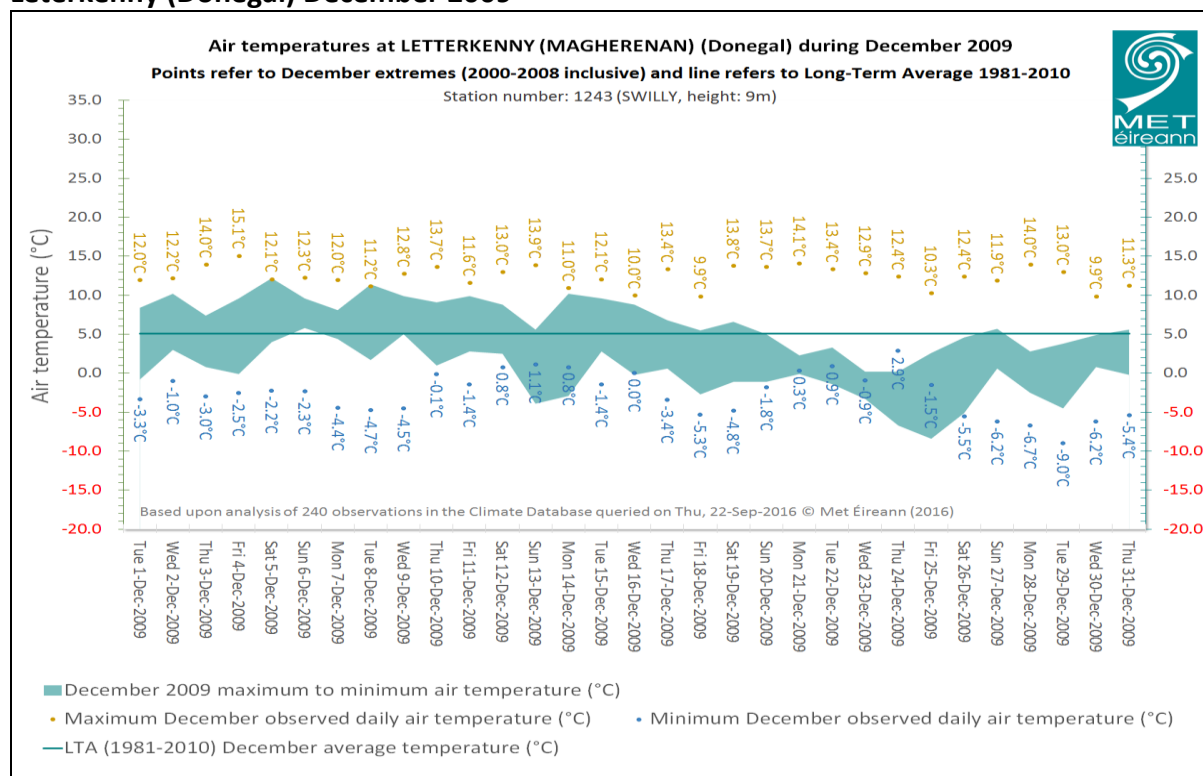
Malin Head (Donegal) December 2009



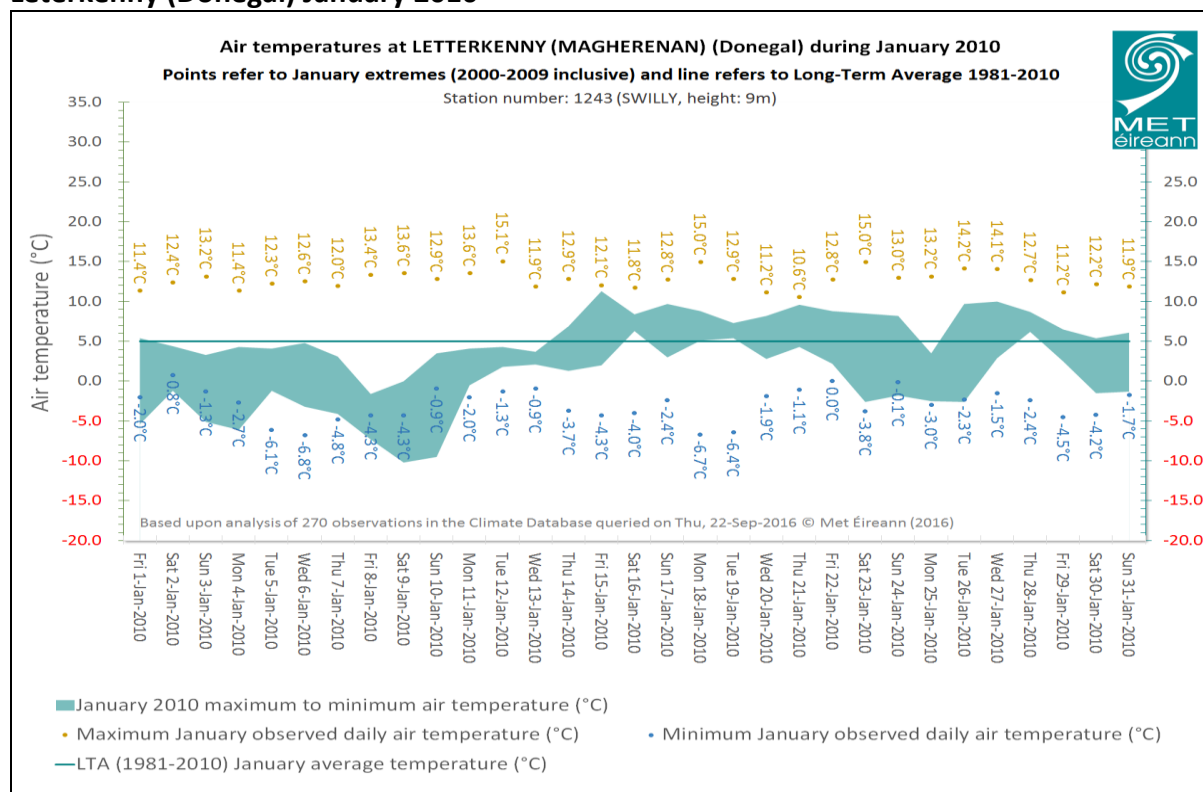
Malin Head (Donegal) January 2010



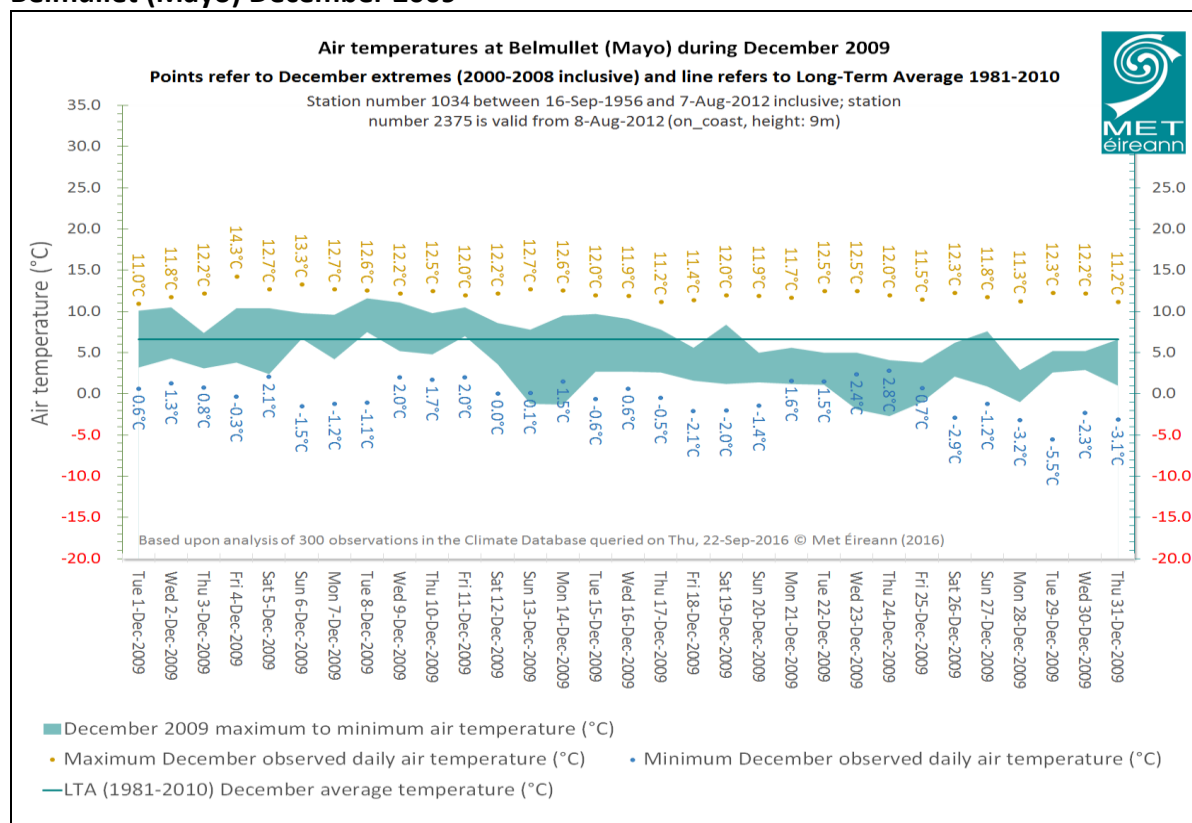
Leterkenny (Donegal) December 2009



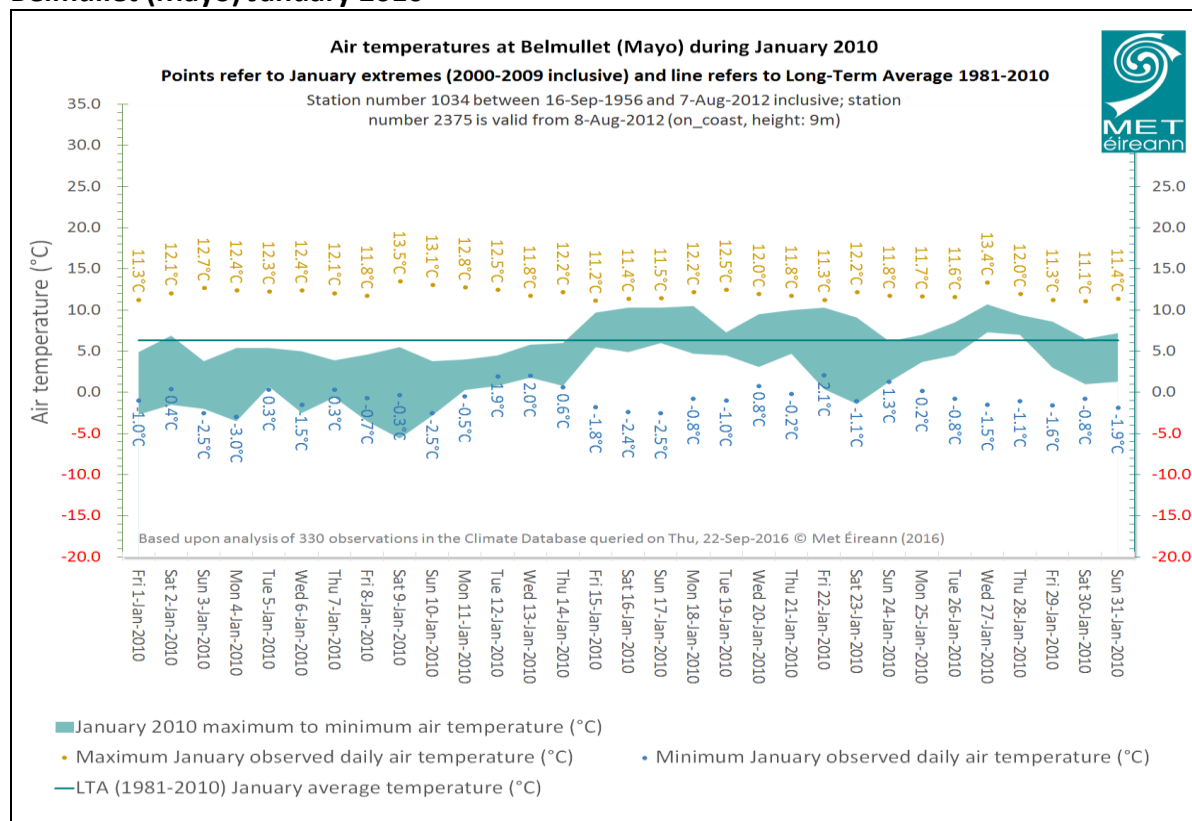
Leterkenny (Donegal) January 2010



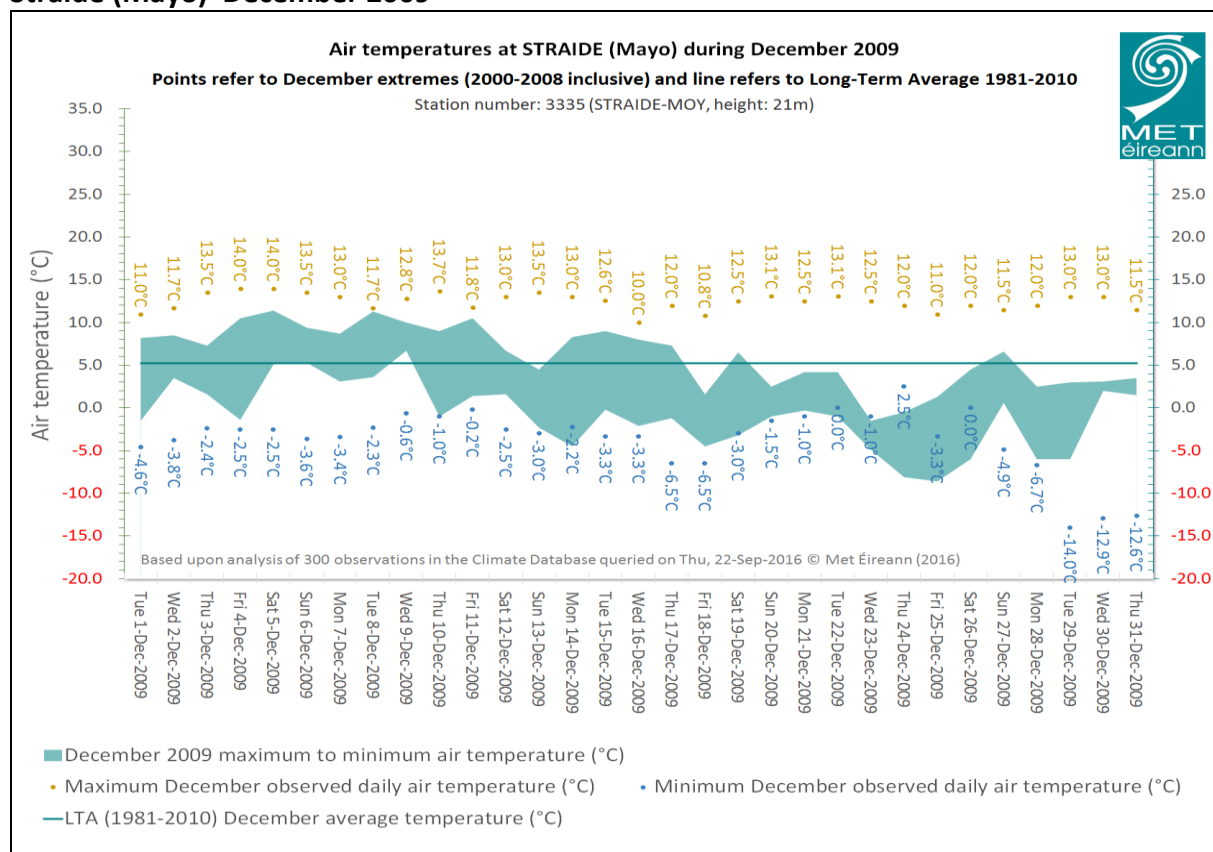
Belmullet (Mayo) December 2009



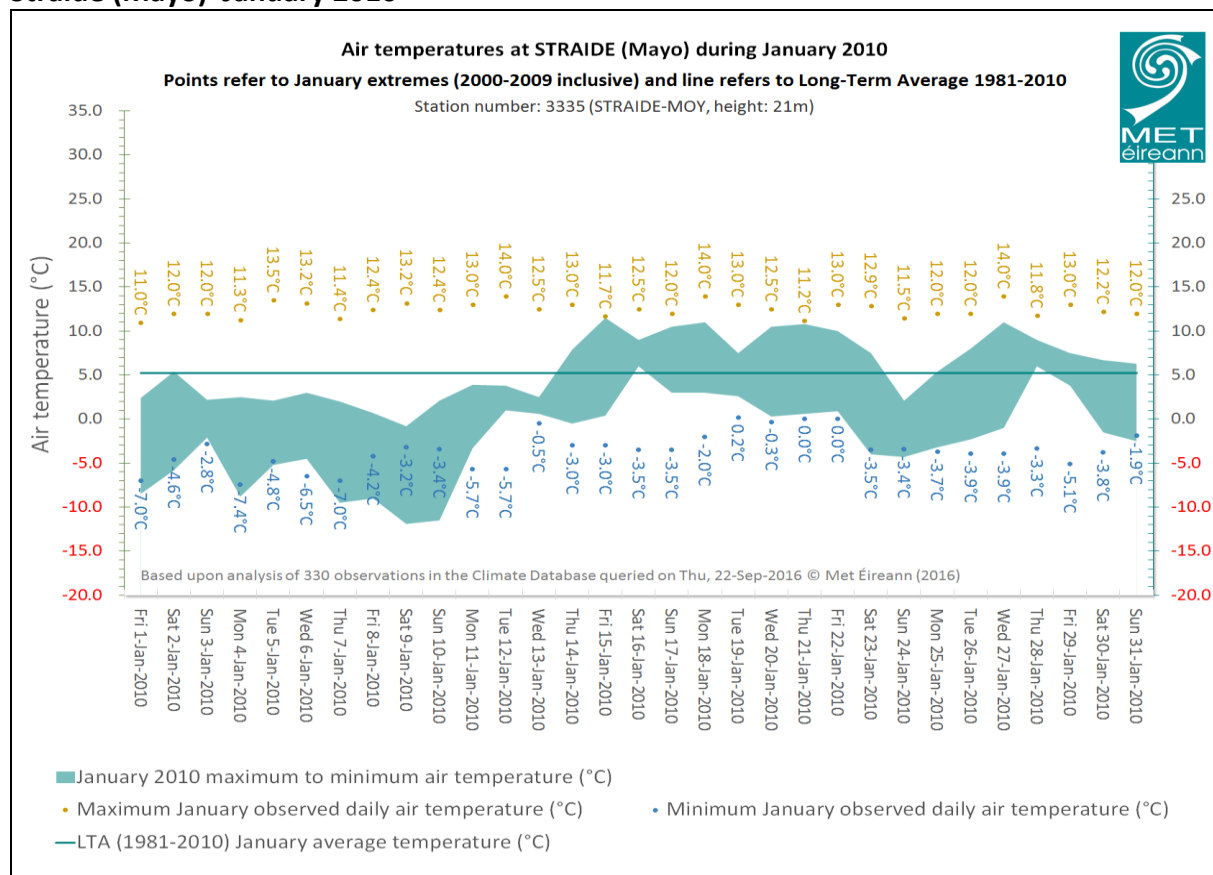
Belmullet (Mayo) January 2010



Straide (Mayo) December 2009

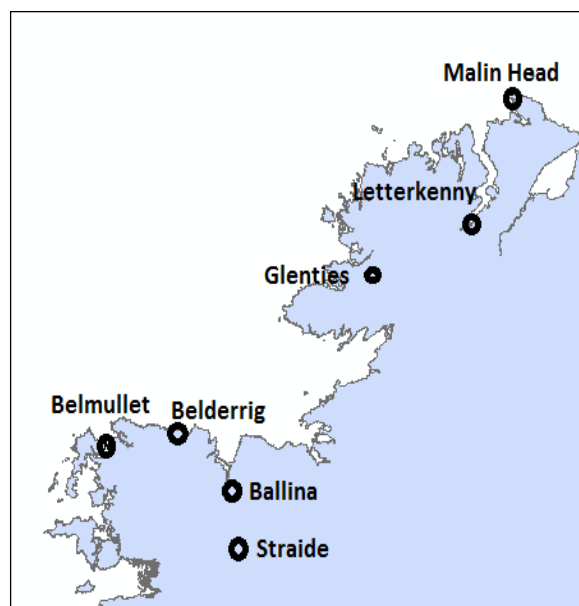


Straide (Mayo) January 2010



Report on the weather conditions of November and December 2010 in the Inishowen area of north County Donegal and Belmullet area of northwest County Mayo

This report has been compiled using Met Éireann records from synoptic weather stations at Malin Head, Belmullet and Knock Airport, and a selection of climatological stations at Letterkenny and Glenties in County Donegal; and Ballina, Straide and Belderrig in County Mayo. Coastal areas are generally several degrees warmer than inland sites, and the differences can be even greater during severe cold spells, this is mentioned text and illustrated in the selection of station graphs in Appendix I.



1 Nature of Weather event

November

Mild, wet and windy weather during the first half of November was followed by a spell of drier but colder conditions, while the last few days of the month were extremely cold with widespread snowfall. At most stations it was the coldest November since 1985, due largely