The Financial Sustainability

Of

Passive House Construction

In Ireland

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The substance of this thesis is the original work of the author and due reference and acknowledgement has been made, when necessary, to the work of others. No part of this thesis has been accepted for any degree and is not concurrently submitted for any other award. I declare that this thesis is my original work except where otherwise stated.

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Abstract

In Ireland the average energy cost for a household in 2006 was estimated to be €1,767, an increase of 4% on 2005 figures. With the state of the current economic climate, home owners are beginning to realise the potential of energy efficient construction methods. The Passive House Standard offers a cost efficient and sustainable construction solution compared to the Traditional Irish construction methods.

This report focuses on the Cost comparison between Passive House construction and traditional construction methods. The report also focuses on barriers that are slowing market penetration of the Passive House standard in the Irish Market. It also identifies potential energy savings that passive house occupants would benefit from. The report also highlights professional opinions on the future development of the Passive House Standard in Ireland.

The conclusions of this report are that the Passive House Standard is a more financially suitable construction solution compared to that of a traditional dwelling complying with the Irish Building Regulations. The report also concludes that the Passive House Standard won't be introduced as an Irish Building Regulation in the future but that it will have a big impact on future building regulations. The hypothesis of this report is supported by data obtained from a literature review, qualitative data analysis and a case study.

The report recommends that in order for the Passive House Standard to penetrate further into the Irish construction market, various barriers must be rectified. Local manufactures must start producing suitable components that suit the Passive House specification. The Building Energy Rating system must be altered in order for the Passive House to achieve its potential BER rating.

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Abbreviations

SEAI	Sustainable Energy Authority of Ireland
PH	Passive House
PHI	Passivhaus Institut
RIA	Regulatory Impact Analysis

List of Figures

List of Tables

Table of Contents

Chapter 1

Introduction

Chapter 1 Introduction

1.1 Background to research

With climate change becoming a major concern worldwide due to global warming and increases in greenhouse gas emissions, the construction industry has seen a major shift towards more energy efficient and sustainable construction methods and solutions. Sustainable development is becoming a major area all over the world due to the Kyoto Protocol being entered into force on 16 February 2005. 184 Parties of the Convention have ratified its Protocol to date. The protocol recognises that developed countries are principally responsible for the current high levels of GHG emissions in the atmosphere as a result of more than 150 years of industrial activity. As a result the Protocol places a heavier burden on developed nations under the principle of "common but differentiated responsibilities."

As a result of this protocol member states have the responsibility to reduce their GHG emissions by 5% on 1990 levels by 2012 and 20% by 2020. Branched from this legislation, the Sustainable Energy Authority Ireland (SEAI) was set up in Ireland in 2002 by the government to promote and assist the development of sustainable energy which will help contribute to reducing GHG emissions.

In results attained from SEAI's report on Energy in the Residential Sector 2008, they state that the residential sector in 2006 used 2,990 ktoe of final energy. This represents 23% of Irelands Total Final Consumption (TFC) and is a 32% increase (1.8% per annum) on 1990(O'Leary et al, 2008).

It can also be seen that the residential sector in 2006 was second to the transport sector which accounted 35% of total energy use. It is also stated by SEAI that the average dwelling was responsible for emitting approximately 8.1 tonnes of CO2, 59% of which was from direct fuel use, with the remainder being from electricity usage.

The average energy cost for a household in 2006 was estimated to be €1,767, an increase of 4% on 2005 figures. From June 2002 to January 2008, the cost of electricity doubled in price, kerosene rose by 78% and natural gas increased by 87% (O'Leary et al, 2008).

Overall it can be seen that the residential sector needs to make vast improvements in energy efficiency in order to help Ireland meet the Kyoto targets. It is seen from various experts in the low energy sector that new and more stringent methods of construction must be tested and incorporated into the construction of residential buildings in order to reduce emissions, expenses and fossil fuel dependency in Ireland. Stemmed from the need of energy efficient improvement in the Irish residential sector, the SEAI published the Passive House Guidelines in 2007.

The Passivhaus Standard originated in 1988 by Bo Adamson, a Professor from the University of Lund in Sweden and Dr. Wolfgang Feist of the Institute for Housing and the Environment. The concept was originally tested on a row of terraced houses by Dr. Wolfgang Feist in 1991 in Darmstadt, Germany (passive house guidelines, 2007). The standard first came to light in Ireland in 2002 when a Swedish architect Hans Eek introduced it at a conference "see the light" which was organised by Sustainable Energy Ireland (SEI). It was introduced into the Irish market by Tomas O'Leary of MosArt Architects in Dublin in 2005. The house which is known as the "Out of the Blue" is the first Irish passive house to be certified by the Passivhaus Institute in Germany, but also has been the focus of various research and demonstration projects funded by Sustainable Energy Ireland to help improve and promote the credentials of the standard within the Irish market.

The Passive House is a building that is constructed to very strict and important guidelines which have to meet certain criteria in order to get it certified. If constructed accordingly the standard results in an ultra low energy building that requires very little energy for space heating and cooling through high levels of insulation, air tight construction, solar gain and a mechanical ventilation system.

The passive house standard has been hugely successful in Central Europe with estimated figures showing the number of passive houses around the world range from 15,000 to 20,000 structures. The vast majority have been built in German-speaking countries and Scandinavia. In relation to the Irish construction industry the standard is slowly growing in popularity with several buildings still at the planning stage. In order for the standard keep progressing in Ireland there are various technical and governmental barriers that need to be overcome. If these barriers are tackled successfully then Ireland would benefit from the standard being implemented

into the construction industry. As a result Ireland would see dramatic reductions in CO2 emissions, dependency of fossil fuels and energy expenses.

1.2 Research Hypothesis

"The Irish Passive House standard is a more financially sustainable construction solution compared to that of a typical dwelling of similar construction complying with current building regulations technical guidance documents."

1.2.1 Aim of research

The aim of the dissertation is to investigate whether or not the Passive House Standard is a more financially suitable method of construction in Ireland opposed to that of the current building regulations technical guidance documents. Another aim is to investigate whether or not the future development of the standard in Ireland will see it being introduced as a building regulation.

1.2.3 Research objectives

- To identify cost related issues of various elements of the Passive House construction compared to that of a typical dwelling in Ireland.

- To identify potential energy savings in the Passive House Design.

- To identify barriers that are slowing down the development of the passive house standard in Ireland.

1.3 Rationale for this study

Incredible potential lies within Passive House standard research on overcoming various barriers in relation to the implementation of the standard in the Irish construction industry. In Ireland, the financial and environmental benefits of this ultra low energy building have particular importance considering the recent economic downturn and Irelands responsibility under the Kyoto targets. In light of these trends, there is a need to identify the cost of the major elements of the Passive House standard compared to the most common type of construction standard in Ireland over the past decade. There is also a need to examine how the functioning of a Passive House has major environmental benefits for the home owner in relation to reduced GHG emissions, removal of fossil fuel dependency as well as an improved internal environment of their homes.

The data obtained will demonstrate that the Passive House standard can replace that of the current building regulations with cost justification. Also it will demonstrate that the environmental benefits of the Passive House will encourage the construction industry to shift towards this Ultra low energy standard. The improvement of energy efficient standards in Ireland requires no justification. Low energy standards have a strong value base that argues that improving energy efficiency of the building is its own justification.

A paucity of research and cost highlighted guidelines exists that accesses potential energy reduction in the Passive House standard compared to that of the current building regulations technical guidance documents .

1.4 Dissertation Layout

The structure of this dissertation consists of seven Chapters. They are:

- Chapter 1- Introduction
- Chapter 2- literature Review
- Chapter 3- Research Methodology
- Chapter 4- Case Study
- Chapter 5- Findings
- Chapter 6- Discussion
- Chapter 7- Conclusion and Recommendations

Chapter 1 Introduction

This chapter introduces the Hypothesis and gives a background into the study being undertaken. The aims of the research are also given which will be achieved by the list of objectives outlined in this chapter

Chapter 2 Literature Review

The literature review provides brief details of the secondary research material available and uncovers any previous studies of a similar nature that exist. It also establishes the information that will be obtained by conducting primary research.

Chapter 3 Research Methodology

This chapter gives an outline to the method of research used to conduct this study and justifies why the methods were chosen.

Chapter 4 case study

This will provide the reader with a illustrate view of the results from the case study. A cost breakdown analysis is also given in this chapter.

Chapter 2

Literature Review

Chapter 2- Literature review

2.1 Introduction

In order to test the hypothesis the researcher undertook a literature review in which all relevant information was researched, which helped gain an understanding of the area. All relevant previous studies on the Passive House standard have been researched. The researcher began by researching relevant literature and studies that incorporate the comparison of the Passive House standard and traditional build.

2.2 Definition of a Passive House

"A passive house is a building in which a comfortable interior climate can be maintained without active heating and cooling systems" (Adamson 1987 and Feist 1988).

For European passive construction, prerequisite to this capability is an annual heating requirement that is less than 15 kWh/ (m^2a). This is not to be attained at the cost of an increase in use of energy for other purposes such as electricity.

Also the combined primary energy consumption of living area of a European passive house may not exceed 120 kWh/ (m^2a) for heat, hot water and household electricity (Feist, 1997).

Also it is encouraged in Ireland that the additional energy requirements may be completely covered using renewable energy sources such as wind or solar.

In order to evaluate the hypothesis the researcher has chosen to look in detail at the major components of a passive house building envelope. Below is a list of the requirements and the major components.

A dwelling is a passive house if it fulfils three requirements:

- Annual heating requirement < 15kWh/(m2a)
- Air-tightness of the exterior shell: n50 ≤ 0.6 h-1
- Combined primary energy consumption < 120kWh/(m2a)

These three requirements are fulfilled by:

- Super Insulation
- Reduced Thermal Bridging
- Air Tightness
- Mechanical ventilation/Heat Recovery
- Minimal Space Heat requirements
- Domestic hot water requirements
- Window Glazing area and orientation

2.3 Passive House Building Envelope

Sustainable Energy Authority of Ireland (SEAI) introduced the passive house guidelines in 2007. The guidelines state that

"*The building envelope consists of all elements of the construction which separate the indoor climate from the outdoor climate". The aim of the passive house is to construct a building envelope that will significantly minimise heat loss and optimise solar and internal heat gain to reduce the space heating requirement to 15KWh/(m2year)*(SEAI, 2007).

The following building envelope parameters are fundamental in this process:

1. Well insulated building envelope

2. High energy performing windows and doors

3. Minimised heat loss through thermal bridging

4. Significantly reduced structural air infiltration

5. Optimal use of passive solar and internal heat gains

Measure/Solution	Passivhaus Standard for the Prototype House in the Irish Climate
1. Super Insulation	
Insulation Walls	U < 0.175 W/m2K
Insulation Roof	U < 0.15 W/m2K
Insulation Floor	U < 0.15 W/m2K
Window Frames, Doors	U < 0.8 W/m2K
Window Glazing	U < 0.8 W/m2K
Thermal Bridges	Linear heat Coefficient Ψ < 0.01 W/mK
Structural Air Tightness	n50 < 0.6/ air changes per hour

Table 2.1 Building envelope specification

(SEAI, 2007)

The above stringent building envelope parameters will obviously add to the budget of a passive house project as opposed to construction of a traditional house. However it is generally agreed by specialists that it is a major requirement to have a well insulated and airtight building envelope in order to achieve a Passive House Certification. Vast cost savings can be made from the reduced utility bills and removal of the space heating system.

2.3.1 Insulation

A study carried out by Jürgen Schnieders from the Passivhaus Institut in Germany highlighted that the specification for insulation levels could be reduced in Ireland because of the milder climate.

"The Irish climate, like others which are strongly influenced by the Gulf Stream and the thermal buffer effect of the sea, is a lot milder than the German one. Solar radiation levels in winter, on the other hand, are comparable to Germany.

Therefore, a lot less insulation than in Germany is required. Under favourable boundary conditions, south facing windows may achieve high net solar gains" (Schnieders, 2006).

2.3.2 Windows

Another study carried out by (Schnieders, 2006) highlighted that the Irish climate is suitable for high levels of net solar gain through high performing windows. The results show that this area of the passive house specification is suited to the Irish climate.

"Under favourable boundary conditions, south facing windows may achieve high net solar gains" (Schnieders, 2006).

2.3.3 Walls

In relation to the Irish building industry the traditional construction methods were said to be acting as a barrier. It can be said that the adoption of new and improved construction methods in Ireland would help develop the standard.

"The brick cavity wall building tradition poses challenges in several countries. To meet these challenges attention must be paid to good detailing, availability of appropriately dimensioned items (such as wall ties), and improvement of site practices will be necessary" (Kaan et al, 2006).

In the case of the wall construction new systems have to be adopted. Specific training should be given to contractors in relation to developing construction methods that will result in a fully operational passive house.

2.4 Energy savings

The potential for energy savings in the passive house is huge. There is various estimates made but past studies have shown that depending on design, savings of up to 90% can be made compared to traditional build.

"Passive Houses offer an energy savings of up to 90 % compared with existing buildings and more than 75 % compared with average new buildings. In terms of heating oil a Passive House uses as little as 1.5 litres per square metre per year – far less than a low-energy building" (http://passipedia.passiv.de/passipedia_en).

2.4.1 Reduced energy consumption in the Passive Standard

A study carried out in 1997 by Dr. Wolfgang Feist shows a life cycle energy analysis comparison of a low energy, Passive house and a self sufficient house. Annual end-use energy consumption is also calculated in the study.

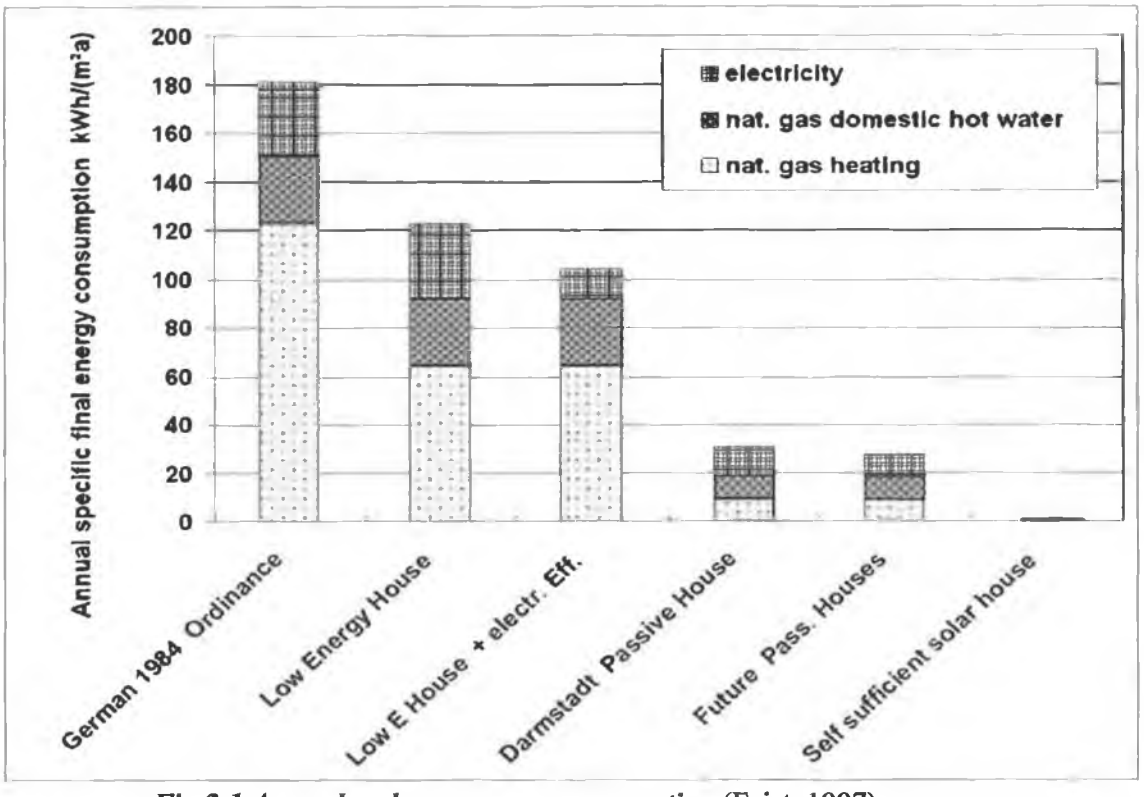

Fig 2.1 Annual end-use energy consumption (Feist, 1997)

The study outlines that a passive house (PH) is a "*building in which the heat requirement is so low that a separate heating system is not necessary and there is no loss of comfort; in Germany, this is the case if the annual heat requirement is below 15 kWh/(m2a)*"(Feist, 1997). Through efficient electricity usage, the total end-use energy requirement including household electricity and domestic hot water is lower than 33 kWh/(m²a).

