2013-10

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Abstract

Large scale, non-invasive and largely off site modular building retro-fit solutions offer scalable opportunities to assist in climate change adaptation for existing residential built stock. In Ireland, local authority housing (LAH) hosts a large proportion of the existing domestic built stock. This paper outlines the basis for development of a methodology to catalogue and analyze existing LAH developments in Cork City based on their thermal energy performance. This process informs location, elevation, orientation, superstructure and current energy rating. Firstly LAH existing typologies are statistically analyzed to produce a generalized house type representation of a mean terrace typology. Climate data is measured at a number of site specific locations; variations within the data are identified and comparisons are analyzed. Weather files generated for various locations are inputted into the statistical energy model and pre-retrofit findings are analyzed. This tests the efficacy of the climatic data files theoretical foundation, looking at the extent to which it generates an effective support to real time sustainable retro-fit modelling. A detailed systematic retro-fit application can then be designed and modelled using a dynamic thermal model based on the typologies identified following the statistical study. Findings from building simulation modelling will further inform the design methodology. Initial energy modelling is done using PHPP (Passive House Planning Package) and DEAP (Dwelling Energy Assessment Procedure) for preliminary findings. Cork City is used as the case study as it hosts such a large topographical variation; illustrating the effect of micro climate on building energy performance. This paper outlines a proposed research methodology to achieve the objectives set out above and identifies some initial findings which support the research hypothesis presumptions. Variations are found in site specific climate files in close proximity to each other. Trends and patterns are also established within the building typologies.

Keywords

Local Authority Housing, retrofit, Energy efficiency, Climate data, Scalability

1. Introduction

The EU adopted the Directive 2012/27EU on energy efficiency to achieving the target of 20% improvement in energy efficiency for 2020; this was done on the 25th of October 2012 (Directive, 2012/27/EU). To deliver this target existing domestic stock will need to play a role, with 40% of energy being consumed by buildings in Europe (IEA, 2010). A key area for substantial energy savings is in refurbishment of existing stock; this is identified by the National Energy Efficiency Action Plan 2009-2020. There is huge potential for energy saving measures in residential built stock. The recasting of the EPBD in 2010 by the EU outlined the roadmap to reaching nearly zero energy buildings by 2020. New tougher challenges are now faced by EU member states; new build and retro-fit must be nearly-zero energy buildings by 2020, 2018 for public buildings (Directive2010/31EU).

1.1 Local authority housing

Housing has been provided by Local Authorities for the last 100 Years. Irish social housing improved living conditions in Ireland and acted to boost home ownership through the tenant purchase agreement (Regan and Paxton, 2001). The basis for social housing was built under British rule in the late nineteenth century. Initially inspired by concerns about public health and social order as well as providing shelter to the poor (Pooley, 1992). The provision of this housing was intended to tackle a housing shortage in the first half of the 20th century; and in the second half of the century to provide basic housing to low income families (Fahey, 1999). Social housing was seen by government not just as a means to provide housing but also as a mechanism for stimulating employment during times of recession (O'Connell, 2007). For the past 90 years, since late 20's early 30's the state has been generating the nation building phase. Central to this initiative has been the generation of the housing stock for the citizen. The stock and its design through time have been premised on the concept of the pattern book. The pattern book is the base design for the building stock generated through the achievement of a mean or an average, to generate a standard superstructure (Gaskell, 1989). This pattern is evident through the design and build of Social housing throughout Ireland; which offers an opportunity to design large scale solutions to improve comfort within these poorly performing buildings.

1.2 Climate data

Currently many Building Performance Simulation (BPS) tools still use very limited sources of climate data. Using accurate local climate data in BPS becomes increasingly more important with low energy retro-fit design. In the case of ultra low energy design the need for accurate climate is increased as solar gains can compensate up to one third of the total losses (Feist, 1993). In a study carried out by John Morehead, a comparison was made between using long term measured in-situ regional TRY data (Dublin) and interpolated Meteonorm data on a Passive House project near Carrigaline, Cork; Morehead recorded that a 30% variation in predicting space heating demand was possible depending on the source of data (Morehead, 2010). Morehead also measured a 41% variation in climate data across Cork County (Morehead, 2012). This further informs us of the importance of using site specific climate data in building simulation modelling at the retro-fit design phase. If there is discomfort due to cold surfaces caused by inaccurate building design stemming from imprecise climate data, heat load is increased to compensate for the discomfort. This leads to inaccuracies in actual pre-build energy consumption forecasting (Fanger, 1970)

Local climate influences both annual energy consumption and internal environment in buildings. The buildings thermo-physical properties and geometry influence how the building responds to its micro climate. This research intends to increase accuracy in simulation output through the application of site specific climate data generation.