to exceptionally low temperatures between the 28th and 30th. Air temperatures fell below -6°C in many places on the 28th and 29th, with new temperature records for November set at a number of stations. The very cold period at the end of the month produced widespread wintry showers, but the heaviest falls of rain were recorded earlier in the month.

December

Spells of exceptionally cold weather during December brought some of the lowest temperatures ever recorded in Ireland, together with heavy snowfalls in places. There were also short periods of milder weather, while overall the month was drier and sunnier than normal. Mean air temperatures for the month were up to six degrees lower than normal in places and it was the coldest December on record almost everywhere. It was also the coldest of any month on record at some stations. The lowest December air temperature ever measured in the country, -17.5°C , was recorded at Straide, Co. Mayo, on the 25th.

2 Historical Context

Previous cold spells of similar depth and duration had occurred in 1947 and 1963 and 2009/10, the return period is approximately 1 in 25-30 years for the cold spell. However for the depth of cold experienced the return periods are probably greater, at least 1 in 50 years.

3 Comparison with 2000's

The cold spell was exceptional for the depth of cold experienced, in duration it was similar in length to the cold spell of late 2009/2010, and both these cold spells were significantly colder and of longer duration than any spell of cold weather since 2000. There was a significant difference between coastal regions and inland (much colder), which was also dependent on wind direction.

4 Weather Diary: No of rain days, duration of cold spell.

The November/December 2010 cold spell lasted approximately 35 days from 20th November to 25/26th December 2010 (defined by first two consecutive days with minimum air temperature below zero to last two consecutive days with minimum air temperature below zero). During this period minimum air temperature were mostly below zero, but there were with occasional days, or consecutive days, with minimum air temperature above zero, coastal stations had significantly less days with air frost.

For the most part the number of raindays in November was between 22 and 25 (Long term average 22-24 days), while the number of wet days (>1mm day) was between 18 and 22 (Long term average 18-21 days).

5 Consecutive days with air temperature remained below zero

In the late 2010 cold spell, the number of ice days (days when maximum air temperature is below zero) recorded varied from zero at coastal location (Belmullet, Malin Head), with 3-5 at other locations including some close to the coast, the maximum number of consecutive days ice days was 7 at Straide in Co Mayo

6 Average range of daily temperature during the cold spell

The range varied considerable, but was mostly between 5 and 9 degrees Celsius, however at the end of cold spell 25/26th December daily ranges of 15-20 degrees Celsius were recorded inland.