The study also states that "*the decisive idea to develop cost efficient passive houses was, that to dispense with a heating system the heat requirement need not be zero: If the maximum heat load is less than 10 W/m2, then the extremely low required heat load can be provided without additional effort via the supply air*" (Feist, 1997) .

This idea would suggest that the removal of the need for space heating system would reduce the cost of construction during the build. The main objective of the research project was to examine to what extent the energy consumption of dwellings can be reduced by exclusively passive measures.

Results from the study show that "*thermal insulation and ventilation save 123 kWh/ (m²a) of running primary energy input every year. The total primary energy investment for better energy efficiency thus pays back in primary energy in less than two years*" (Feist, 1997).

The study also outlines the importance that the thermal insulation has to play in the Passive House standard.

"Thermal insulation plays the decisive role in the PH standards, production energy input for the mid-terrace house changes exclusively when the insulation thickness is varied. The reason lies in the reduction of the radiators (steel) caused by the reduction of the maximum heat load. At a thickness of approx. 23 cm this house finally reaches the passive house standard: Now the heat distribution system and the remaining radiators can be dispensed with, resulting in a drop in PEI" (Feist, 1997)

This shows that the Passive House standard has an overall Lower PEI as opposed to traditional build projects. As a result it can be seen that the PH Standard would be a far more financially viable solution.

The overall outlook of the study produces some interesting themes to investigate. The study shows that the development of a cost effective passive house is needed to be improved. Services such as:

- Highly insulating, thermal-bridge-free envelopes with various constructions, but all with U-values < 0.15 W/ (m2K).
- Further improved super-glazing with even lower heat losses (U-values lower than 0.7 W/ (m^2K)) and yet high solar transmittance factors (more than 55%).
- Window frames made of reinforced integrated PU foam elements, with U-values lower than 0.7 W/ (m2K).
- Compact building services systems with counter-flow heat exchanger for ventilation and the domestic hot water system, and simple, cost-effective back-up heating systems. (Feist, 1997).

This was also backed up by a study carried out by the UCD Energy Research Group in Ireland. The research showed that there were substantial energy savings to be made from constructing a passive house as opposed to a traditional build. The study was carried out to investigate the potential for energy and CO2 emissions reduction when the passive house space heating standard of 15 kWh/m2 is applied on the Irish new build housing market.

Results found that the energy usage difference between the two building methods was 8,222kWh a year.

"A typical Irish dwelling, constructed as per 2002 building regulations, consumes 9,722kWh/year of delivered energy on space heating and as a result releases 2,855kgCO2/year into the atmosphere. The space heating requirements for the same size of dwelling built to Passive House standards was found to be only 1,500 kWh/year of delivered energy which equates to 176kgCO2/year.
The difference in delivered energy consumption and carbon dioxide emissions between the two construction types for a single building over one year was therefore 8,222kWh/year and 2,680kgCO2/year"(Kondratenko et al, 2006).

2.5 Passive vs. Traditional Cost

Reviews of the literature on the Passive House standard reveal that there is substantial cost savings to be made when applying the Passive House standard as opposed to that of the traditional build.

De Keulenaer, (2006), believes that on the one hand there are some extra costs such as more heat insulation along with special window frames and glass and also costs for the airtight implementation, but also he states that there are savings from the lower budget of a heating system.

He also states that *"on the other hand the energy bill is four to ten times lower than in conventional house"* (De Keulenaer, 2006).

De Keulenaer confirms that it is possible to keep any extra over cost on a passive house to that of a traditional house as low as 0-15%.
"Depending on the design it's possible to realize passive house projects with an initial cost increase of 0-15 % compared to traditional building. The cost increase can be on the low end thanks to the builder's participation on the construction of his house , prefabrication, efficient project management, continuous commissioning" (De Keulenaer, 2006).

He also comments on how the *"Energy savings bring also social price, like reduced CO2 emissions"*.

Also according to Cost Efficient Passive Houses as European Standards (CEPHUS) the *"Passive House standard offers a cost-efficient way of minimizing the energy demand of new buildings in accordance with the global principle of sustainability"*, (http://www.cepheus.de)

The project states that the Passive House concept is built upon two basic principles:

1. *Optimize what is essential*
   CEPHEUS suggests:

"What makes the approach so cost-efficient is that, following the principle of simplicity, it relies on optimizing those components of a building which are necessary in any case: The building envelope, the windows and the automatic ventilation system expedient anyway for hygienic reasons" (http://www.cepheus.de).

They go on to talk about how improving the efficiency of the essential components will eliminate the need of a separate space heating system. So from the savings that will be made, they

"Will largely finance the extra costs of improvement" (http://www.cepheus.de).

2. *Minimize losses before maximizing gains*

   The second principle outlines how the Passive House prevents heat from escaping. They say that the standard *"gives precedence to loss minimization"* (http://www.cepheus.de).

Another study carried out by Dr. Wolfgang Feist in 2007 shows that a single family home can be retrofitted with an overall extra cost compared to traditional build as low as 8%.

The study shows that the improved building components required the installation of

1. Additional insulation,
2. Better windows (triple pane with two low-e coatings),
3. Insulated window installation
4. Heat recovery ventilator and its associated ductwork:

Additional thermal insulation in the wall, roof and slab on the ground cost an additional €4,800. The Passive House windows cost an additional € 5,400 .Ventilation with heat recovery cost €5,200. Savings from smaller oil tank, boiler; elimination of radiators was calculated as -€1,400

Sum of additional capital outlay was in the region of 14.000 €

Feist states that

"In any case, a Passive House single family home can be created for this amount which is about an 8% increase in construction costs compared to the German average"(Feist, 2007).

2.6 Market penetration

The 15th Anniversary of the Darmstadt, Kranichstein Passive House, Dr. Wolfgang Feist outlined that the cost of the passive house structural elements are on the decline.

"Since first Passive House prototypes in Kranichstein structural extra costs for Passive Houses have been reduced by a factor of 7: from over 50,000 Euro to between 6,000 and 15,000 Euro per unit today", (Feist 2006).

In 2006 the Department of Communications, Energy and Natural Resources (DCENR) introduced the Greener Homes scheme. The reason it was brought in was to help stimulate consumer investment in renewable heating solutions. Another aim of the scheme was to help develop the market for renewable technologies and fuels. The objective of the scheme was aimed at reducing CO2 emissions in the domestic sector. The scheme was formed into two phases. Phase one ran from April 2006 to August 2007. A total of 16,000 grants were approved during phase one.
Phase two of the Scheme was launched in October 2007. Included was a range of new objectives including revised product and training standards which was aimed at improving standards across the industry.
It can be said that the scheme was a major success as it developed the market, in order to allow sustainable development to grow in Ireland.

2.7 Barriers in development

Research carried out by the PEP - Promotion of European Passive Houses in 2006 gave a list of barriers that are effecting the development of the passive house concept. Barriers that were highlighted were:

Most frequently encountered barriers in partner countries are: limited know-how; limited contractor skills; and limited acceptation of Passive Houses in the market (Kaan et al, 2006).

In relation to the Irish building industry the traditional construction methods were said to be acting as a barrier also.

The brick cavity wall building tradition poses challenges in several countries. To meet these challenges attention must be paid to good detailing, availability of appropriately dimensioned items (such as wall ties), and improvement of site practices will be necessary (Kaan et al, 2006).

It was also outline in the research that windows are acting as a barrier in some countries. This is definitely true for the Irish market as there are no local window manufactures that are producing sufficient operating windows that fit the passive house specification.

The other barrier that is encountered in several countries is the lack of good window components. However, in other countries (such as Austria) these components are readily available. By temporarily importing these components, this barrier can be overcome. As demand increases it is expected that local availability will improve (Kaan et al, 2006).

The study also states recommendations for overcoming theses barriers. It outlines that more information and training is needed to be given to contractors and installers. *To overcome these barriers, a great deal of attention must be paid to providing practical information and solutions to building professionals, providing practical information and training to installers and contractors and communication about the Passive House concept to the market (Kaan et al, 2006).*

2.8 Change in current building regulations

Mandatory regulations concerning the conservation of fuel and energy in dwellings (Technical Guidance Document - Part L) were first introduced to Ireland in 1991. These building regulations were revised again on several occasions with the 2011 draft regulations being the most recently revised.

The purpose of the Part L regulations is that they focus on reducing energy consumption primarily by lowering required U-values, increasing insulation levels and minimizing thermal bridging. The guidelines state that:

Part L (Conservation of Fuel and Energy) of the Building Regulations sets out the statutory minimum standards of energy efficiency and carbon dioxide emissions that apply to a newly constructed building, a new extension to an existing building or an

existing building undergoing a material alteration or a material change of use. (Technical Guidance Document - Part L, 2011)

In 2010 the Minister for the Environment, Heritage and Local Government, Mr. John Gormley, T.D. published the draft Building Regulations (Part L Amendment) Regulations 2010 and the associated draft Technical Guidance Document L – Conservation of Fuel and Energy – Dwellings (2010) for public consultation. These revised regulations are aimed to achieve a 60% improvement over that of the 2005 regulatory requirements in the energy performance and carbon dioxide emissions for new dwellings on and from 1 July 2011. (www.environ.ie)

Research into the draft regulations show that the Irish building regulations are definitely shifting towards the Passive House standard. The author has looked at some of the changes that are incorporated into the draft regulations. The ultimate aim of the revised building regulations was to achieve zero carbon standard by 2013.

"The ultimate aim of achieving a carbon neutral standard for dwellings by 2013" (Regulatory Impact Analysis, 2010).

Future energy saving projections are highlighted in the Regulatory Impact Analysis Conservation of Fuel and Energy in New Dwellings, 2010.

"Low Carbon Homes 2013 – 70% Improvement of residential buildings relative to 2002 building regulations" (Regulatory Impact Analysis, 2010).

The report states cost savings that can be made if a certain designed dwelling complying with the 2011 regulations is constructed. The costs are calculated on the current prices of fuel.

As a result of these measures the average dwelling will save the energy equivalent of 30kWh/m2 per annum. Based on current fuel prices this will result in savings of €134 per dwelling per annum (Regulatory Impact Analysis, 2010).

These suggested savings are relatively far of the potential savings that the passive house standard offers. In studies reviewed earlier in the research, (Kondratenko et al, 2006) states that

"*The difference in delivered energy consumption and carbon dioxide emissions between the two construction types for a single building over one year was therefore 8,222kWh/year and 2,680kgCO2/year"* (Kondratenko et al, 2006).

2.9 Conclusion

The literature review conducted by the researcher has highlighted potential cost savings between the Passive House standard compared to that of the current building regulations. It has also found numerous barriers that are halting the progression of the standard into the Irish market. Potential energy savings from building to the passive house standard were brought to the researcher's attention during the literature review. This will form a basis for the primary research that will be conducted later in the research.

Chapter 3

Research Methodology

Chapter 3- Research Methodology

3.1 Introduction

This chapter outlines the research design, data collection and procedures of the research study. The methodology selected for this study is both qualitative and quantitative as it attempts to see what a passive house owner, contractor, designer and City Council members have experienced during their time of constructing a certified passive house. It can help tease out and explore hypotheses that are not explained by quantitative approaches (Barbour and Kitzinger, 1999). The researcher also combines both qualitative and quantitative data collection in the form of a case study on a specific dwelling built to the Passive House standard.

3.1.2 Aim of research

The aim of the dissertation is to investigate whether or not the Passive House Standard is a more financially suitable method of construction in Ireland opposed to that of the current building regulations technical guidance documents. Another aim is to investigate whether or not the future development of the standard in Ireland will see it being introduced as a building regulation.

3.1.3 Research objectives

- To identify cost related issues of various elements of the Passive House construction compared to that of a typical dwelling in Ireland.
- To identify potential energy savings in the Passive House Design.
- To identify barriers which are slowing down the development of the passive house standard in Ireland.

In a research project it is extremely important to select the most suitable research methods. These methods play a huge roll in validating the chosen research. To complete an accurate and completed account of information the researcher took a detailed look into the different types of research methods that were available and realistic to achieve. From the research of such methods the information established that research falls into two main categories. These are:

- Primary research
- Secondary research

The methods of research used in a research project are singly dependent upon the information required to prove or disprove the hypothesis. Therefore it is necessary to establish what information is needed before concluding on the methods to be used.

- An overview of government legislations (e.g. Passive House standard in Ireland)
- Information suggesting that the extra over cost of a passive House should fall in between 0% to 10% of a conventional house.
- Evidence proving the policies, plans and strategies implemented has not successfully overcome a number of barriers in the implementation of the standard in Ireland.
- Professional opinions with regards to energy conservation, Passive House standard and cost related issues.

3.2 Secondary research

"Secondary data analysis refers to research findings based on data collected by others". (Frankfort 1992)

Secondary research was carried out to obtain information into the background of the subject area. Research was undertaken in the form of a comprehensive literature review. The review proved to be an outstanding source of background information.

The literature review was assembled from several areas such as:

- Sustainable Energy Ireland publications
- Building Regulations
- Academic journals
- Governing body websites(e.g. SEI)
- Databases (science direct, Academic)
- Textbooks, newspapers, trade journals
- Recent Government reports on Energy Conservation

Search engines such as Google and Yahoo were also used to complete the literature review. Key words such as "Passivhaus Design" along with "energy conservation in the home" were used to gather research for the review.

3.3 Primary research

Primary research was carried out to obtain the rest of the information that was going to be used to test the hypothesis. Following research into possible research methods the researcher gathered from (Foddy 1994) and Frankfort (1992) as well as the information gathered from the secondary research the author decided that one to one semi structured interviews would be the most appropriate method along with a Case study.

"*Interviews come into their own when we need to ask numerous open-ended questions, or open-ended probes, where the interviewer has to record verbatim the answers given by the respondents.*" (Oppenheim 1992).

There are three types of interviews structured, semi-structured and unstructured. Structured interviews consist of a predetermined set of questions that are easily analysed. Semi-structured interviews are detailed as a framework for the topic itself. They are slightly more difficult to analyse but there is no set of predetermined questions that will give the researcher a more in depth response and allow more information to be gathered.

3.3.1 Research design

One to one interviews were conducted with members of the Galway City Council, Structural Engineers, Passive House owner as well as Passive House Specialists. Throughout this research study, the cost issues relating to the Passive House standard and energy conservation in the residential sector were investigated. The project was influenced by a number of aspects relating to energy efficient construction methods and technologies within the passive house design.

These include the following;

1. Passive House shell
2. Mechanical ventilation/Heat Recovery
3. Minimal Space Heat requirements
4. Domestic hot water requirements

5. Window Glazing area and orientation

6. Planning

3.3.2 Ethical considerations

The ethical principles governing this research were informed consent, anonymity, voluntary participation and freedom to withdraw.

Total confidentiality and anonymity was explained before the beginning of each interview. Participants were informed that they were free to withdraw at any time and the researcher answered all questions about the study. According to Bowling (2002) this voluntary consent safeguards the freedom of the participant to choose to participate in the research or not, and reduces the legal liability of the researcher. Permission was sought for the use of a tape recorder. The researcher also explained to the participants the purpose for using the tape recorder and that the tapes would not be listened to by anyone else other than the researcher.

3.3.3 Sample Frame

Participants were City Council Engineers and also members of the City council planning authority as well as passive house specialists. Purposeful sampling was employed in this study. Participants were recruited from known, easily accessible populations. Bowling (2002) has highlighted that purposeful sampling has the advantages of ease of recruitment, easier monitoring and follow-up, generally good response rates and retention of sample members.