1.3 Retrofit

This research is complimenting pre-existing frameworks for domestic retrofit such as for example Tabula (Tabula, 2012). Tabula is a building typology brochure and web tool (www.building-typologies.eu) which was funded by Intelligent Energy Europe, Dublin City Council, Electric Ireland and Sustainable Energy Authority of Ireland. Tabula identifies the most common residential building typologies nationally; it provides relevant building energy information. It catalogues them and provides a tabulated set of retro-fit guidelines. Tabula is based on the BER (Building Energy Rating) database, which uses the DEAP method (Tabula, 2012). DEAP calculations are based on IS EN 13790 (2008) and use a similar calculation procedure as the Standard Assessment Procedure (SAP) which is used for energy ratings in the UK (SEAI, 2013). DEAP is used to show compliance with the Energy Performance of Buildings Directive (EPBD) in Ireland and includes parts of Irish

Building Regulations (SEAI, 2013). The work proposed in this paper is intended to compliment efforts like the Tabula platform; concentrating on large scale LAH terraced built stock. Dynamic thermal modelling of terraced units using TRNSYS (Transient system simulation tool) (www.trnsys.com), PHPP (passiv.de) and DEAP analysis will give sufficiently accurate data for energy consumption estimations pre retro-fit design.

2. Methodology

Cork City was chosen as the case study for this research based on its topographical variation and number of terraced LAH typologies. The Methodology is then broken up into three steps. Step one is cataloguing existing LAH. Step two is to generate site specific climate data and analyze and finally step three is to develop an optimum retro-fit solution.

2.1 Cataloguing existing case study LAH

The cataloguing process firstly involved the identification of all LAH developments in Cork City. Maps from Cork City Council helped to identify developments. Once identified, developments are broken up into new ongoing developments and older traditional developments. The following steps are taken for the analysis of each development: (i) identify number of typologies in development, (ii) photograph and document typologies, (iii) survey buildings to establish variations, (iv) count all units from maps, (v) determine percentage orientation using color referencing on maps, (vi) calculate initial building energy rating (BER) of each building type, (vii) determine variations in site elevations, (viii) vertical sectional study to determine superstructure. An example of this analysis method is graphically communicated in figure 1.0

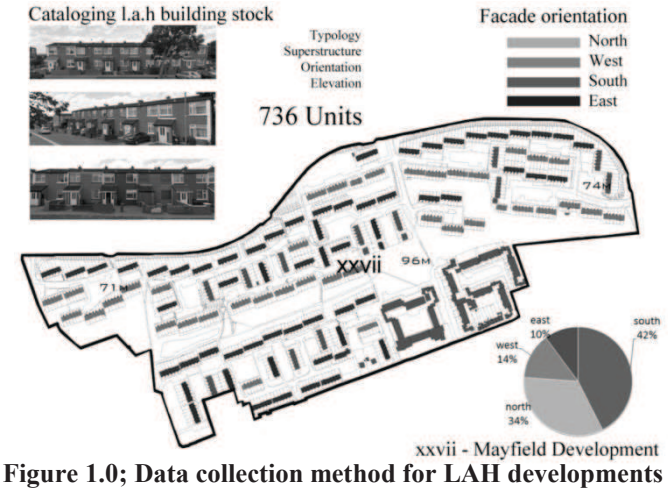

Figure 1.0; Data collection method for LAH developments

From the cataloguing of LAH building stock a spreadsheet has been generated to record and list findings based on the cataloguing criteria. Following analysis of each LAH development, data is then analyzed using a proprietary statistical computing package namely SPSS (Statistical Package for the Social Sciences) to generate a statistically significant model. This is done by converting re-occurring building elements into numerical data to generate a representative model which represents the mean. A number of re-occurring problematic areas will also be identified and addressed through statistical analysis.