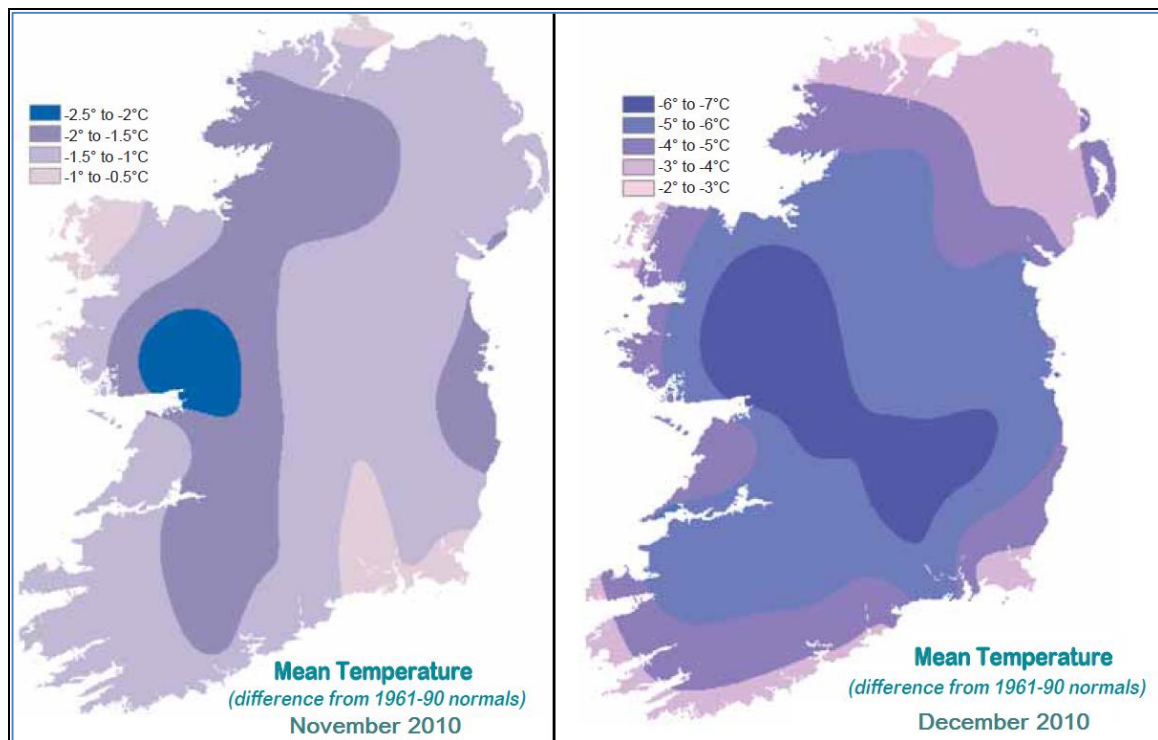
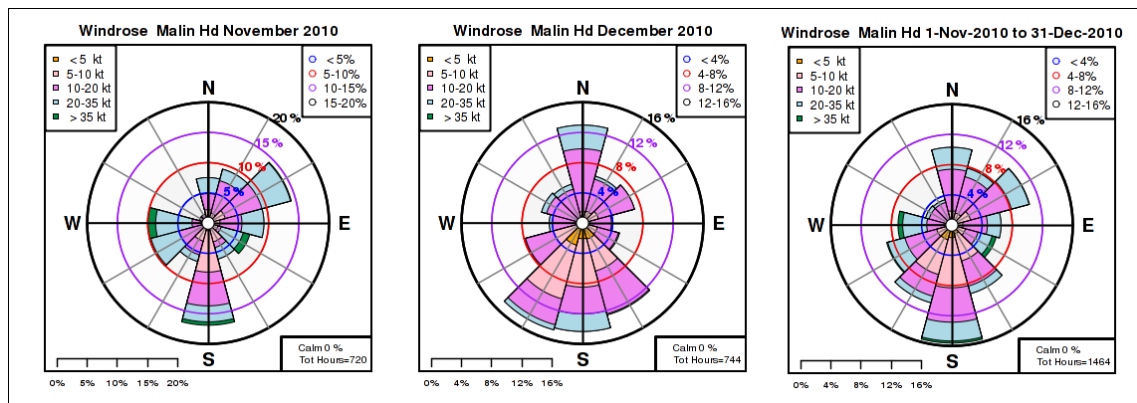
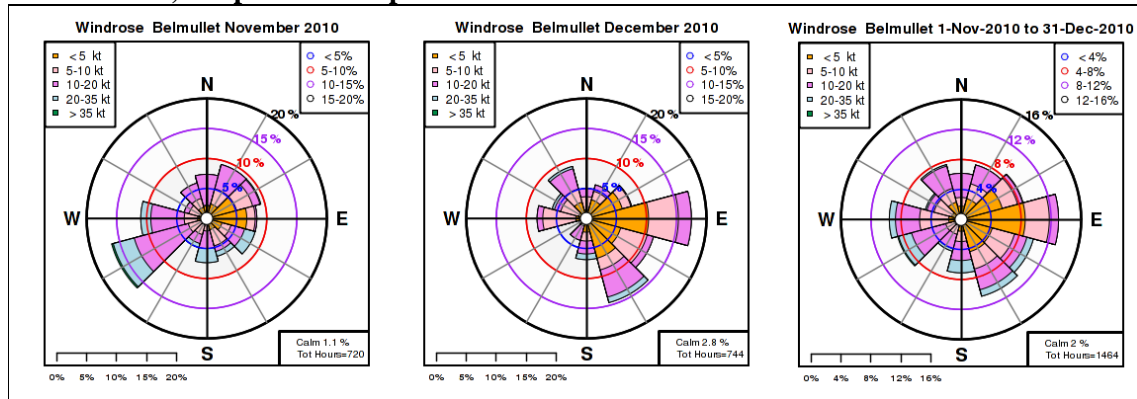
7 Maximum temperature range in one day

The maximum daily range in Co Mayo was 20 degrees on December 26th

8 Mean daily temperature departure from average temperatures in the 2000's

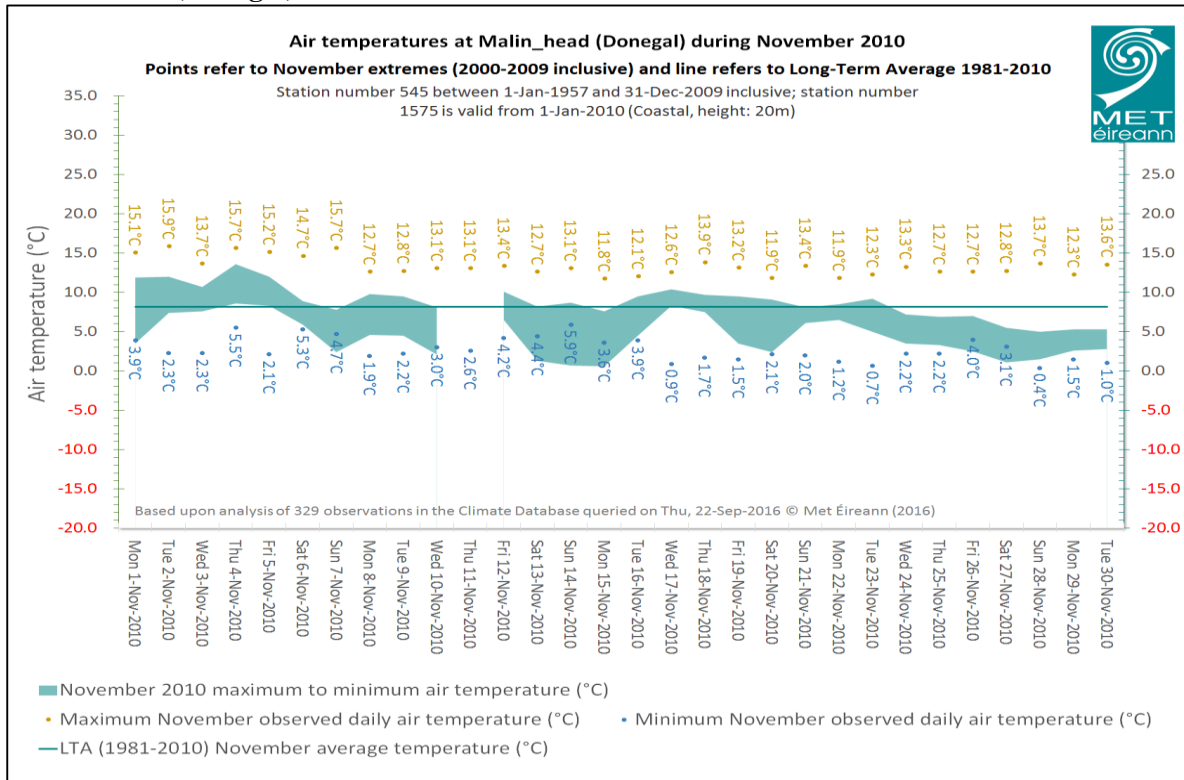
In November 2010 the mean daily temperatures were 1.5 to 3 degrees Celsius below average temperatures in the 2000's, with milder values close to the coast. In December temperatures inland were 4-6 degrees Celsius below average, and 2-4 degrees below average nearer the coast. (See also Appendix I)