3.3.4Sample size and Sampling strategies

Sampling is a major problem for any research. We can't study every case of whatever we are interested in, nor should we want to. Every scientific enterprise tries to find out something that will apply to everything of a certain kind by studying a few examples, the results of the study being, as we say, "generalizable." (Becker,1998).

The selection criteria for the one to one interviews were that participants had to have relatively good experience and insight into energy conservation such as low energy buildings, planning restrictions and cost of energy efficient construction methods and technologies along with a good understanding of the Part l building regulations. This study excluded persons that did not believe they had a good understanding of the

above criteria. Recruitment and participation in the study took place in the months of June and July.

3.4 Interviewees:

The Director of Services for Transportation & Infrastructure and Parks & Recreation, Mr Ciaran Hayes was contacted by telephone call. He was asked on his experience of the set criteria. From the list of the selection criteria he put the researcher in contact with more suitable participants for the interviews that deal with specific areas of the above criteria

Interviewee 1

Peter Keavney

Mr Keavney is one of three qualified Energy Engineers in Ireland. He has an Honours degree from the South Bank University in London. In 1997 he set up and manages the Energy Agency Galway. Mr Keavney has vast experience with low energy buildings, Passive House design, energy conservation cost issues along with consultations for the Draft building Regulations Part L for 2011. Mr Keavney's background and profession made him a suitable participant during this research as he fitted the selection criteria outstandingly.

Interviewee 2

Lars Pettersson

Mr Pettersson founded the company Scandinavian Homes in 1991. He started building his own house first and quickly found out that there was very high interest in the type of low-energy and later passive houses, which the company provides.

Mr Pettersson has 19 years experience with low energy houses. To date his company has constructed 265 houses. Out of which 25 are passive house construction. His company were one of the first to introduce the Passive House standard in Ireland. Mr Pettersson has vast experience with low energy buildings, Passive House design, energy conservation cost issues along with consultations for the Draft building Regulations Part L for 2011. Mr Pettersson's background and profession made him a suitable participant during this research as he fitted the selection criteria outstandingly.

Interviewee 3

Jeff Colley Phone interview

Mr Colley set up a magazine company called Construct Ireland in 2003. It is a magazine that focuses on sustainable building. He is now seven years involved in producing one of the most popular sustainable building magazines in Ireland and possibly Europe. He is co-founder of EASCA, the Environmental and Sustainable Construction Association, which he founded with Duncan Stewart from RTE. Professor Tom Woolley from Queens' University Belfast and also Paul Leech from Leech-Gaia Ecotecture are also involved to promote the viability of sustainable construction in Ireland. Mr Colley won the Green Leader Award in 2010 with his magazine also winning the Green Communications Award. Based on all of his experience he was deemed a suitable interviewee for this research.

Interviewee 4

Thomas Connell

Mr Connell is the Director of Services for Planning, Economic Development, Corporate Services, Community and Culture with Galway City Council. He has 29 years experience, working in various departments within local authorities which he brings that experience into the planning and economic development. He has vast experience with the planning and development act and the city development plan. Based on his experience, the researcher believed he was a suitable interviewee to take part in this research.

Interviewee 5

Shane Hanniffy

Shane Hanniffy has been working as a Structural Engineer over the past eleven years. He went into partnership with his father Sean who was originally a drafts man until focusing more on structural design. Together they established their company S. Hanniffy & Associates Consulting Engineers in Maree, Co Galway in 2005. They would have a good understanding of the Passive house standard as well as energy efficient products. Shane was a suitable interviewee as he fitted the selection criteria.

They have recently overseen and completed a Passive House project in Maree, Oranmore, Co Galway. It is a fully certified passive house. The house will be discussed in detail in Chapter 4.

Interviewee 6

Johnny White

Mr. White has been involved with the sales and marketing of construction products for the past 12 years. He has vast experience in dealing with clients who require low energy products and solutions. Over the past 2 years he has become a partner in the company Passive House systems Ireland which are based in Dublin. The company offers various solutions and services to clients that are aiming to get there building passive house certified.

Interviewee 7

Kevin O'Grady

Mr O'Grady specialises in the construction of airtight building envelopes. Coming from a construction background he has over the last number of years worked mostly in airtight construction. He works in accordance with SIGA manual for craftsmen. He has a huge interest and in-depth knowledge of various airtight systems and methods which the researcher felt made him a suitable participant for interviewing.

Interviewee 8

Seamus O'Loughlan

Mr O'Loughlin is the owner of Viking Hi Tec Ltd. They are a sustainable building company that specialises in passive house construction. Mr O'Loughlin has indebt knowledge of passive house materials, systems and costs understanding of the standard. He is a suitable participant for this research.

Interviewee 9

Gearoid Hanniffy

Mr Hanniffy was interviewed mostly as a result of the researcher conducting the case study on his Passive house. He conducted broad research himself on the passive house standard before deciding to go with the passive design for his new dwelling. The researcher felt that he was a suitable interviewee from his experience during the construction of his home.

Interviewee 10

Gavin O'Sea: Phone Interview

Mr O'Sea works for the organisation greenbuild.ie that specialise in the Building Energy Rating of dwellings in Ireland. He has conducted investigations into the BER calculations of passive homes in Ireland. From his experience within his profession the researcher felt that he was a suitable participant in the research.

3.4.1 Access

All interviewees that participated in the research were contacted via telephone call. The purpose of the study was explained and fortunately all agreed to participate. Preliminary dates were arranged with all Participants.

3.4.2 The Settings

Each participant obliged to facilitate the research either at their own facility or a location that suited their schedule. This was a major advantage as a majority of the participants were easily accessible. Participants were familiar with the location and the surroundings, which is important in creating a comfortable atmosphere (Krueger, 1994).

3.5 Data collection

Comprised of the following:

3.5.1 Procedure

Interviews:

Ten interviews took place. An office room or a suitable table was provided by each of the participants. This had the advantage that participants were familiar and comfortable with their surroundings. Also, all participants were obliging and welcomed the research. As discussed in the initial telephone call, the duration time was given again to assure the participant on his freedom to withdraw if needed. An introduction to the purpose of the study was again given and every effort was made to make sure all participants felt relaxed. Each interview commenced with participants saying their first name. An open ended questions approach was undertaken with the researcher undertaking the role as moderator .Certain issues were addressed before the focus groups began;

- Speak freely on your own experiences and opinions.
- Speak loudly and clearly

Each interview lasted for roughly 20-40 minutes. Once the interviews finished, the researcher gave feedback and highlighted the key points made by the interviewee. All notes were collected and tapes listened to.

3.5.2 Pilot study

A pilot interview was carried out to familiarise the researcher with the interview format and process and to identify any difficulties that might arise in the study. A participant was selected from a local construction company. This pilot study proved to the researcher that;

- The length of the Interview was reasonable
- The questions did not appear to be too intrusive
- Terminology was appropriate and "user friendly".

The pilot interview was transcribed and analysed to evaluate its quality. The researcher identified times when the participant began discussing issues that were not really relevant to the study. It was felt that this was time consuming and distracted from the aim of the research.

3.5.3 Reflection on study process

During one particular interview, a participant had to leave early due to another appointment. This could not be avoided and fortunately did not interrupt the data that was gathered. On one occasion the researcher was unable to use the voice recorder due to the participant being uncomfortable with it on. Fortunately this did not interrupt the data that was gathered. Before each interview commenced, the researcher bonded with the participants and built rapport. This made the participant's relax and feel at ease with the research process.

Each interview began with the participants introducing themselves and giving their background and experience of the research area.

All interviewees were asked the following probes;

- Energy Conservation Passive versus Traditional
- Design Passive versus Traditional
- Construction Passive versus Traditional
- Cost Passive versus Traditional
- Conclusion

Most participants identified key cost issues between Passive and traditional build that were affecting the penetration of the Passive Standard into the Irish market. The researcher presented himself as a student and participants acknowledged this and tried to answer questions to the best of their ability. Participants were generally interested in the fact that their own opinions were being sought.

All interviews ran freely and smoothly and the researcher felt that, as the interviews went on most participants enjoyed them and didn't mind if the duration of the interview exceeded the stated duration at the start.

3.6 Data analysis

Data analysis consists of examining, categorizing, tabulating, or otherwise recombining the evidence, to address the initial propositions of the study (Yin, 1984)

The interviews were analysed separately after the data collection was completed. The recorded interviews were transcribed verbatim. Each recording took 2-3 hours to transcribe. The researcher employed the following method.

All interview texts were read and re-read while listening to the tapes. The researcher made written comments and observations during the interviews. These were all included. Once an understanding of the whole text was obtained, thematic analysis began. Each interview was given a code number. The text was again read sentence by sentence and themes and sub-themes were highlighted and underlined. Additional comments were written on the margin of all texts. All cross cutting themes and sub-themes were then clustered together. The researchers then cut and paste the data to develop emerging themes. These emerging themes gave the researcher an insight into the major financial differences between the Passive House standard and a building complying with the current building regulations.

3.7 Quality of the data.

To ensure validity, generalisability and reliability in the research data, a co-moderator reviewed interview transcripts to see if the proposed themes and sub-themes accurately represented the data.

Co Moderator: The Co Moderator was a past classmate that held a BSc Honours in Construction Management

3.8 Case study

In order to understand the major cost elements of the passive house standard compared to that of the current building regulations the researcher carried out a case

study of a passive house during the construction stage through to the completion of the project.

3.8.1Objectives

The case study was carried out to further research and investigates the major construction and cost elements of constructing a certified passive house in the Irish climate and Market. The following elements are investigated in detail in the chapter 5:

- Design and construction
- Materials and Passive solutions
- Cost
- Opinions

Dependability refers to the clear documentation of the research process. A clear description of the research process has been given from start to finish. All details have been included in the study. Credibility was insured by the use of direct quotes from the transcriptions in this research study.

3.9 Conclusion

This chapter presented the research methodology utilized in this study and the rationale for choosing qualitative approaches. The researcher believes that this approach to data collection is the most suitable for identifying what factors are the major costs differences between passive and traditional build.

Chapter 4

Case Study

Chapter 4 – Case study

4.1 Introduction

In order to understand the major cost elements in the construction of a passive house compared to that of a typical dwelling of similar construction complying with current building regulations technical guidance documents the author carried out a case study of a passive house during the construction stage through to the completion of the project.

4.1.1Objectives

The case study was carried out to further research and investigates the major construction and cost elements of constructing a certified passive house in the Irish climate and Market. The following elements are investigated in detail in the following chapter:

- Design and construction
- Materials and Passive solutions
- Cost

4.1.2 Background

The Passive House is located in Ahapouleen, Maree, Oranmore, Co Galway. It is the first passive house of its kind in Galway. The building was constructed by Passive House Builders in Galway. They are specialists in the design and build of Passive and Energy Efficient homes. Shane Hanniffy was the designer and Structural Engineer on the project. The Owner of the house is Gearoid Hanniffy who is a local resident from Maree. Planning permission was obtained in 2008 and construction began in August 2009. Passive House Builders carried out the PHPP calculations during the design of the project.

4.1.3 Decision making process

The passive house construction is a big change away from the traditional construction methods. This section of the case study outlines the social reasons, why the client Mr Hanniffy went down the passive route.

The main reason was the energy savings that could be made with the passive house construction.

"I was in a house in Tipperary and they spend three and a half thousand on oil for one year's fuel supply. That was a big influence on my decision to go down the passive route."P9

4.2Design and Specification

The client Mr Gearoid Hanniffy consulted with S. Hanniffy & Associates and Passive House Builders in order to design a dwelling that could meet the Passive House standard. Over lengthily negotiations they compiled a design that the client was happy with and submitted the drawings for the planning application to Galway City Council. Figure 4.1 below shows the original design that was submitted of the Passive House.

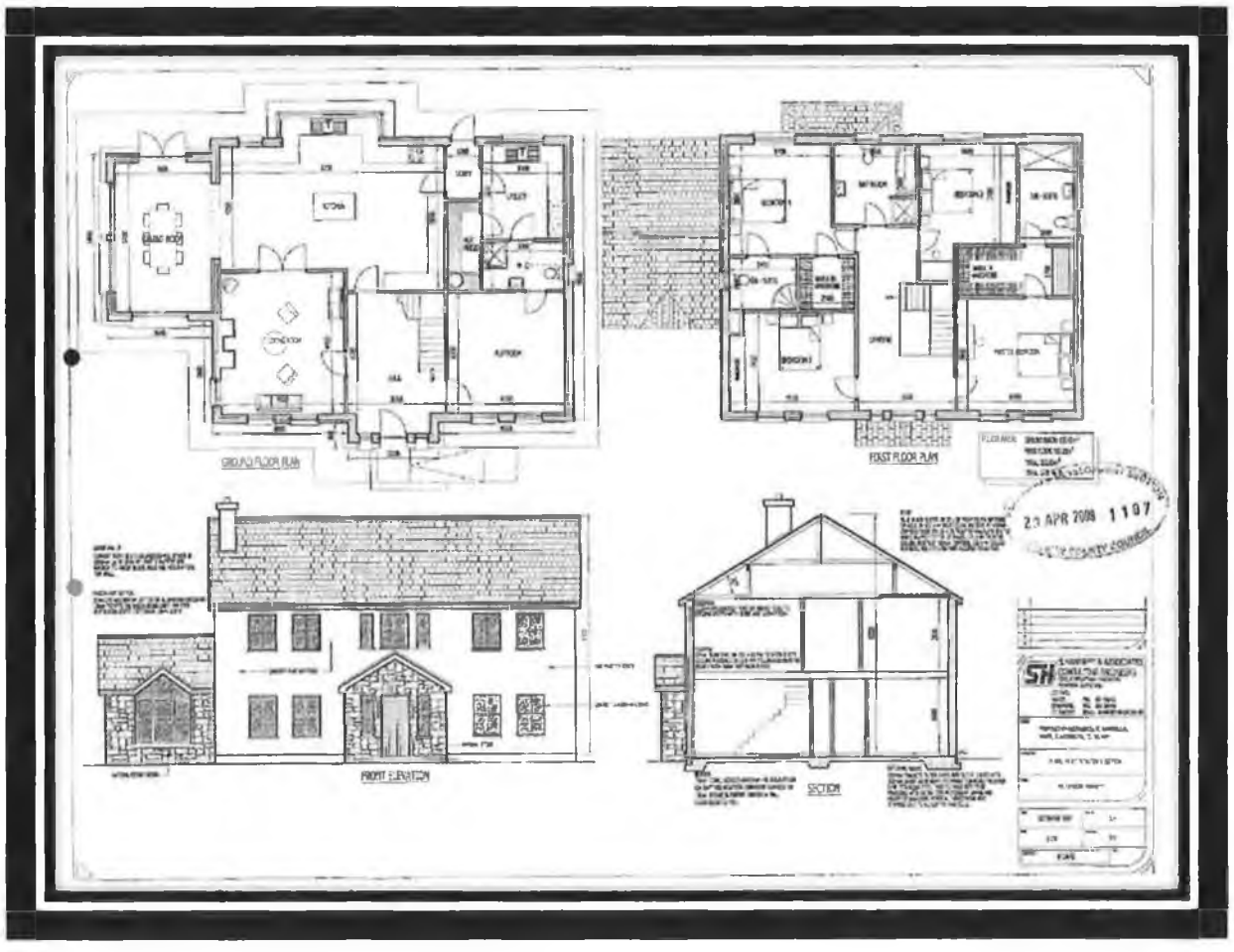

Figure 4.1 Original Design of Passive House

The Galway city council declined the application on the grounds that the site is located in a '*landscape sensitivity designation*' .This meant that the design had to be revised and that the following alterations had to be made:

- Passive House could not to exceed 8m
- Boxed eaves and flush verges to be integrated into the design

This was a setback for the project, but the client stated that they were expecting a few alterations to be made anyway. The main obstacle was trying to get a passive house design to comply with the local development plan.