2.2 Site specific climate data – importance to quantifying large scale retrofit solutions

Site specific climate data is generated at a number of LAH developments using Meteonorm software (www.meteonorm.com). The effect of local climate on building energy consumption will be assessed. Future weather files will also be generated using Meteonorm to future proof the final retro-fit design. In simulating the climate data at the chosen sites in Cork City the dynamic model of Perez et al. (1991) was used. Meteonorm software uses a method of interpolation to develop site specific weather data (Remund, 2010). Generally measured data can only be used close to a weather station, however Meteonorm software is able to interpolate between different weather stations which allows for site specific micro climate data to be produced at any geographical location in the world (Schneiders, 2009). The three nearest weather stations used by Meteonorm in these simulations are Cork Airport, Valencia and Shannon. This allows for an accurate calculation of many meteorological parameters at any site. This software is able to generate input data in text format which feeds into building simulation software packages (Remund, 2010). The primary inputs are mean ambient temperature, slope beam irradiation, horizontal irradiation, precipitation, wind, sky and ground temperatures (Remund, 2010).

HORIcatcher version 1.23 (www.meteonorm.com) is also used in addition to Meteonorm to account for local horizon obstacles affecting incident solar radiation. HORIcather is used to take a 360 degree picture of the horizon; to establish precise solar energy input. HORIcather software then transforms the picture to allow input into Meteonorm software (Meteonorm, 2013). This practice becomes increasingly more important in an urban setting as there are many obstacles most importantly effecting winter solar irradiance which become increasingly important in low energy retrofit. The combination of simulated climate data and measured horizon obstacles from HORIcather are inputted into the building simulation software. The results outputted from the dynamic thermal model will further inform the design and through a process of iterative design, the optimum Retrofit application should be obtained.

2.3 A proposed methodology for selection of optimum retrofit solutions

By studying LAH typologies and variations within superstructure it is envisaged that this will guide the study into potential retro-fit applications. The advantage of basing this study on repeated building typologies is it offers a systemised modular retro-fit methodology which can be constructed largely off-site. Figure 1.1 describes methodology overview for the execution of this research.