9 Wind roses, temperature maps

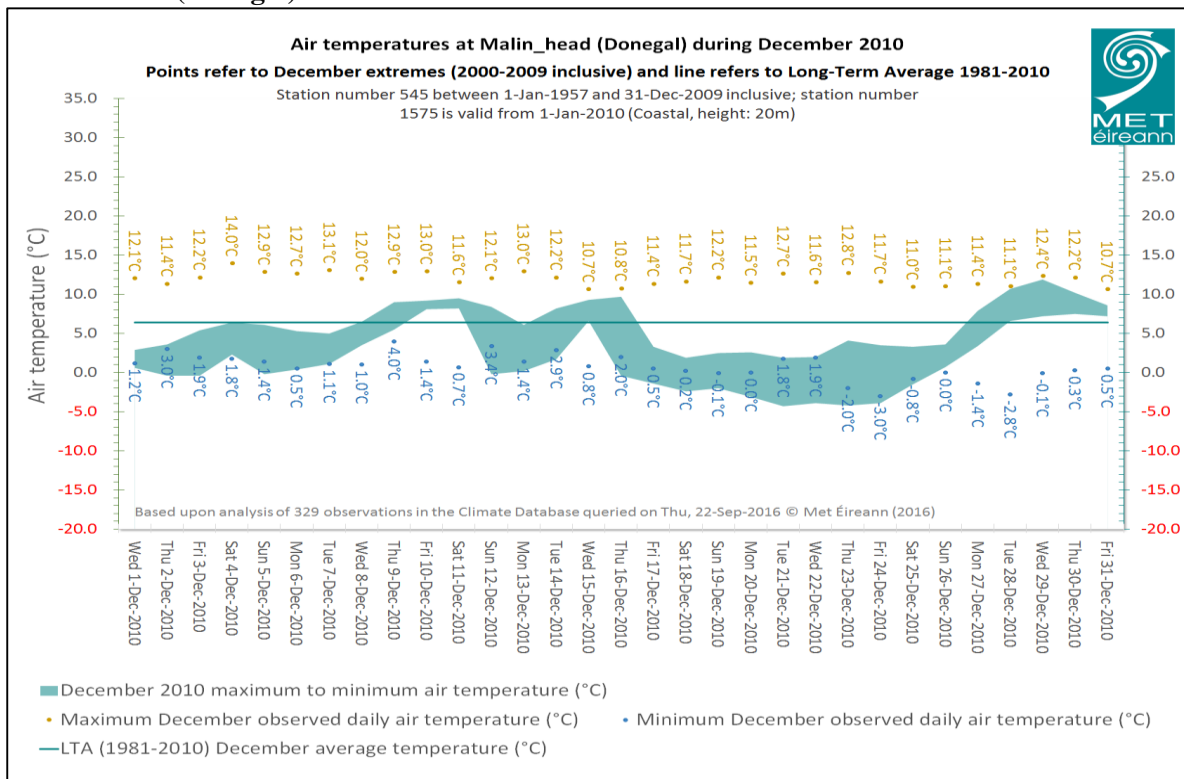


Appendix I Plots of Station Temperature Data for November and December 2010

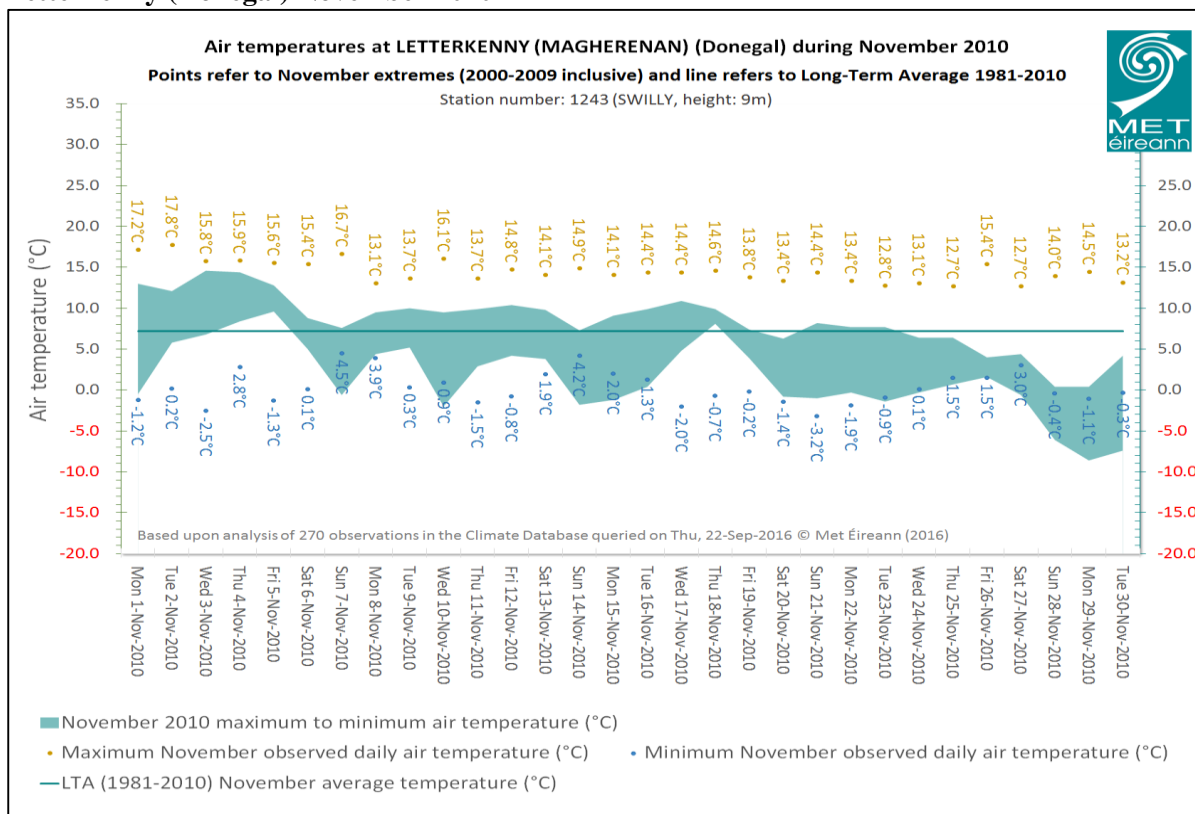
Malin Head (Donegal) November 2010



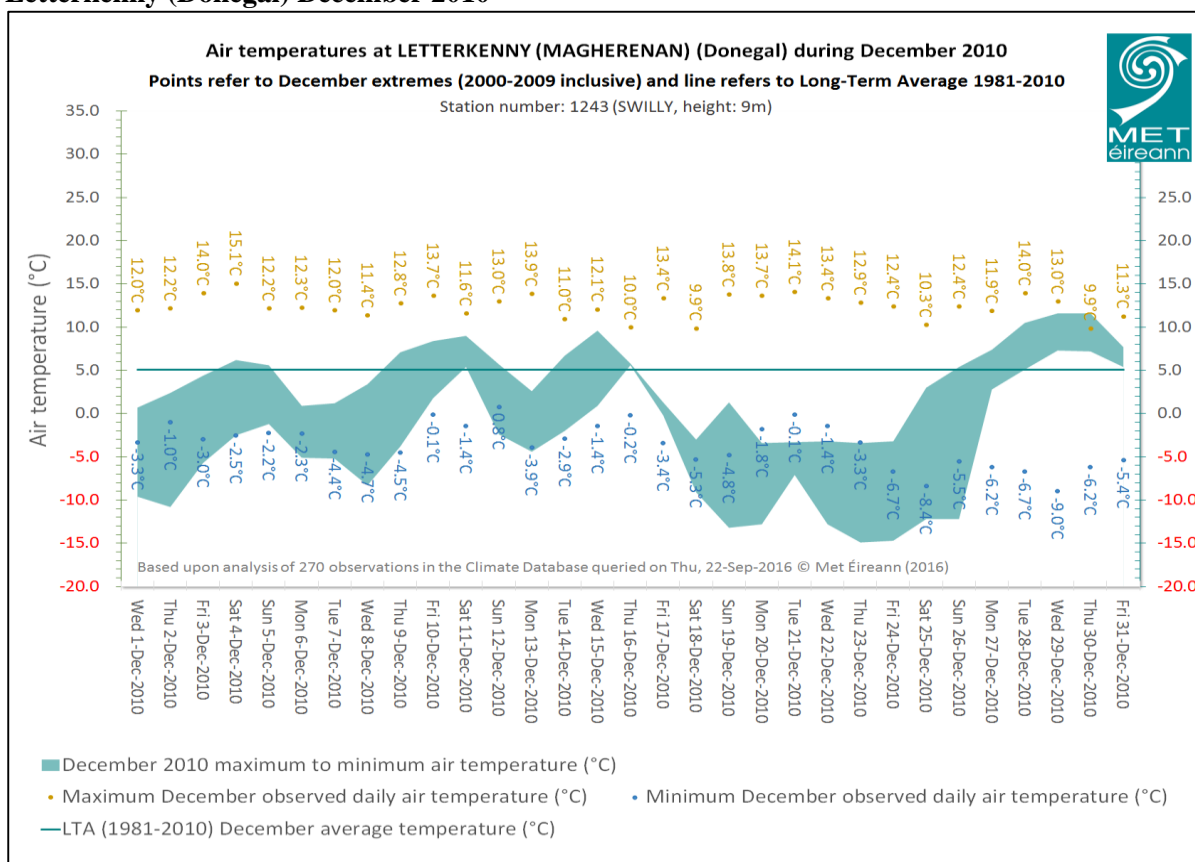