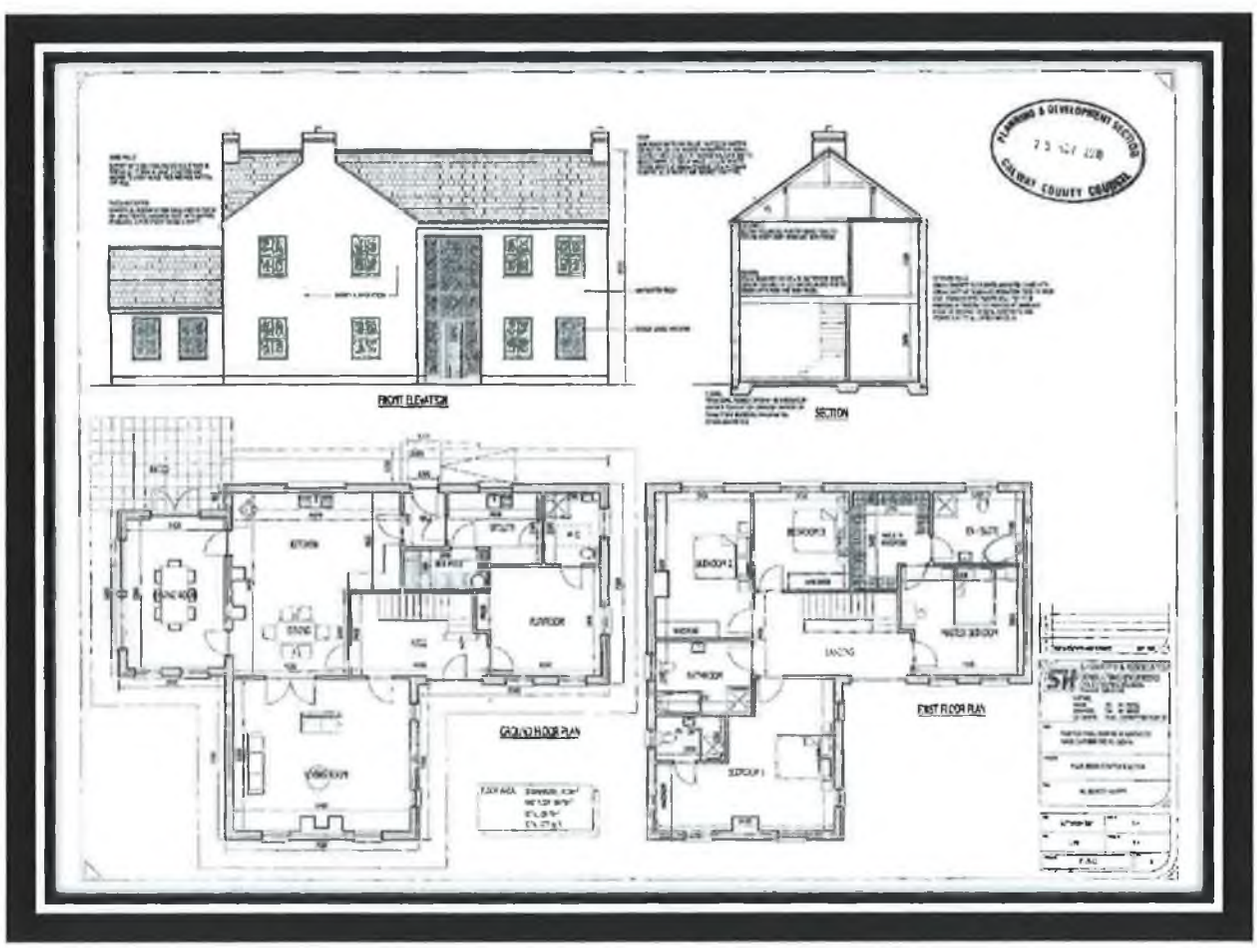

Figure 4.2 Revised Design of Passive House

Figure 4.2 above shows the revised design of the Passive House. It is a narrower sized plan in an L shaped layout. The second application was granted and construction work began in August 2009.

4.2.1Alterations made in the Layout

In order to sustain suitable solar gain the layout of the Dwelling had to be tilted more to the south. The original layout had to be in line with the road according to the development plan. Also the garage had to be moved in order for the sun room to get sufficient solar gain. One issue that the client had was the sewer pipes all had to be internally laid so he had no time to dwell on the location of the pipes.

4.3Specification

Table 5.1 below shows the specification of the various different elements in the Passive House

Item	Specification
Insulation Spec/U Values	Wall 0.12 Roof 0.1 Floor 0.12 Thermal bridge factor is 0.01
Window Spec	Windows 0.8
Main Space Heating System	97% efficient condensing oil boiler
Space Heating System Controls	Thermostates
Heating Source in Living Room	Underfloor heating from boiler. No Open fire or stove
Hot Cylinder Volume/Insulation	300Ltr and 100 mil insulation
Solar Hot water	-----
Ventilation Unit	PAUL DC300 and is on Appendix Q
Percentage of low energy lighting	100% LED/CFL

Table 4.1 Passive House Spec

4.3.1 Key Points:

- For the heating of the hot water there are no solar panels. This is done by a 97% condensing oil boiler.
- There is under floor heating in the living room but it is not connected so far as they hope they don't have to use it.
- The sunroom acts as a heat supply that leads into the kitchen. There are suction points at this source that supply the warm air around the house.
- The heat demand for the house is 10W/m2.

4.4 Construction

As mentioned earlier construction began in August 2009. The project was completed in the summer of 2010 with the client moving into the Passive house at the end of August 2010. The Passive House has been fully certified by the Passive House Institute (PHI) in Germany.

4.4.1 Foundations and Floors

System: Passive Slab Insulated Foundation

Installed: Viking House

Foundation Type: Passive Slab G element

Cost: Review Cost Analysis

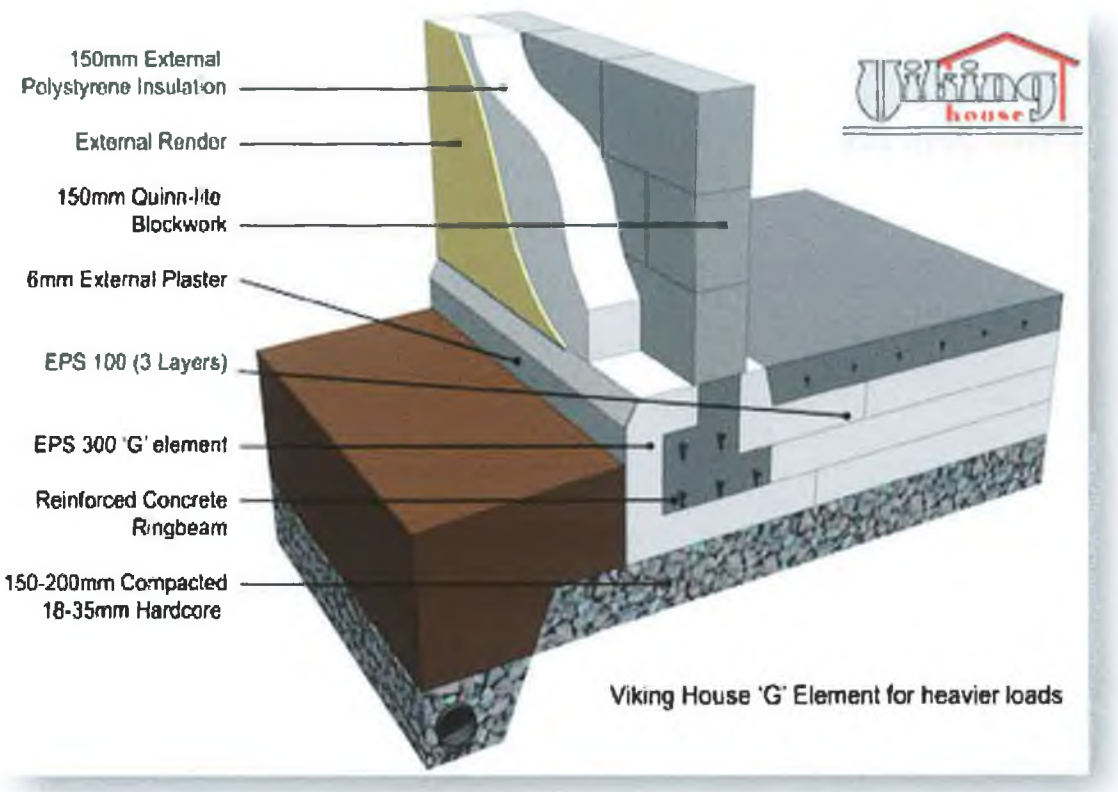

Fig 4.3 Viking House G element Foundation

The foundation for the Passive House was supplied and installed under Viking House certification. The company provides Passive House services which have all their systems certified by the PHI in Germany. Figure 4.1 above shows the detail of their foundation, floor and wall junction. The actual specification of the foundation for the house can be seen in Appendix B, Detail 3 & 4.

It is estimated that the U-Value of the Viking House Foundation if installed properly can be as low as 0.08 W/m²K. This is a very good result as the required foundation U-Value in the passive house guidelines is U < 0.15 W/m2K. Also it far betters that

of the 2005 Irish building regulations which States that the dwelling must have a floor U-Value of 0.25 W/m²K. The system eliminates any cold bridges between the wall and floor.

4.4.2 Description of Strip Foundation

View Appendix B, Detail 3

The foundation consists of 100mm Screed on 3 layers of EPS 100 Insulation. The strip foundation is wrapped with 1 layer of EPS 300 Insulation which comes up to meet the 250mm EPS 70 external insulation of the wall. This is an important detail in order to ensure the air tightness of the building envelope. Figure 4.2 below shows the detail of the two insulations joining.

Fig 4.4 Foundation Insulation joins Wall insulation

This foundation system is a big change from the traditional strip foundation. The workmanship has to be a lot more competent compared to the 2005 Irish building regulations foundations. The reason for is that there is to be no gaps in the insulation and the concrete in order to avoid cold bridges and achieve the required u-value to make the envelope airtight.

4.4.3Passive House Wall System

System: Quinnlite Blocks with 250mm of EPS External Insulation

Installed: Passive House Builders

Suppliers: Viking House

Type: Quinnlite Breeze Block Construction

Cost: Review Cost Analysis

The walls of the house were constructed by Passive House builders in Galway. The system was constructed using Quinnlite blocks that had EPS External insulation attached directly to the block work using special adhesive. Figure 4.1 shows the detail of the wall construction.

4.4.4 Detailed Description of Walls

View Appendix B Detail 3

The walls consisted of 15mm internal render finish on the airtight layer. This was over the 215mm Quinnlite B3 Blocks which was followed by 250mm EPS 70 External insulation that had an 8mm external render finish. The walls also had to have a 215mm x 325mm Concrete Bandbeam along the top of the wall to insure that the wall was structurally sound.

When the wall was finally constructed it was calculated that it would deliver an excellent 0.12 U-value which can be seen from the Literature review that it is well within the Passive House standards and also the 2005 Irish building regulations. The wall also delivers an 11 hour decrement delay which slows down the heat loss and also helps eradicate against summer overheating.

Figure 4.5 External Insulation being applied

Figure 4.4 above shows the external insulation being applied. The system provides a well insulated building envelope. It has zero cold bridges as there is no cavity between the insulation and the block work. It is a relatively new system on the Irish market and is sure to be developed in the coming years.

4.4.5 Roof and Ceilings

System: Pitched roof

Constructed: Passive House Builders

Type: Traditional Pitched roof

The roof that was designed for the passive house is a traditional pitched roof that had to be within the planning guidelines. The U-Value of a roof constructed to the current building regulations is 0.16W/m²K. This is very close to the 0.15 W/m²K U-Value that is set in the Passive House Guidelines.

4.4.6 Solution

In order to lower the U-Value the amount of insulation was increased to 450mm of quilt cellulose insulation with 225mm laid between the ceiling joists and 225mm laid in the opposite direction over the joists.

The U-value that was calculated after using this approach was 0.13W/m²K. This is better than the Passive standard required U-Value.

Fig 4.6 Pitched roof for the Passive House

Figure 4.5 shows the outline of the pitched roof. The only extra over cost compared with traditional built roof was the increased insulation levels. Mr Hanniffy outlined that the roof construction was not a major issue with regard achieving the recommended U-value or any extra over cost. Together Passive House Builders and S. Hanniffy & Associates consulted a few other options with the client before opting to increase the insulation of the traditional method which he thought was the most practical and cost efficient. This means that the roof took no longer to carry out than a standard roof.

4.4.7 Windows and Fittings

System OPTIWIN Austria

Installed Passive House Builder

Type Alu2wood window

The windows were one of the main issues with the build. There was a waiting period of 9 weeks and also they had to be imported from Austria. The windows have a U-value of 0.77W/m²K. The windows were installed by Passive House Builders under competent workmanship to ensure all precautions were taken to seal the windows to the Quinnlite block work securely at every joint for air tightness. Externally the window was installed flush to the external edge of the block work with the insulation overlapping the frame 35mm to eliminate thermal bridging. The costs of the windows were the most expensive element to date costing nearly double the price than a window conforming to the Irish 2005 Building standards.

Fig 4.7 Internal and External window details

4.5 Mechanical Ventilation with Heat Recovery

System: Mechanical Ventilation with Heat Recovery

Installed: Passive House Builders

Type: PAUL 300DC

Cost: €6000 (Includes Ducting and Labour for installation)

The ventilation system that was used in the Passive House was PAUL heat recovery unit thermos 300 DC. It is used for balanced mechanical ventilation in the house and uses a highly efficient counter-flow channel-type heat exchanger. The heat exchanger has a heat transfer surface area of 60 m2. Suction points are placed in the sunroom, kitchen, bathrooms and the utility. These points take in the warm air and distribute it around the house.

The thermal efficiency of this exchanger is much higher than that of conventional cross-flow plate heat exchangers. The high-efficiency electronically commutated radial fans with integrated electronic power control provide an excellent cost/benefit ratio of 1:20 to 26. The programme allows the air flow rate to be regulated in 3 steps. The fan power of the 3 steps can be varied in 1% increments.

The programmer functions for the Passive House are:

- 8 independent timing programs with weekday timer for presetting the operating times and power setting of the ventilation fans,
- Control of the motorised summer bypass valve,
- Intake/exhaust balancing,
- Filter monitor function,
- Frost protection for downstream hot water duct heater,
- There are several boost switches and a standby circuit with a power input of less than 2 W.

Figure 4.8 Ventilation Ductwork

Figure 4.9 Ventilation housing insulation

Figure 4.10 Ventilation controls and boost switches

Also the Client Mr G. Hanniffy has other optional features such as:

- Controlling a frost protection pre-heater,
- Regulating a ground to air heat exchanger or a ground to brine to air frost protection,
- A heating circuit such as heating circuit pump or electric back-up heater up to 2.1 kW and addition of several boost switches.

The ventilation system that was incorporated in the Passive House is a fully soundproofed and heat-insulated design. The entire housing is made of EPP foam and thus contains no thermal bridges. The intake air is cleaned via a G4 filter, or optionally via a pollen filter. On the extract side, the unit is protected from dirt and contamination by a G4 filter.

4.6 Building envelope Air tightness

The airtightness was carried out in accordance with the SIGA *Manual for professional craftsman.*

Installed: Passive House Builder

System: Majpell 5 Vapour control layer

Type: Majpell roll and sealing tape

Cost: The researcher could not obtain a Figure for m2 of airtightness construction. There would be significant cost added for the implementation of the airtight barrier and also time added onto the project.

As one of the major requirements of the Passive House standard the dwelling had to pass the pressurization test and get a maximum result of 0.6 h-1. In order for this to be achieved the buildings had to be constructed to be permanently airtight.

To make the building shell airtight a vapour control layer was applied and bonded air tightly to the inside of the ceiling and corners and around windows and doors. The rest of the walls were plastered and said to be airtight. Subsequently proof of air tightness was provided with the Blower-Door-Test by checking the airtight layer for compliance with the required values.

If there were permeable areas in the building shell they could cause high energy loss, uncomfortable draught and could lead to massive damage to the building.

4.6.1 Description of Works:

The airtight membrane was placed onto the ceiling plasterboard and the corner of the walls of the building. As discussed in the interview with Mr O'Grady, all critical areas had to be carefully sealed to be airtight. These were as follows:

- The area where the vapour control layer is joined to the plastered masonry
- Were the vapour control layer overlapped
- All circular and angular penetrations
- All base-joints
- Any leaks in the vapour control layer
- All windows and doors.