Malin Head (Donegal) December 2010



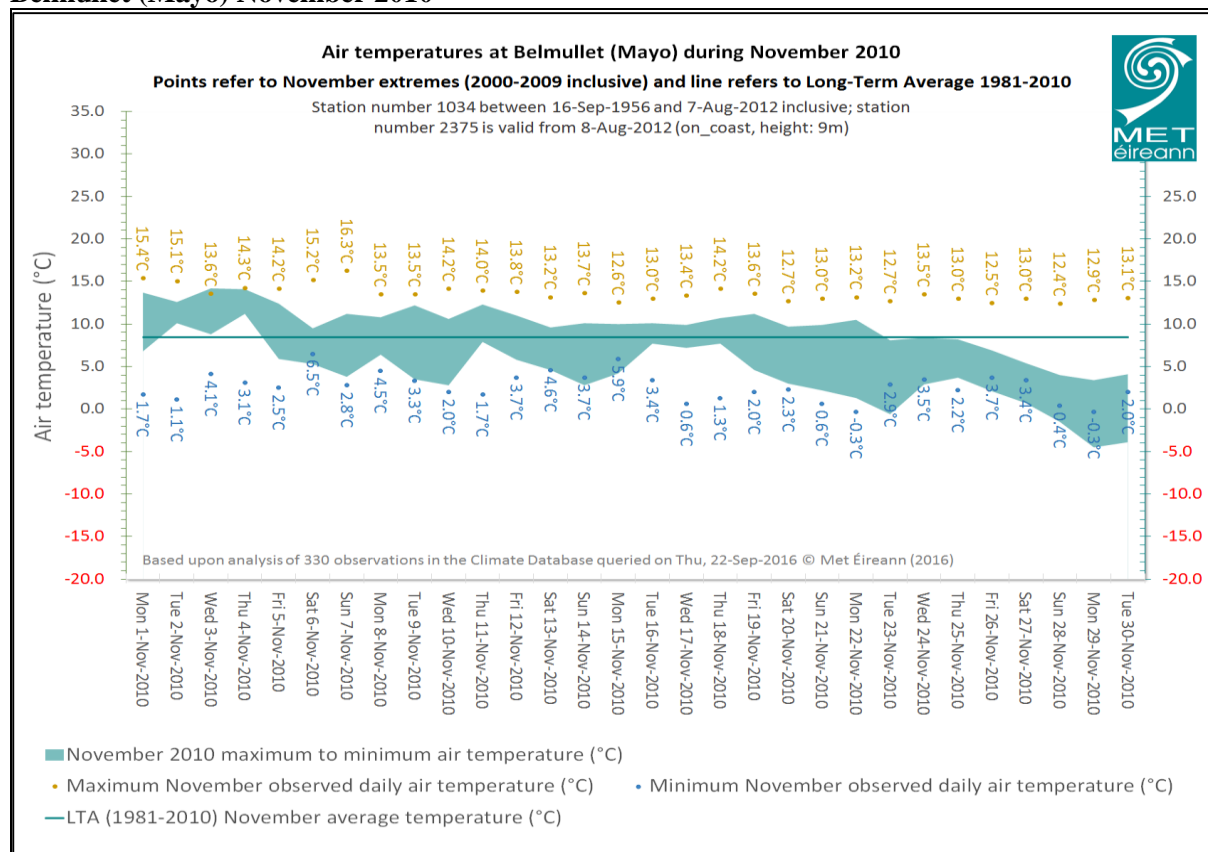
Letterkenny (Donegal) November 2010



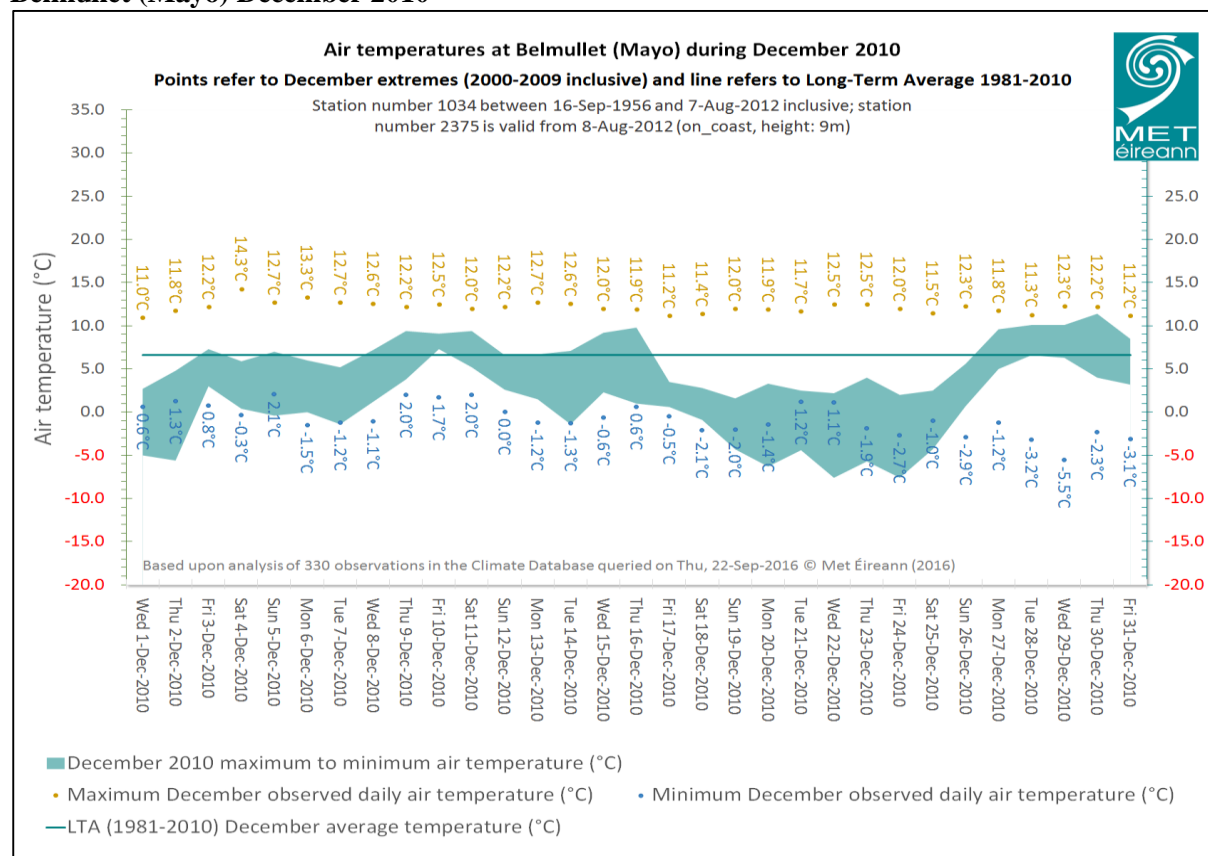
Letterkenny (Donegal) December 2010



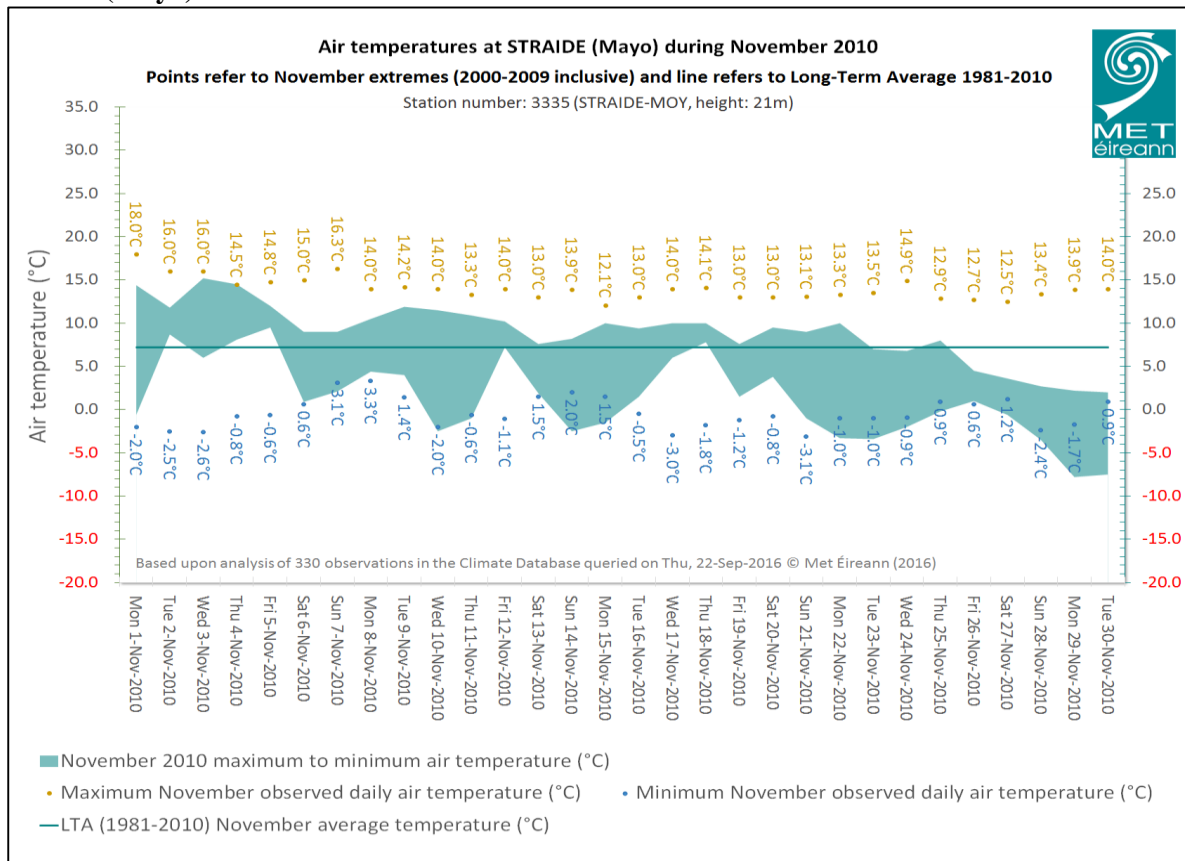