Steps taken when applying the airtight membrane:

1. Double-sided adhesive Twinet was used when they were mounting the Majpell onto the ceiling.
2. They had to unroll the Majpell and cut it to the correct size
3. They then had to stick it down with the smooth side and the writing facing out.
4. They had to overlap the sheets by approx. 10 cm
5. Passive Builders had to bond the Majpell with the smooth side and the writing facing out
6. Attach battens crosswise along the structure in order to bear the weight of the insulation.

Fig4.11 Passive House airtight membrane

Figures 4.9 above shows the vapour barrier in place at the ceiling of the Passive House.

4.7 Cost Breakdown of Passive House shell

In order to achieve the objective of identifying cost related issues of various elements of the Passive House construction compared to that of a typical dwelling in Ireland, the researcher undertook a cost breakdown analysis of certain elements of the passive house shell and compared them to the cost of the traditional methods. It should be noted that these are estimated costs on a specific case study and shouldn't be taken as an overall cost of passive house construction methods. The researcher would like to reference these costs to Seamus O'Loughlan of Viking House Dublin.

As seen from the above Case study the traditional roof was used. With the only difference in price being added was the insulation levels and the airtightness implementation. For this reason the researcher took the elements of the foundation and wall construction from the passive house and compared them to traditional methods.

The researcher compared the prices of constructing:

1. Traditional strip foundation against Passive Slab foundation
2. Traditional cavity wall construction against EPS External insulation on Quinnlite Blocks.

4.7.1 Foundations

The researcher took a benchmark measurement for the foundation of 20m x 10m foundation (200m2) for the Cost Comparison

20m x 10m foundation (200m2) Cost Comparison

Traditional strip foundation (0.16 U-value) reduced Cold Bridge

Digging strip foundations (60m external and 40m internal)	€350.00	
Pour 90cm x 30cm footings (30m3 of concrete)	€2,500.00	
100m of rising walls, 15 blocks/m = 1,500 blocks @€0.40/block	€600.00	
Cold bridge elimination foamglass blocks 100m@€25/m (1 layer)	€2,500.00	
200m2 slab x 150mm = 30m3 of concrete	€2,500.00	
Concrete pump (twice)	€1,500.00	
Steel	€1,000.00	
Floor Insulation (150mm Kingspan x 200m)	€4,000.00	
Radon barrier and sump	€750.00	
Stone	€500.00	
Backfilling around the rising walls	€350.00	
Labour	€5,000.00	
Machine hire	€500.00	
UF Heating pipes	€2,000.00	
70 mm UF heating screed (15m3 of concrete)	€1,250.00	
Total for Traditional method		**€25,300.00**

Passive Slab (0.10 U-Value) Cold Bridge free

Stone	€1,000.00	
LL foundation elements (60m@€25/m inc Vat)	€1,500.00	
Concrete for ringbeam and slab (25m3)	€2,000.00	
Concrete pump hire	€750.00	
Steel	€1,000.00	
Radon barrier and sump	€750.00	
Machine hire	€500.00	
Labour	€5,000.00	
Floor Insulation (300mm EPS x 200m)	€5,000.00	
UF Heating pipes	€2,000.00	
Engineers opinion to facilitate sign off	€300.00	
Patent fees	€500.00	
Total for Passive Slab		**€20,300.00**

Table 4.2 Foundation Cost Analysis

4.7.2 Wall construction

The researcher calculated the area of the external wall in the case study to be 275m2

Total wall Area	336m2
Deductions of windows and doors and external glazing areas	61 m2
Total wall construction area	**275 m2**

Traditional 300 cavity wall with 60mm Insulation

10 blocks m2 x 2 leaves	20 blocks m2	
275m2 x 20 blocks	5,500 B	
Rate €4.00 a Block	Includes Block, Sand, Cement, Cavity Insulation Damp courses and Labour	
5,500 Blocks x €4.00	€22,000	excluding 13.5% VAT

Total for Traditional wall **€22.000**

EPS Insulation system		
60euro m2 material		
10 euro m2 Labour	70 Euro m2 for Eps insulation	
275m2 x €70	€19.250	
Quinn lite Block		
€15 per m2		
275m2 x €15	€4.125	
labour @ 50c a block		
10 blocks m2		
2750 blocks @ 50c		
Total cost of Labour	€1375	
materials & Labour total	5,500	
EPS + quinn lite	5,500 + 19,250	24,750
Total for EPS System		**€24.750**

Table 4.3 Wall Cost Analysis

4.8 Analysis

From the cost analysis it can be seen that the cost of traditional foundation is more expensive than that of the passive slab that was used. The main reason for this is the reduction in concrete in the passive slab foundation. Also there are various elements like the foam glass blocks for cold bridge elimination that do not need to be incorporated into the passive slab.

The breakdown of the foundations show that the passive slab is around 25% less expensive compared to that of a traditional slab.

In relation to the wall construction the cost analysis shows that the EPS System is marginally more expensive but in the same financial region. With the potential

benefits with the EPS system, it suggests that it is a more financially viable construction method.

4.9 Conclusion

The case study has highlighted several cost issues with the passive house construction. It has also identified a few barriers in relation to the construction of a passive house. The cost breakdown analysis identifies cost comparisons between the passive house and traditional construction. The researcher would like to stress that these costs are analysed to specific dimensions and design. Costs will vary with changes in design and fluctuations in labour.

Chapter 5

Findings

Chapter 5 - Findings

5.1 Introduction

The main aim of this study is to identify and understand issues and factors that relate to the Passive House standard being introduced as a building regulation in Ireland, and also to highlight the similar cost comparison between the two types of construction. Two methodologies have been employed, the case study and Qualitative data collection through the use of interviews.

The following are findings from both the Qualitative data and the case study.

5.2Qualitative findings

Certain abbreviations have been made in order to best present these findings. The letters *P* stands for Participant, and the numbers between 1-10 relate to the interviewee code number that was listed in Chapter 3 Research Methodology. E.G Interviewee 1, Peter Keavney = P1 and also findings from the case study will be labelled CS.

From analysing the qualitative data, certain themes emerged. Themes will be presented under one of the two following headings;

5.2.1 Future Development of the Passive House standard in Ireland

1. Importance of energy conservation to clients
2. Planning Barriers
3. Flaws in the BER System
4. Local material sourcing
5. Zero carbon by 2015. Gone beyond Passive standard
6. Importance of trained and competent management
7. Market Penetration
8. Part "L" Draft building regulations 2011
9. Future progression of the standard in Ireland
10. Designing

5.2.2 Cost issues with Passive House construction

1. Building envelope
2. Windows
3. Heat recovery system
4. Energy Savings
5. Financial substitution
6. Cost comparison of two standards
7. Opportunities for reducing cost

5.3 Future development of the Passive House standard in Ireland

All participants spoke about the future development of the Passive House standard in Ireland. There were various sub-themes that emerged from the qualitative analysis under this theme that test the research hypothesis.

5.3.1 Importance of energy conservation to clients

All interviewees were probed on the importance of energy conservation and the importance it had on clients and potential house builders. One in particular stated that

"In the new build market it has a big importance because people have to build in accordance with the building regulations anyway. But also new build clients have a different mindset; they seem to think more about energy efficiency"P3

When asked on the area of energy conservation and the importance it had on his clients one interviewee stated that:

"At the moment it has got a lot more important to clients. It would be about 50-50 with traditional build, but anybody who goes with traditional build is now beginning to insulate a lot more".P5

He stated that the importance of cost plays a major role in the decision the client makes.

"Most people would want to have the energy efficient design, but when they way it up against the cost they realise that it is a lot more expensive and have to go with the traditional design. Cost is still a major issue with clients". P5

He also pointed out that with the *"the external windows and doors being so expensive, with them being triple glazing they are a lot more expensive compared to the traditional windows which has a big impact on the client's decision". P5*

When asked on the importance of energy conservation to his clients, one participant stated that "*for a majority of his clients it is very important. People want to make a difference*". He also believes that the Passive House standard is growing in Ireland. He stated that

"Clients have started to generally look for a design of an energy efficient building. Some would usually have some research done themselves on the various options or solutions that are out there. That is why I believe the passive house standard will begin to grow in the Irish market. It is generally the best solution as the savings the clients will make over the life of the house will persuade them to go down the passive route. People are giving out about the banks and paying back mortgages. But what they seem to forget is the amount that they are paying to heat their homes and pay the electricity bills". P6

5.3.2 Planning Barriers

At a local authority level, participants generally agreed that there was a need for change in the planning system if the Passive House standard is going to develop and become common practice in Ireland.

This was also one of the findings from the Case study during this research and the difficulties that the original design had at the planning and design stage of the project. Some of the alterations that needed to be made did not suit the passive house design. CS

One of the interviewees spoke about a need for passive house designers to be on the planning authority because they understand the difference between traditional and passive construction.

"There has to be maybe, Architects or Passive designers introduced to the planning system because they would understand certain differences between traditional design and the passive design. For instance, traditionally all houses were in alignment with the road but the passive has to be in a different orientation, also a lot more glazing should be allowed and so on."P1

Another interviewee highlighted that the current development plan is currently being reviewed and that there will be a new development plan in January 2011. He also believed that the planning authority look favourably on energy efficiency and sustainable development.

"*We are proactive and positive towards energy efficiencies that are tied in with a dwelling house and new energy methods and all of that so it is really biased going down that road. We are reviewing the development plan at the current time and we will have a new development plan by January 2011 that will be all geared towards sustainability." P4*

5.3.3 Flaws in the BER System

One important theme that emerged in relation to the development of the standard in Ireland was that the BER system does not look favourably on the Passive House, in relation to the software that is used to calculate the BER rating. Interviewees were critical in relation to the DEAP software that is used in the calculation of the Building Energy rating of a Passive house.

"A big element of the DEAP software is that it looks very favourably on a very efficient heating system such as a boiler and a very effective control system that would be zoned. There is certain bonus points you could say for having does. This is a disadvantage in relation to a passive house as there would usually be no heating system. Also when the assessor inputs the Heating system of the passive house such as the heat recovery, it assumes that it uses direct electricity from the grid even do it is very little usage it is still a big minus for a passive house." P11

Also the interviewee spoke on research he had done on the BER calculations and the method that is used. He believed that the government would take as much as they

could of the passive standard and place them into the regulations without making the Passive standard a regulation.

"I believe the government will take as much as they can from the passive standard. I don't think it will be introduced do because of a few various reasons. One in particular is the method we use in Ireland under EN 13829 for air tightness. We use method "B" which is a totally different method to method "A" which the Germans use and a few other European countries". P11

One interviewee also stated that *"I feel the BER System is practically done with as far as I'm concerned."P1*

"The government have invested too heavily on this system to admit to them making a mistake. It is a pity because it is holding the development of the passive standard back."P3

5.3.4 Local material sourcing

A majority of participants felt strongly about local material sourcing. They believe that Passive House standard should be achieved with local materials and that it is the only way the standard can become common practice in Ireland.

From the case study it was found that major elements such as the windows and ventilation system were sought from different countries such as Austria and Germany respectively. This is a big issue in relation to the standard being developed in Ireland. CS

One of the interviewees spoke about how he believed that a person could build a passive house from local materials and that the certification process is a minor specification.

"We could start building passive houses from local materials. The certification process is rubbish. A sticker on the window doesn't say that it can't be produced in Ireland. Munster joinery is claiming they are developing passive house specification windows. This would be a big help in the progression of this type of construction."P1

One interviewee stated that if Irish manufactures started to develop passive certified services and materials it would probably make them cheaper.

"*I suppose it would and the insulation as well if they started to produce it, if there was a bigger market for it that would reduce the cost"P5*

Another interviewee stated that *"you can't buy the airtight rubber seals for the ventilation system in Ireland which would also reduce the cost if they were produced locally."P2*

5.3.5 Zero carbon by 2015. Gone beyond Passive standard

A majority of the interviewees spoke on the governments aims for the future and were the passive house standard could play a major role in its outcome. One interviewee spoke on the targets of the building regulations and the future reductions that the government is aiming for.

"In the 2008 regulations there was an aim of 40% reduction. By 2011 and so on there is an aim of a 60% reduction in carbon emissions. These will be revised in 2012 and then by 2015 we hope that it will aim for zero carbon building regulations which will mean Passive standard and beyond."P1

He also spoke about the importance of reinvestment. *"It's all about reinvestment especially at local authority level. It's not about taking the savings and spending them in another area. The savings should be put back into the sustainable development projects."P1*

5.3.6 Importance of trained and competent management

One important theme that emerged was the importance of getting skilled labour and proper trained management in order for the passive house system to be a success in Ireland. Various interviewees spoke about a proper scheduling of works. Also they spoke how there should be funding for tradesmen and management to go to countries such as Germany and get trained and shown step by step construction works in different climates. One interviewee stated that

"It is not to be a FAS course; these people should be allowed funding to go and get trained and shown every detail of passive house construction. They should be trained on how to manage and plan a passive house project."P1

Another participant was also asked on the area of constructing a passive house and the difficulties that may arise. He stressed how important it was to have proper management of the project, better training of skills and labour.

"The major barrier in the construction process of a passive house is that it needs a proper and functional work schedule. Labour has to be trained to use these new building methods. Proper management of the project is the most important issue during the construction stage"P3.

Another interviewee also commented on the importance of the workman ship especially around the openings such as windows and doors in order to successfully create an airtight envelope.

"However it can be difficult to seal the windows and door frames in order to make them airtight. Close supervision along with proper workmanship is a big help. Ideally we would try limiting the openings to as little as possible in our designs such as ductwork and so on. It makes it a lot easier in the long run during the construction stage".P6

5.3.7 Market Penetration

The participants also spoke about how they felt the standard would become popular in the Irish market. A majority believed that the private sector holds the key to the advances of the standard and the potential for a big impact on the Irish Market. One interviewee stated that

"The private sector holds the key really to the development of the standard. The big reason for this is that at the moment it is really a social decision. People want to do it for themselves for financial reasons and also for the environmental side of things. If it grows in this sector then the government will be under pressure to maybe change the BER system and give funding towards retrofit projects and so on. It is

better to upgrade one house to passive standard than to spend millions doing a few houses and just upgrading with traditional methods that is in place now." P1

Another also highlighted that one of the major markets in energy efficient design is the self build market.

"The reason for this is that people who are building one off houses out the country tend to be using a bigger design. They are not connected to a gas supply so the usual fuel source is oil. This is one reason why these potential clients are beginning to prioritise energy conservation because of fuel prices".P3

Another interviewee felt that the price of passive house construction would fall if there were more passive houses being built in Ireland. He also commented on the opportunity that there is to create a home that has surplus energy that you could sell back into the grid, making the house more of an investment.

"It's really ambitious but the aim would be to create housing that makes surplus energy from renewable that would be self sufficient." P1

5.3.8 Part "L" Draft building regulations 2011

Another theme that emerged was discussions on the 2011 Draft regulations. Nearly all participants spoke about theses and had a good understanding of the alterations that were made. One common topic that arose was on the matter of the airtightness. Most of the interviewees felt that it was a bit lacks and it could have been reduced even further. One interviewee spoke about the reason for this.

"They are good in general but one criticism I would have is that they lack in the airtightness area of the regulations. I felt that they could have reduced it even further"P3.

"The reason for this is that there is nervousness in the department about the airtightness and the strict use of the ventilation systems. They don't want to force people into having to use them. It's fine for someone who is willing to maintain it and look after it but some people mightn't be into that area."P3

5.3.9 Future progression of the standard in Ireland

When discussing about their opinions on whether they felt the passive house standard would be incorporated into the Irish building regulations a majority felt that

it probably won't become fully passive but that it will definitely be moving in the direction of a passive design.

One participant felt that the passive house design would probably be too expensive to expect everybody to build to the standard.

"Yes it could do, I don't think it will become fully passive but it is definitely moving closer to it. I don't think it will be made fully passive, it's too expensive to expect everybody to do it but it will get closer and closer". P5

A majority of interviewees felt that the passive house standard will have a major role to play within the future building regulation. However, it can be seen that they do not believe that the regulations will become fully passive standard.

One participant also expressed that he believes the passive house standard will eventually prove more economical compared to the traditional construction standards.