Belmullet (Mayo) November 2010



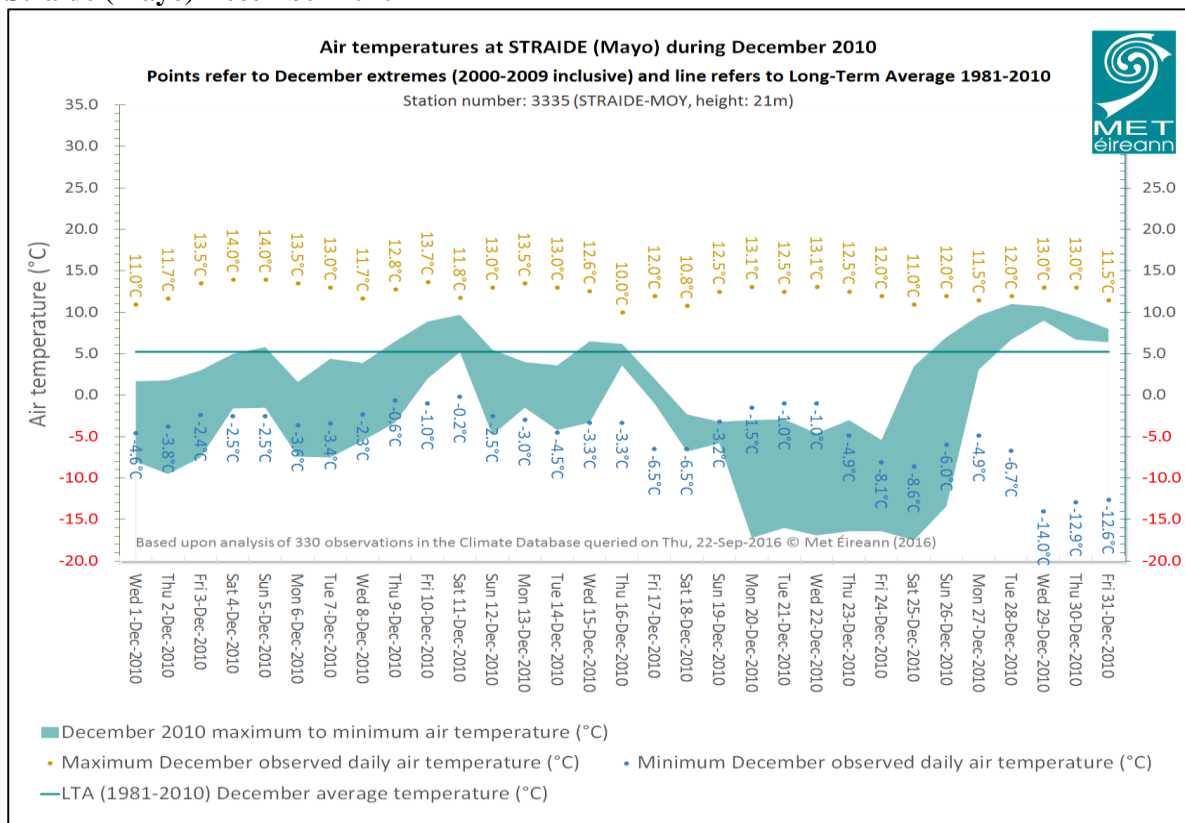
Belmullet (Mayo) December 2010



Straide (Mayo) November 2010



Straide (Mayo) December 2010



Appendix 3

Summary of the Requirements under Parts A, C and D of the Building Regulations.