"For me the passive house standard is a more financially viable solution compared to that of the traditional build. The savings that can be made on an annual basis speak for themselves. Also the emphasis put on energy efficiency by the government is playing a huge role in the development of the standard. We can see from the 2011 draft of the new building regulations that it is definitely moving in the direction of the passive standard".P6

He also commented on that when the clients realise the savings they will make in the long run that it doesn't take much convincing in order to get them to go the passive route.

"*As soon as they realise they are going to make vast annual savings by going with the Passive House standard it doesn't take a lot of convincing, it's not a hard sell at all". P6*

One interviewee spoke about how he felt that the passive design will be exceeded by 2015.

"For me the passive standard will be exceeded by 2015 and hopefully zero carbon can be a realistic target."P1

Also he spoke about how there should be more retrofit funding brought in, in order for Ireland to meet there reduction targets.

"For me there should be a big emphasis put on the retrofit side of the sustainable development. The upgrades should be brought as close as possible to the passive standard"P1

He also highlighted how *"Fingal county council were one of the first local authorities to raise requirements for planning permission above the national level, they set the trend for the local authorities to develop low energy housing."P1*

One interviewee stated that he feels that the passive is the correct approach for the future.

"For me it is the correct approach as it is the way forward. Unfortunately I don't see it becoming a regulation in Ireland which is a pity"P3.

5.3.10 Designing

Another also spoke on the matter of the difficulty in designing a passive house. When asked on his opinion on how difficult it is to design a passive house compared to that of a traditional build he said that:

"it's not really that difficult to design a passive house, it's just a little bit different to be honest, you still have to look out for the same things, its tested probably more but it's not really that hard to design".P5

The participant also commented on the different construction issues of a passive design compared to the traditional build. He pointed out that obviously the air tightness but also with the structure it is a bit different.

"*yes well I suppose with the structure there's more probably especially with the way our client went with the quinnlite blocks there is a bit more calculations involved in it because you have to check all the walls to see if they will stand up to weight, there is a bit more to it."P5*

Another interviewee was also probed on the difficulty to designing a passive house in accordance with the passive house guidelines. He felt that it was difficult to design if it was a retrofit project but not so difficult to do for a new build. The major difficulty arises if the Passive house standard is not prioritised from the start.

"A good design will make the standard achievable. Good planning from the offset which prioritises simplicity such as minimum external surfaces will result in successful completion."P3

Another interviewee also outlined that another major design issue would be the foundations.

"The foundations also would be a lot more difficult during the construction. The way you have to do them, with the concrete on top of them then. They are a lot more different. The ways you have to do them then the raft foundations are a lot different to the standard bearing". The most difficult factor of the design from my point of view would probably doing the foundations and checking all the walls for stability would be".P5

One interviewee felt that if you can't build a passive house in the Irish climate then you should get out of the building industry.

"If you can't build a passive house in the mild Irish climate then you should get out of building altogether. It is only difficult when you have severe climates in winter and summer like other countries have."P2

5.4 Cost issues in relation to the Passive versus Current Building regulations.

5.4.1 Building envelope

Another major theme that emerged was the importance of the complete insulated and airtight building envelope. From the case study it can be seen that the cost difference between the two standards is quite marginal. One interviewee stated that they usually estimate it at about 10% extra but that from his experiences he has just seen very marginal difference.

"We usually go on 10% but at the current time I have only seen very marginal differences in the cost. You should be able to build a passive house for the same price really."P1

Another interviewee said that the cost between some of the passive construction and traditional is very similar. He stated that it can even be cheaper to construct to the passive design.

"The difference lies in the type of construction method. It's about building different as opposed to building more expensively. Labour and materials should be the same; it's just about a learning curve." P8

One interviewee stated that *"if someone asked me in the morning to build a house, I think I would be able to build a passive house cheaper than a traditional house."P8*

5.4.2 Windows

From the case study it was highlighted that one of the major cost differences between the passive house and traditional build was that of the windows. It can be seen from the study that the windows were between fifty to sixty percent more expensive compared to the Irish building standard windows. Nearly all of interviewees spoke of the need for local Irish manufactures to start producing triple-glazed windows that would meet the specification for passive house build. One interviewee stated that

"Windows are a major issue with this type of construction. They are far more expensive and at the moment they have to be brought in from Germany and Austria. All of this creates a long waiting period which might affect the decision of the clients going down this route." P1

On the issue of local manufacturing one client outlined that there is an Irish company claiming that they can produce this product. He stated that
"Munster joinery is claiming that they are able to produce this kind of window. This would be a big boost for the standard in Ireland."P2

5.4.3 Mechanical, Ventilation Heat recovery system

From the case study it can be seen that one of the major cost elements of the passive house is the whole house mechanical ventilation system with very efficient heat recovery.

When asked on his experiences of major cost elements in the design of a passive house one interviewee believes that in some cases the major elements work out to be cheaper.

"If you take the Mechanical Ventilation with Heat Recovery system for example, here is a service that incorporates the heating, ventilating as well as recovering the heat all in one product. In traditional buildings the clients might have had the usual space heating appliances with radiators, boilers, gas, ECT. The passive system reduces these appliances into one product which would be on par if not cheaper than the traditional products. Also with the grants that the SEAI have introduced it does

make the energy efficient route an awful lot more economical. The MVHR system would be in and around six grand but it varies with size obviously". P6

Also another participant outlined that

"The cost of the ventilation system would be around six grand, you can get them for around four grand but to get a proper one would set you back around six."

One interviewee stated that he has seen them put into houses for around two and a half but that a correct figure would be around six grand.

"I've seen them put in place for as little as two and a half grand but six would be a better figure in the passive house case." P1

5.4.5 Energy savings

This was a major talking point with a majority of the participants. One interviewee spoke on how the reduced energy bills also have a social as well as an economical benefit.

"People will have more disposable income in their pocket. Less of a risk for landlord's relation to rent and so on." P1

It can also be seen from the case study that there is substantial savings to be made from reduced fuel and energy bills.

"I put 200 euro worth of oil in the tank and it should nearly do me the year. I hope!"

5.4.6 Financial substitution

Another theme that emerged from the interviews was that in some areas building materials cost more but would balance out from savings in other areas of construction.

One Interviewee stated that:

"An example of this would be in the foundations, where a lot of insulation is used thus making a saving on the amount of concrete used" P8

Another interviewee stated that:

"Although your spending on the ventilation and heat recovery it should balance itself out with the removal of a primary space heating system such as radiators and boilers"P3

5.4.7 Cost comparison of two standards

In relation to the cost comparison of the two types of construction, a majority of the interviewees believed that you can build a passive house for the same price as a traditional house. One participant stated that

"We are working hard on trying to get the price of the passive house down to that of standard build and I think we are there."P8

When asked about the cost comparison of the passive house standard compared to the traditional build in Ireland another participant believes that the overall extra cost of a passive house compared to a traditional house would be definitely in the region of 10% to 20% more expensive.

"Well it definitely would be 10 to 20% dearer than a traditional build."

He also outlined what elements would add to the extra cost of the passive house over traditional build.

"*well windows I suppose, the external windows and doors are definitely more expensive, obviously insulation would be more expensive, the ventilation system wouldn't be that more expensive, most people are going with the heat recovery even in the traditional build anyway so that wouldn't really act as an extra cost over traditional design."*

Another participant finished up on this theme by pointing out that overall the cost of the Passive House projects he has been involved on have been in the same financial region as traditional houses built to the Current building regulations.

"Most *of the projects I have been involved in have usually been on par or in the same region as traditional built projects. A little selling point that we use is that we incorporate a basement level into the build which increases the floor area so it brings down the square meter age of cost"*

5.4.8 Opportunities for reducing cost

Interviewees were asked on their recommendations for reducing the cost of the passive house construction. A majority found it hard to see were this could be achieved. However there were a few recommendations made. One interviewee stated that it is:

"Important to prioritise from the start. Simplicity goes a long way to reducing cost. Minimum external wall area will make it easier and cheaper to build. So it really goes down to having a good design from the start."P3

Another felt that the potential for reducing cost could lie in the local manufacturers.

Locally produced materials that fit the passive house specification would reduce the cost by reducing import costs.P3

One major concern another interviewee had was in relation to the Passive House certification.

"Theses strict regulations are based on Germany and Austrian climates which have very cold winters and high moisture summers. The regulations need to be reduced for the Irish climate. This would mean that insulation specifications could be reduced which in total would reduce the cost of the construction process".

He also commented on the Passive house institute in relation to their certification process.

"You see it is a business to them. We pay them to get our products certified. If I told them that our ventilation system scored a COP of 4.5 and it wasn't tested by a certified PHI Certifier they would ask us to reduce it by a certain percentage like 12.5%".

Another interviewee was asked on his recommendations to reduce cost on the passive standard. He struggled to see were cut backs or reductions could be made. He pointed out that it is really down to materials.

"It's really material and stuff, it's kind of hard to reduce material and that kind of thing. I suppose the more people that build them the more the material would come down."

5.5 Conclusion

This chapter has highlighted the major findings from the interviews and case study. The researcher feels that the findings outlined in the chapter test the hypothesis set out at the start of the research. The findings will be discussed in the next chapter.

Chapter 6

Discussion

Chapter 6- Discussions

In this chapter, findings will be discussed in relation to relevant literature. It will discuss all emerging themes from both methodologies as well as the future development of the Passive House standard in Ireland. This chapter will also discuss recommendations for overcoming various barriers in the implementation of the standard in Ireland. Also the limitations of the study and methodological difficulties encountered as well as providing recommendations for future research. This chapter will be presented under the following headings:

- Introduction
- Influencing factors
- Barriers
- Future progression of the standard in Ireland
- Cost issues in relation to the Passive vs. Current Building regulations

6.1 Introduction

The Case study on the certified passive house and the qualitative data collection from the interviews identified various barriers that are slowing down the development of the standard in Ireland. Data that was collected also highlighted energy savings that could be made and the financial comparison of the two types of construction.

6.2 Influencing factors

One of the themes that emerged was the importance of energy conservation to the clients and main influencing factor in their decision in the type of construction they would go for. It emerged that the main influencing factor was the economical benefits that they would receive from going with the passive house standard. This was no great surprise for the researcher as during the current economical climate, clients are tightening their pockets and want to see long term benefits straight away. However this does not mean that the passive house standard will not succeed in the Irish market. From the findings from the case study it can be seen that the client's main motivation for going with the passive house was the savings he will make from reduced fuel and energy bills.

6.3 Barriers

Findings from both the case study and interviews highlighted areas in the planning systems that are acting as barriers in the penetration of the passive house standard into the Irish market. It was identified from the case study that during the planning stage, the current development plan for the Galway city area did not suit the passive house design. This criticism was also agreed by a majority of the interviewees that believed the planning board could do with the introduction of passive house specialists during the planning applications for the passive house. However with the current development plan being reviewed, which will result in a new development plan being introduced in January 2011 that will be totally geared and aimed at sustainable development, this barrier may be rectified. The new development plan will look kindly on the passive house design which will be a big advantage for the passive house over traditional build. Also it will help accelerate market penetration in Ireland.

Another barrier that was highlighted was the limited know how and lack of skilled and competent management in Ireland that are specialised in the management of a passive house project. This finding in particular is consistent with that of Kaan et al, (2006). Findings from the study showed that most frequently encountered barriers in Ireland were limited know-how; limited contractor skills; and limited acceptation of Passive Houses in the market. Findings from both studies show that there is a need for skilled and trained installers, contractors and designers in Ireland. With the Passive House Academy leading the way in Ireland that specialise in providing high quality training in all aspects of Passive House, this barrier will be rectified in the future.

Another issue that arose during the qualitative data analysis was that the Building Energy Rating system did not look kindly on the Passive House. Interviewees felt strongly that the DEAP software that is used to calculate the energy performance of a building needed to be changed in order to give a more realistic rating of the passive house. One interviewee in particular felt that this would be one of the main issues regarding the introduction of the passive house standard as a building regulation in Ireland. He felt that the government had invested too heavily into the BER system to admit to it having its flaws. It was also highlighted that the method that is used in Ireland to calculate the airtightness of a building envelope somewhat differs from that of Germany and Austria. These are just two examples of the changes that are needed to be made to the BER system in order to help with the development of the Passive House concept in the Irish market.

The problem with the lack of local window manufactures that are producing glazing that suits the specification of a passive house also arose. Nearly all interviewees felt that in order for the standard to progress in Ireland, local manufactures need to start producing products that meet the standard. This finding is consistent with that of Kaan et al, (2006). Findings from the study show that barriers that are encountered in several countries are the lack of good window components. Findings from both studies show that there is a need for local manufactures to start producing suitable window components for the passive house in Ireland. However with Munster Joinery claiming they are producing windows that meet the passive house specification this barrier may be reduced in the coming years. If the company proves a success more

companies are sure to follow in their footsteps and start producing passive house components.

Building differently was another major theme that emerged during the findings. One of the barriers highlighted during the qualitative analysis was that of the traditional building methods used in Ireland. According to Kaan et al (2006) the brick cavity wall building tradition poses challenges in several countries. In order for the development of the passive house standard to progress in Ireland the adoption of new construction techniques needs to be implemented into the construction industry. Construction workers need to get specialist training and inductions that will develop their skills on these new construction methods.

6.4 Future progression of the standard in Ireland

It can be seen from the research findings that a majority of the interviewees believe that the passive house standard will develop and become more common in the Irish construction industry. However they do not see it being introduced as a building regulation in the future. They stated that they believe the government will take as much of the passive design as they could and incorporate it into future building regulation. This can be seen from the draft part L building regulations technical guidance document 2011 that the building regulations are definitely moving towards the passive design. With the 2011 regulations being revised again in 2012-2013, there is sure to more progression of the regulations towards the passive design.

One interviewee in particular said that he feels that by 2015 the building regulations will be so close to the passive standard that they will surpass the standard. He believed that the zero carbon building regulations can be a realistic target and that the BER system will be scraped at that stage. This shows the influence that the passive standard could play in Irelands building regulations. There is sheer potential in the passive house construction that will ultimately go a long way in relieving Ireland on its dependency of fossil fuels and help meet the targets for reducing CO2 emissions.

6.5 Cost issues in relation to the Passive House Construction

It can be seen from the case study and the interviews during the research that the cost of constructing a passive house in Ireland in the current market is on par if not cheaper than traditional methods. A majority of the interviewees felt that the cost differences between the two types of construction are marginal. One interviewee in particular stated that he believes he could build a passive house cheaper than a traditional house. This finding in particular is consistent with that of De Keulenaer (2006). Findings from the study show that depending on the design it's possible to realize passive house projects with an initial cost increase of 0-15 % compared to traditional building. Also findings from Feist (2007) show that the extra over cost of upgrading a traditional house to one of passive standard could be done for a little as 8% increase of the original construction cost. Findings from the case study highlight that there was very little extra cost between constructing with the passive design opposed to going with traditional methods.

Financial substitution was also highlighted as an area that can reduce the cost of the passive construction over traditional methods. Interviewees generally agreed that if the client spent extra money in one area of the design, they had opportunities to save in other areas. An example of this was with the removal of the space heating system would help fund the heat recovery system. This finding in particular is consistent with Feist (2007). Findings from the study show that there is substantial savings to be made from the removal of the space heating system. Findings from both studies show that substitution of different elements between the two types of construction methods will somewhat balance out resulting in marginal cost differences between the two methods.

Energy savings was a major issue in the client's decision to go with the passive design in the case study. Although this was not part of the research question it still was brought up during the qualitative analysis and literature review. The financial benefit of the passive House Standard is the biggest selling point to the clients. The research into this objective proved that there are substantial operational savings to be made when applying the passive house standard over traditional build. This finding in particular is consistent with that of (Kondratenko et al, 2006). Findings from the

study show that there can be as much as 8,222kWh/year difference in savings between the two types of construction.

6.6 Conclusion

This chapter has highlighted that cost is the main social reason on why clients choose to build a passive house. It also discussed various barriers that were highlighted throughout the research findings and gave recommendations on how they might be rectified.

The chapter also established a view on were the future progression of the standard in Ireland will take it. It identifies that the Passive House standard may not be introduced as a building regulation but that it will have a big influence on future regulations.

Various cost issues have also been highlighted that show that the passive house construction methods are just as financially viable as the traditional methods.

Chapter 7

Conclusion & Recommendations

Chapter 7 Conclusion and Recommendations

7.1 Aim and objectives

Firstly a brief discussion on whether the overall aims and objectives were achieved. This study was more or less completed within the designated time frame. Given the allocated time frame and resources available to complete this research, the researcher is satisfied that the overall aim and objectives of the study have been achieved.

7.1.1 Aim of research

The aim of the dissertation was to investigate whether or not the Passive House Standard is a more financially suitable method of construction in Ireland opposed to that of the current building regulations technical guidance documents. Another aim was to investigate whether or not the future development of the standard in Ireland will see it being introduced as a building regulation.

7.1.2 Research objectives

- To identify cost related issues of various elements of the Passive House construction compared to that of a typical dwelling in Ireland.
- To identify potential energy savings in the Passive House Design.
- To identify barriers that are slowing down the development of the passive house standard in Ireland

7.2 Achievement of aim and objectives

Overall the author of this research feels that the aims and objectives set at the start of the study have been achieved. The study has identified the barriers that are slowing the development of the passive house standard in Ireland. The research has also established cost comparisons between passive house construction and the traditional construction methods as well as establishing potential energy savings that can be achieved through the passive design

It confirmed through the interviews and the literature review that there are numerous barriers that are effecting the development of the standard in Ireland. Barriers such as local manufacturers that produce materials and components that suit the passive house construction methods are scarce. Also problems with the BER system were highlighted and discussed in this research.

The case study also highlighted issues in regard to the cost differences between passive house construction and traditional construction methods. However the author believes that in relation to cost analysis on the case study that it has to be noted that it is on a specific case study and is not a guaranteed breakdown of passive houses in general.

The overall result of the research is that the Passive House construction is a more financially suitable method of construction in Ireland opposed to that of the current building regulations technical guidance documents. The research also found that the Passive House Standard won't be introduced as a Building Regulation in Ireland but that it will heavily influence future building regulations.

7.3 Limitations during the research

The researcher believes that the research targets were both realistic and achievable. However gathering data on the cost breakdown proved difficult as it is a personnel issue between the client and the contractor. However the researcher believes that the methodology used to calculate the cost breakdown is generally accurate and as a result formed a good base of this research that tested the hypothesis.

7.4 Recommendations:

The author believes that the hypothesis that was set at the start of the research has been strongly supported throughout the study. However the author believes that there needs to be further research into the future development of the passive house standard in Ireland. The researcher hopes that a majority of the barriers outlined in this research will be rectified within the coming years which would boost passive house market penetration in Ireland.

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APPENDIX A – Interview Probes

Interviewee Background

As an introduction to the interview could you give a brief discussion on your Profession, Background, and Experience in the area of sustainable construction/development?

Energy Conservation

Importance to your Clients?

What are the Main influencing Factors In your clients Briefs?

- Cost
- Performance
- Design

What is your opinion on the current state of sustainable development in Ireland?

Barriers in the Development of the Passive House Standard

In your opinion are there certain barriers in the development of the Passive House Standard in Ireland?

How do you feel these barriers may be overcome in the Future?

Construction Differences

What are the main differences in constructing to the Passive House Standard compared to constructing to the Current Building regulation?

From your experience, what is the most difficult element of the Passive House Construction?

Cost

From your experience what are the major cost elements of a passive house?

What is your opinion on the cost comparison of the two types of construction?

Have you any recommendations on reducing the cost of construction?

Future development of the PH Standard

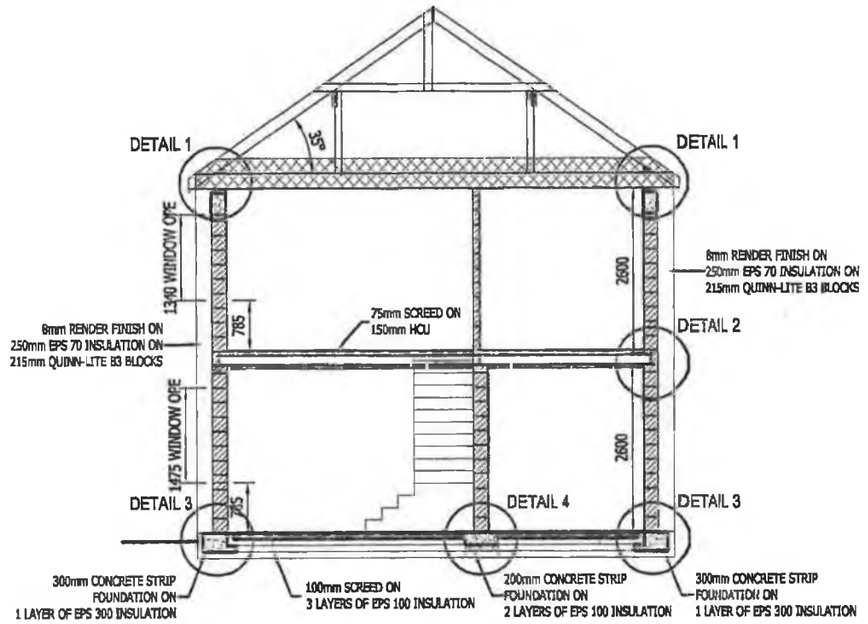
What are your views on the current situation of sustainable construction in Ireland?

Do you think the passive house standard will be introduced as a building regulation in the future?

Do you see the Passive House penetrating the Irish market in the coming years?

Appendix B - Passive House Drawings

FRONT ELEVATION



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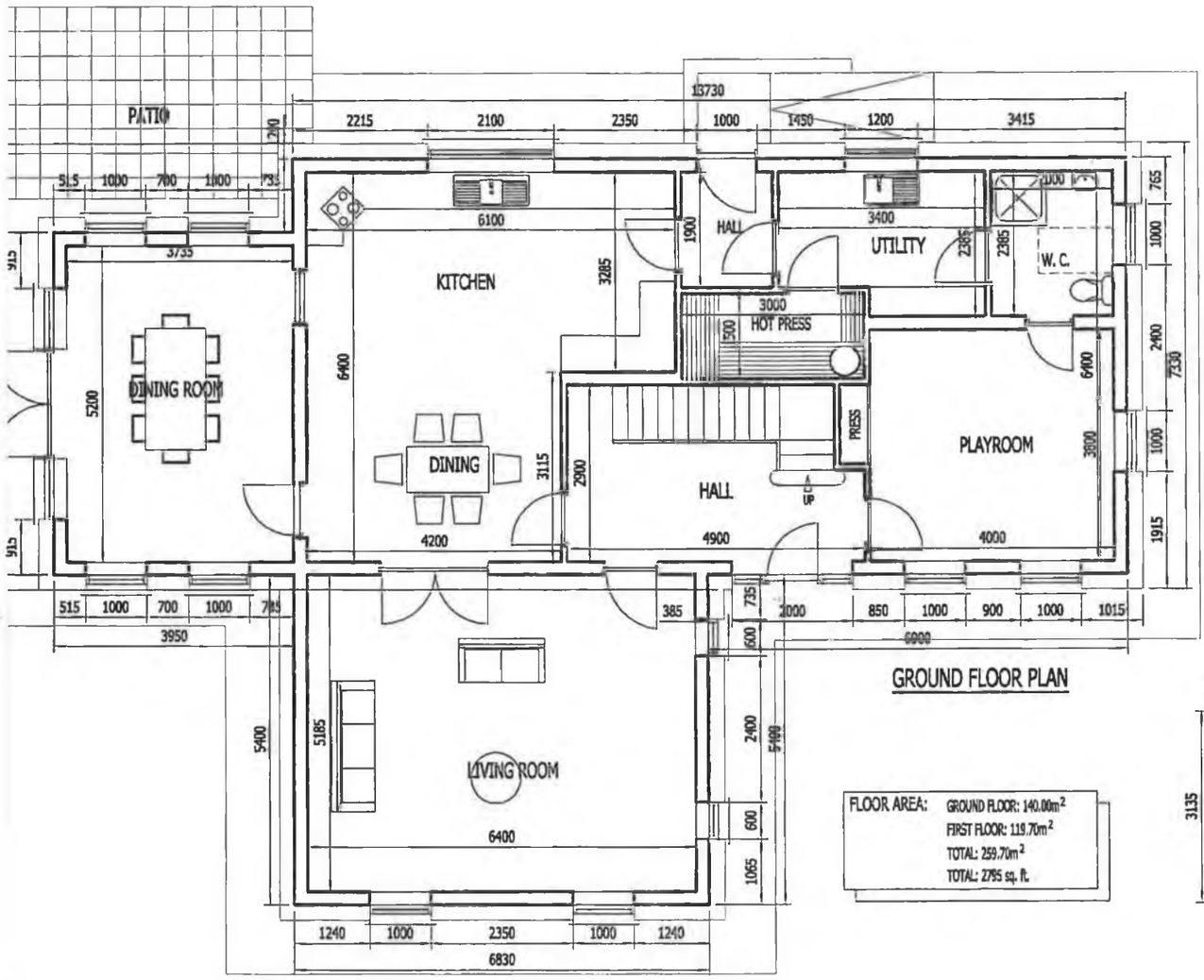
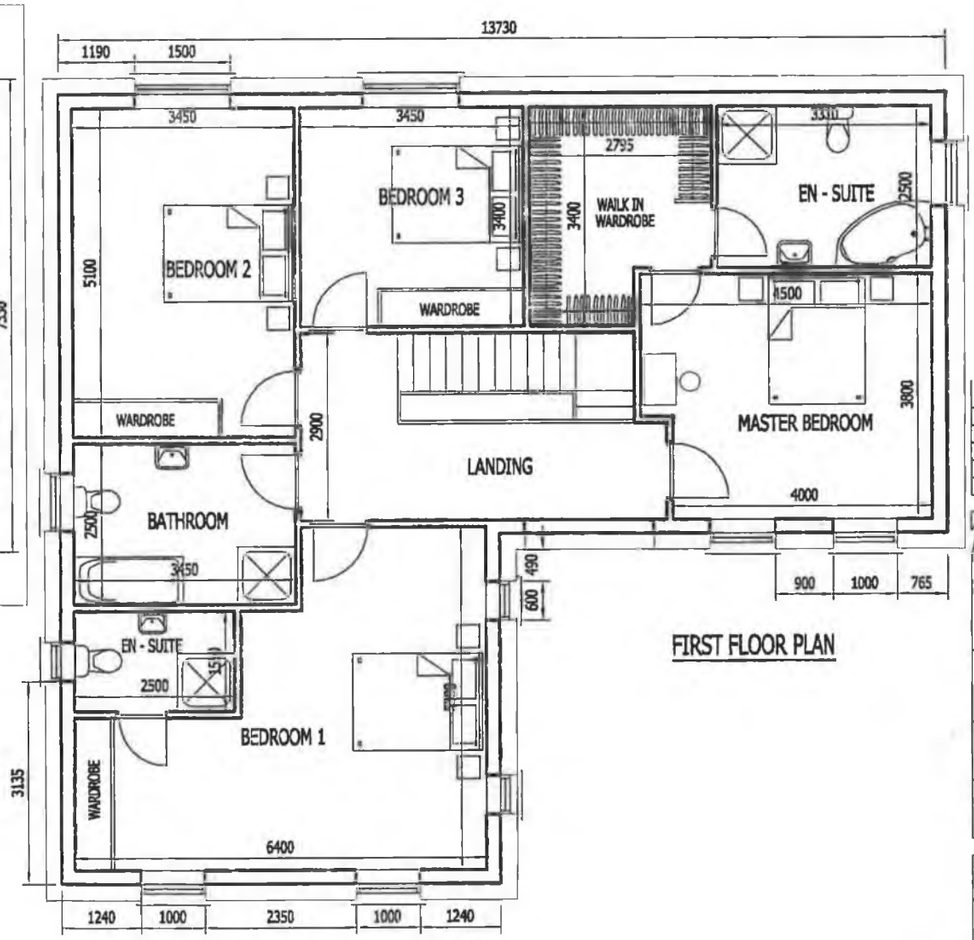


GROUND FLOOR PLAN

FLOOR AREA: GROUND FLOOR: 140.00m²
FIRST FLOOR: 119.70m²
TOTAL: 259.70m²
TOTAL: 2795 sq. ft.



FIRST FLOOR PLAN

E	WALLS REVISED FOR QUINN-LITE BLOCKS	APRIL 2009
D	CAVITY WIDENED/CHIMNEY REMOVED	FEB. 2009
C		
B		
A	BOX EAVES/OVERHANGS REMOVED	SEPT. 2008

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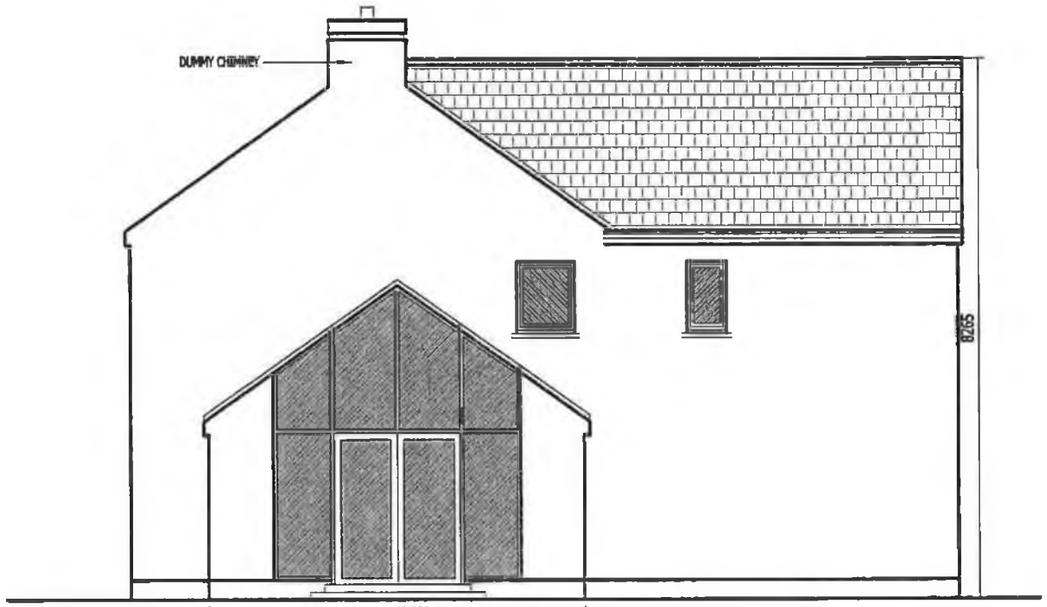
Project:
PROPOSED DWELLINGHOUSE AT AHAPOULEEN, MAREE, CLARINBRIDGE, CO. GALWAY

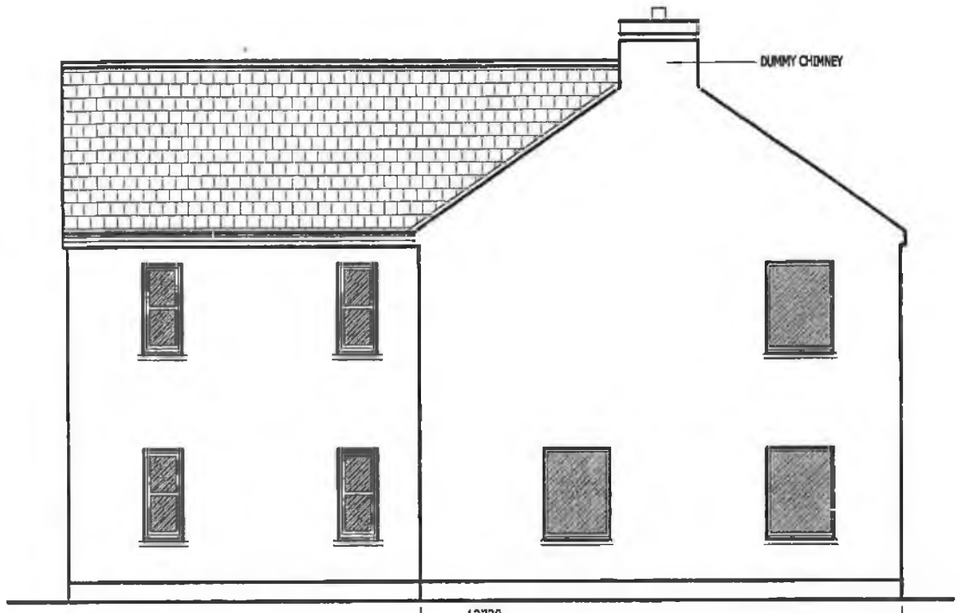
Drawing Title:
PLANS, FRONT ELEVATION & SECTION