Table A.1 Building Regulations Requirements and relevant TGD provisions

Part A – Structure (1991 to 2012)

Loading.

- A1** (1) A building shall be so designed and constructed that the combined dead, imposed and wind loads are sustained and transmitted to the ground –
- (a) safely, and
 - (b) without causing such deflection or deformation of any part of the building, or such movement of the ground, as will impair the stability of any part of another building.

TGD A 1991

Section C21 of TGD A states *“walls should be properly bonded and solidly put together with mortar and constructed of :.....(c).....normal density blocks to I.S. 20: 1987 Part 1....”*

Section 2 states: *“The following Codes, Standards and References are appropriate for all buildings, and when applied in accordance with the conditions specified below, may be used to meet Requirements A1 and A2.....The design and construction of a structure is in accordance with the relevant recommendations of the codes of practice and, Standards.....”*

....STRUCTURAL WORK OF MASONRY

I.S. 325 :Part 1: 1986

BS 5628: Part 3: 1985....”

TGD A 1997

Section 1.1.3.2 of TGD A states *“All walls should comply with the relevant requirements of I.S. 325:Part 2: 1995 ...”*

Section 1.1.3.5 of TGD A specifies the materials used and the minimum designations, strengths and other qualities. Solid concrete blocks *“Should have a thickness required by par. 1.1.3.4 and conform to the requirements of designation S5 in accordance with I.S. 20: 1987 Concrete Building Blocks Part 1: Normal Density Blocks.....”*

Structural work of masonry

I.S. 325 Part 1: 1986

I.S. 325 Part 2: 1995

BS 5628: Part 2: 1985...”

Part C – Site Preparation and Resistance to Moisture (1991 to present)

Resistance to weather and ground moisture

C4 The floors, walls and roof of a building shall be so designed and constructed as to prevent the passage of moisture to the inside of the building or damage to the fabric of the building.

TGD C 1991	TGD C 1997	TGD C 2004
<p>Sub-section 3.2 states:</p> <p>“WALLS</p> <p>3.2.1 All walls should:</p> <p>(a) prevent moisture from the ground from reaching the inside of the building (see Diagram 9), and</p> <p>(b) not be damaged by moisture from the ground, and</p> <p>(c) not carry moisture from the ground to any part of the building which would be damaged by it.</p> <p>3.2.2 External walls, in addition to meeting the requirements of 3.2.1, should:</p> <p>(a) resist the penetration of rain or snow to the inside of the building, and</p> <p>(b) not be damaged by rain or snow, and</p> <p>(c) not carry rain or snow to any part which would be damaged by it.....</p>	<p>Sub-section 3.2 states:</p> <p>“WALLS</p> <p>3.2.2 All walls should:</p> <p>(a) prevent moisture from the ground from reaching the inside of the building (see Diagram 8), and</p> <p>(b) not be damaged by moisture from the ground, and</p> <p>(c) not carry moisture from the ground to any part of the building which would be damaged by it.</p> <p>3.2.3 External walls, in addition to meeting the requirements of 3.2.1, should:</p> <p>(a) resist the penetration of rain or snow to the inside of the building, and</p> <p>(b) not be damaged by rain or snow, and</p> <p>(c) not carry rain or snow to any part which would be damaged by it.....</p>	<p>Sub-section 3.2 states:</p> <p>“WALLS</p> <p>3.2.1 All walls should:</p> <p>(a) prevent moisture from the ground from reaching the inside of the building (see Diagram 8), and</p> <p>(b) not be damaged by moisture from the ground, and</p> <p>(c) not carry moisture from the ground to any part of the building which would be damaged by it.</p> <p>3.2.2 External walls, in addition to meeting the requirements of 3.2.1, should:</p> <p>(a) resist the penetration of rain or snow to the inside of the building, and</p> <p>(b) not be damaged by rain or snow, and</p> <p>(c) not carry rain or snow to any part which would be damaged by it.....</p>

<p>MOISTURE FROM OUTSIDE (EXTERNAL WALLS)</p> <p>3.2.5 IS 325: Part 1: 1986 Use of Masonry, Part 1, Structural Use of Unreinforced Masonry covers recommendations for the structural design of unreinforced masonry constructed of normal density blocks and bricks.</p> <p>BS 5628 Code of Practice for the use of masonry, Part 3: 1985 Materials and components, design and workmanship contains recommendations for design and execution of brick and block masonry.</p> <p>.....</p> <p>BS 5262: 1976 Code of Practice for external rendered finishes includes recommendations on rendering on all common types of old or new backgrounds</p>	<p>Standards and other references</p> <p>IS 325: Part 1: 1986 Use of Masonry, Part 1. Structural Use of Unreinforced Masonry; Amd No1: 1998; Amd No2: 1992</p> <p>BS 5262: 1991 Code of practice for external renderings</p> <p>BS 5628 code of practice for use of masonry Part 3: 1985 Materials and components, design and workmanship AMD 4974</p>	
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Part D – Materials and Workmanship (1991 to present)

Materials and Workmanship

D1 All works to which these Regulations apply shall be carried out with proper materials and in a workmanlike manner.

Definition for this Part

D2 In this Part, “proper materials” means materials which are fit for the use for which they are intended and for the conditions in which they are to be used.....”

Appendix 4

Letter from the National Standards Authority of Ireland.

01/12/2016

Paris Beausang
Secretary to Expert Panel
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Dear Paris

Re - Expert Panel to investigate the problems that have emerged in the blockwork of certain dwellings in Donegal and Mayo

Request for clarification from NSAI, dated 20 October 2016

Further to your letter of 20 October 2016 to Maurice Buckley, CEO, NSAI and NSAI's subsequent attendance at a meeting of the Expert Panel on 7th November 2016, NSAI has consulted further with the panel of experts currently revising guidance to I.S. EN 12620 *Aggregates for concrete*, and consisting of Members of the NSAI Aggregates Panel and Concrete Standards Consultative Committee, in relation to the assertion that:

'As far back as 1949 Statutory Instruments for blocks and aggregate, listed mica as a harmful impurity and said that the quantity of such impurities in coarse aggregate shall not exceed 1%. Later standards no longer specify that 1% maximum'.

The assertion implies the 1% limit is on the quantity of mica or other harmful impurities in the sample.

Following from our consultation we confirm that NSAI has the following understanding of the requirements.

1. S.I. No. 288 of 1949 (I.S 20) part II, 3 (a) limits harmful impurities to 1% in coarse aggregate passing a No. 200 sieve, according to the test method specified in Annex A *Determination of amount of material passing a No. 200 Test sieve*.

This test is a quantitative wet sieve analysis test which measures the total quantity of material passing a No. 200 sieve.

2. The limit of 1% in coarse aggregate passing the No.200 sieve according to Annex A is not a limitation on the quantity of any particular material in the total sample.

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3. The limit of 1% coarse aggregate passing the No 200 sieve applies to the fraction or quantity of any material passing the No.200 sieve.
4. As the limit of 1% does not apply to the total mica quantity in the sample, the statement that "later standards no longer specify that 1% maximum" is irrelevant.
5. It has been brought to our attention that there is ambiguity surrounding the interchangeability, or not, of the terms harmful impurities and harmful materials in the context of the requirements in S.I. No. 288 of 1949 (I.S 20) part II, 3 (a).

S.I. No. 288 of 1949 (I.S 20) part II, 3 (a) refers to harmful materials and harmful impurities in aggregates, under the heading of "Harmful impurities".

This wording is ambiguous, and may be interpreted differently.

However, we are satisfied that whilst the ambiguity has been highlighted, it does not affect statements 1 – 4 above.

We trust the above clarifies our position but should the Expert Panel have further queries, we would be glad to assist.

Finally we would appreciate the opportunity to comment on content of the draft report pertinent to NSAI, prior to its publication.

Yours sincerely

Yvonne Wylde

cc M Byrne, Chair NSAI Aggregates Panel

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Appendix 5

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