Client:
MR. GEAROID HANNIFFY

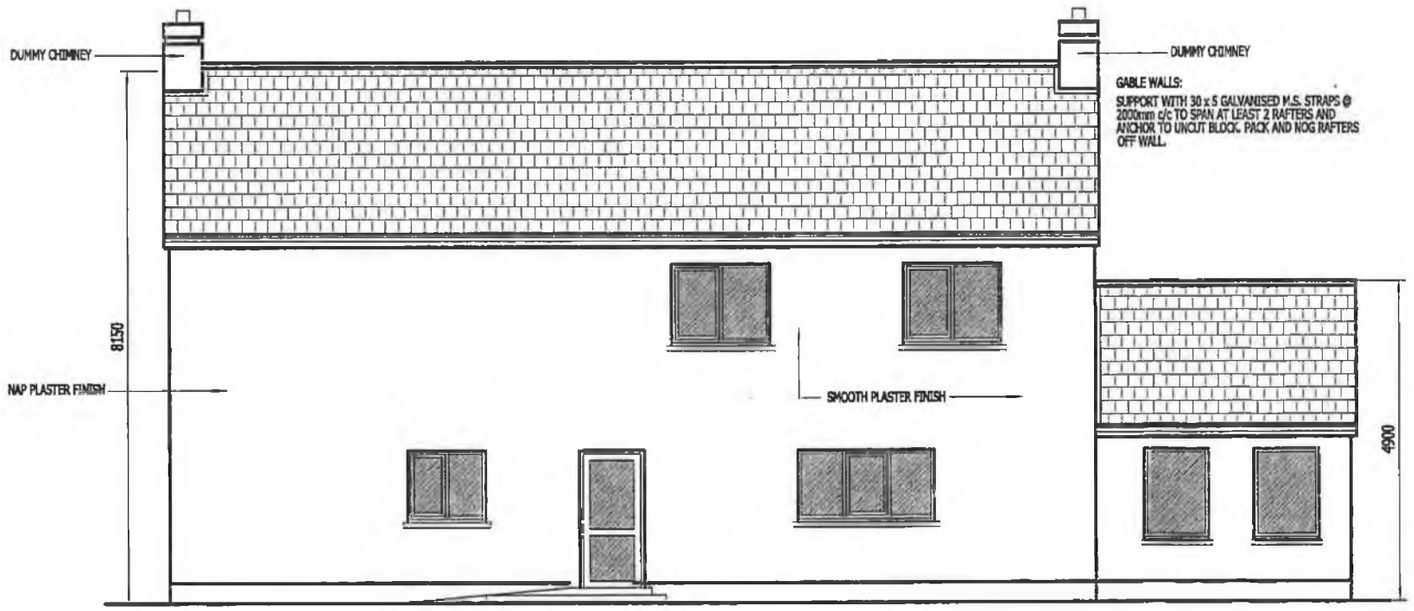
Date: SEPTEMBER 2007	Drawn By: S.H.
Scale: 1/100	Checked By: S.H.
Drawing No. 07139-02	Rev. E



SIDE ELEVATION (West)



SIDE ELEVATION (East)



REAR ELEVATION

Fire Safety :

1. All bedrooms to be provided with windows in accordance with the provisions of section 1.5.6. Technical Guidance Document B as follows :

(A) The window should have an openable section which can provide an unobstructed clear ope area of at least 0.33m² with a min. width and height of 450mm

(B) The bottom of the window opening should be not more than 1100mm and not less than 800mm (600mm in the case of a rooflight) above the floor, immediately inside or beneath the window or rooflight

(C) In the case of a dormer window or roof light, the distance from the eaves to the bottom of the opening section of the rooflight, or, where the window is vertical, the vertical plane of the window, should not exceed 1.7m, measured along the slope of the roof.

(D) The ground beneath the window should be clear of any obstructions, such as railings or horizontally hung windows, and should be suitable for supporting a ladder safely. The area should be of sufficient size to provide a place of safety from a fire in the house.

Fire Detection and Alarm Systems:

A fire detection and alarm system to be provided in accordance with B.S. 5839 : Part 6 : 2004

NOTE:

ALL WORKS TO COMPLY WITH THE BUILDING REGULATIONS 1990/2000 AND BUILDING CONTROL ACT. 1991, CURRENT IRISH STANDARDS AND CODES OF PRACTICE.

ALL WORKS TO COMPLY WITH PART M (REVISED), PART L (2002) AND PART F OF THE BUILDING REGULATIONS.

ALL WORKS TO BE CARRIED OUT IN ACCORDANCE WITH STRUCTURAL ENGINEERS DESIGN AND SPECIFICATION.

PROVIDE VENTS TO ALL HABITABLE ROOMS. PROVIDE A VENTILATION OPENING HAVING A TOTAL AREA NOT LESS THAN 6500mm² IN ALL HABITABLE ROOMS CONTAINING HEAT PRODUCING APPLIANCES.

EVES OPE EQUAL TO A CONTINUOUS STRIP 15mm WIDE.

PROVIDE RADON BARRIER PROTECTION UNDER FLOOR.

THE MAIN DWELLING ENTRANCE SHOULD HAVE A LEVEL AREA AT LEAST 1.2m WIDE x 1.2m DEEP. THE APPROACH TO THE LEVEL AREA SHOULD HAVE A CLEAR UNOBSTRUCTED WIDTH OF AT LEAST 900mm.

THE MAIN DWELLING ENTRANCE SHOULD HAVE A MINIMUM CLEAR OPENING WIDTH OF 800mm.

MECHANICAL EXTRACT VENTILATION CAPABLE OF EXTRACTING AT A RATE OF 15 LITRES PER SECOND TO BE PROVIDED IN ALL BATHROOMS AND W.C'S WITH NO WINDOW.

THIS DRAWING TO BE USED FOR PLANNING APPLICATION ONLY.

E	WALLS REVISED FOR QUINN-LITE BLOCKS	APRIL 2009
D	CAVITY WIDENED;CHIMNEY REMOVED	FEB. 2009
C		
B		
A	BOX EAVES/OVERHANGS REMOVED	SEPT. 2008

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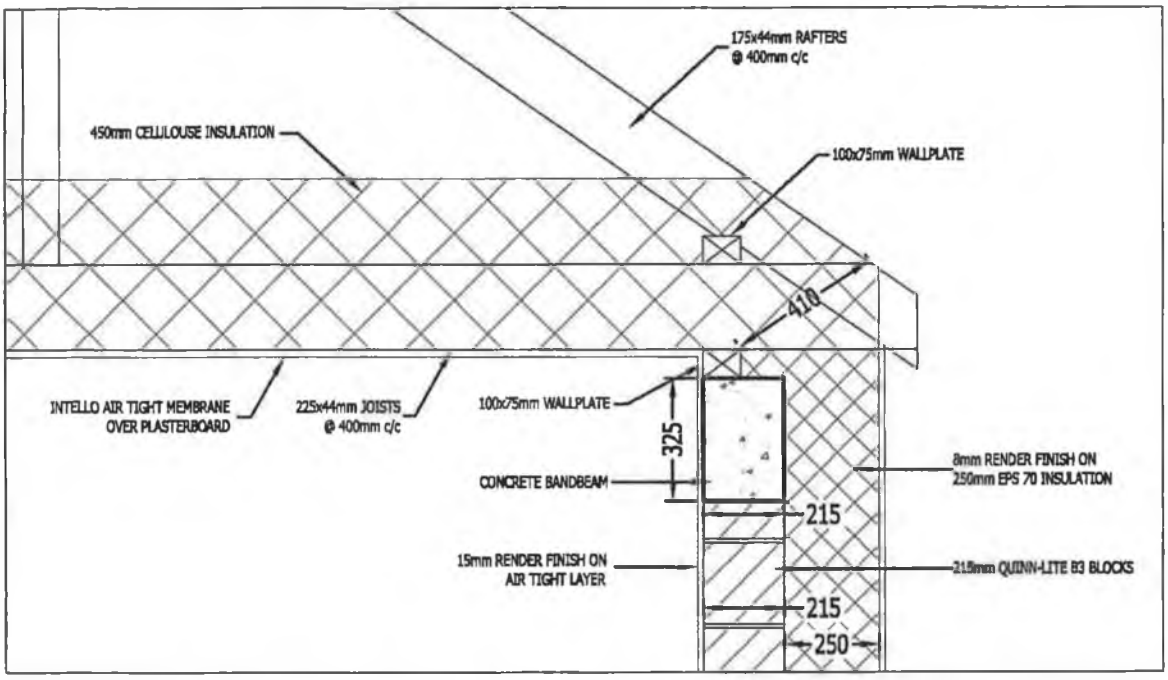
Project:
PROPOSED DWELLINGHOUSE AT AHAPOULEEN,
MAREE, CLARINBRIDGE, CO. GALWAY

Drawing Title:
ELEVATIONS

Client:
MR. GEAROID HANNIFFY

Date: SEPTEMBER 2007	Drawn By: S.H.
Scale: 1/100	Checked By: S.H.
Drawing No. 07139-03	Rev. D



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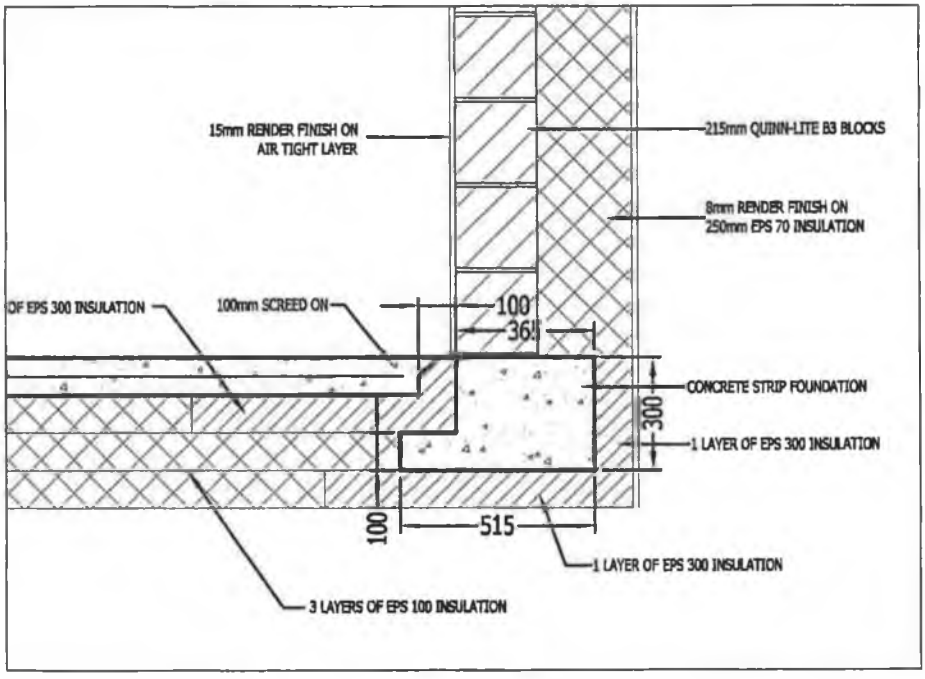

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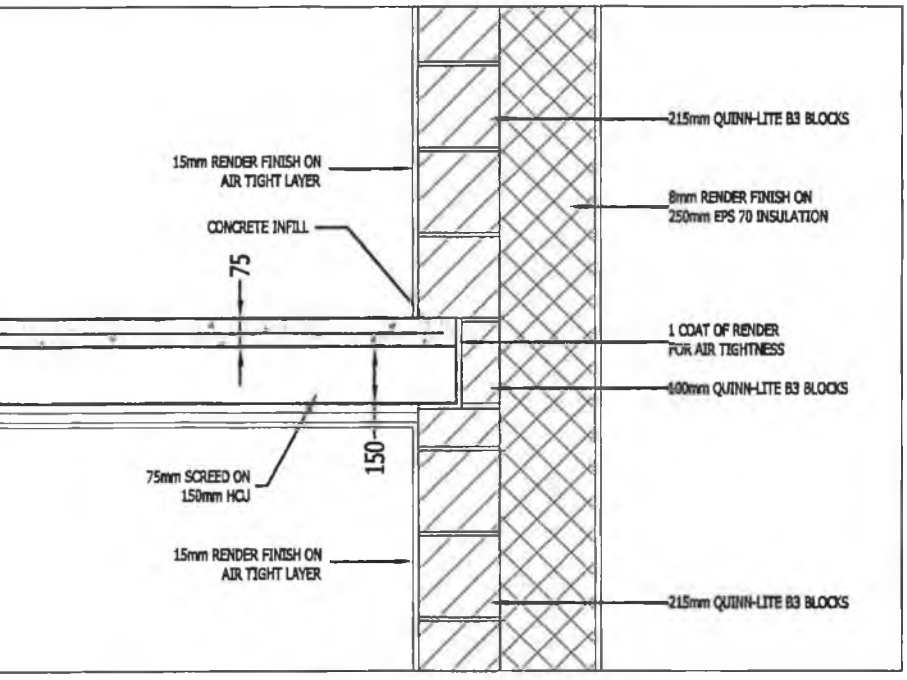

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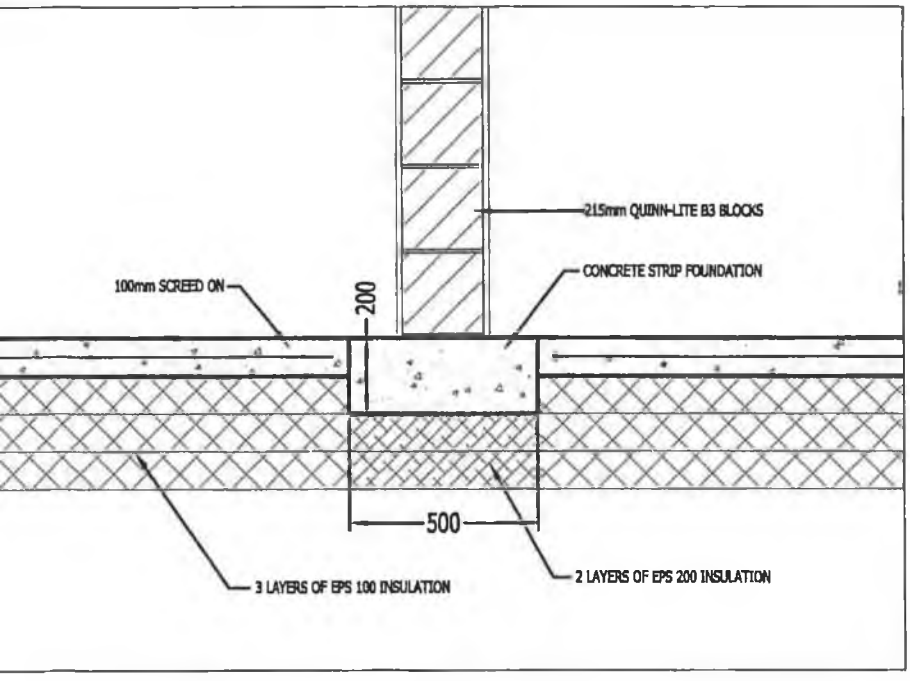

DETAIL 4

E
D
C
B
A

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Project:
PROPOSED DWELLINGHOUSE AT AHAPOULEEN, MAREE, CLARINBRIDGE, CO. GALWAY

Drawing title:
HOUSE DETAILS

Client:
MR. GEAROID HANNIFFY

Date: JUNE 2009	Drawn By: S.H.
Scale: 1/20	Checked By: S.H.
Drawing No. 07139-20	Rev. -