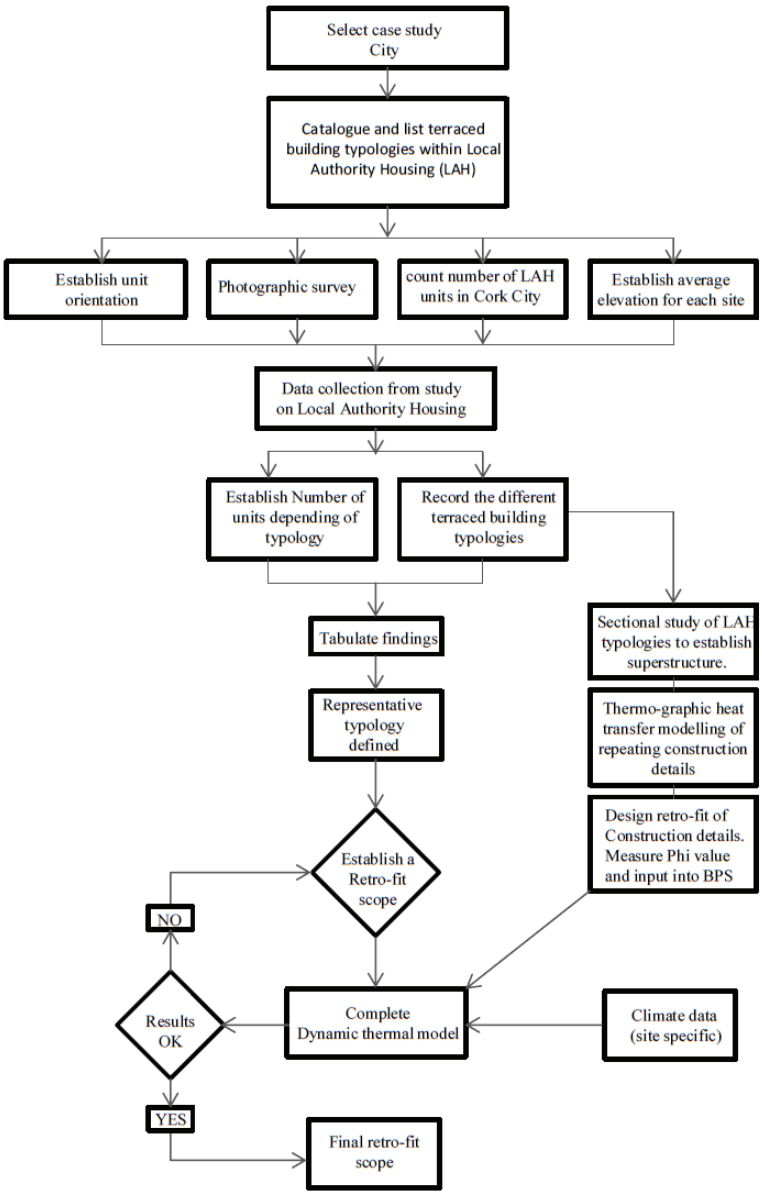

Figure 1.1; breakdown of methodology

3. Preliminary investigations

3.1 Initial results from cataloguing LAH in Cork City

The total numbers of units within the older traditional schemes are counted and color coded depending on orientation. Figure 1.2 describes the total number of units depending on orientation and percentage orientation. Orientation is based on façade orientation as front façade generally has a larger proportion of glazing. Retrofit challenge is increased due to limited solar gain to the 3,286 north facing units (Cork City Council maps, 2013)

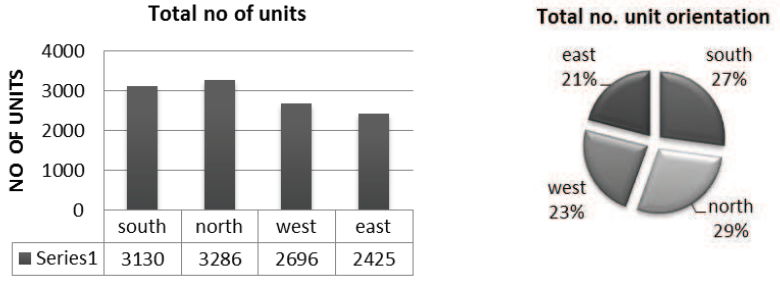

Figure 1.2; Total number of units and percentage unit orientation

The total numbers of units counted within the older traditional schemes are 11,537 units (Cork City Council maps, 2013). This number of units are in Cork City; the same typologies exist nationally. Once the retro-fit application is designed the intension is to apply this nationally to test the efficacy of findings. These tests will be carried out using site specific weather files for each location nationally

3.2 Initial analysis of climate variations within cork city

Ten LAH developments are chosen across Cork city, weather files are produced for the ten LAH traditional developments using Meteonorm software. Maximum distance between weather files generated is 7km, with a minimum distance of 500m. Figure 1.3 shows the variations in elevation for the ten weather files produced.

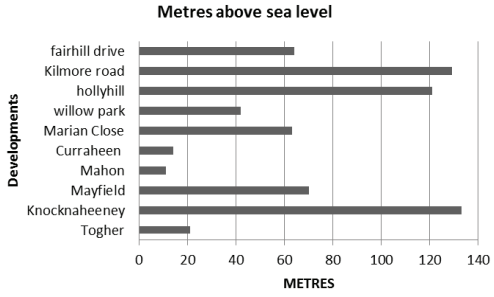

Figure 1.3; meters above sea level

The ten weather files are broken up in Figure 1.4, to analyze variations; average ambient temperatures, average sky temperatures, average ground temperatures and vertical solar irradiance are graphed. Variations are found through extrapolation of data from weather files. Figure 1.4 A-J illustrates variations in climate data generated at the 10 chosen LAH developments.

Ambient temperature: the temperature of the air around you, inside or outside. Sky temperature: the equivalent temperature of the clouds, water vapor, and other atmospheric elements that make up the sky to which a surface can radiate heat. Ground temperature: the temperature of the ground near the surface. Solar irradiance: the total frequency spectrum of electromagnetic radiation given off by the sun. Global radiation: included both radiation reaching the ground directly from the sun, and that received indirectly. Diffuse radiation: radiation received from the sun after reflection and scattering by the atmosphere and ground. Direct normal radiation: solar irradiance measured at a given location on Earth with a surface element perpendicular to the suns rays.

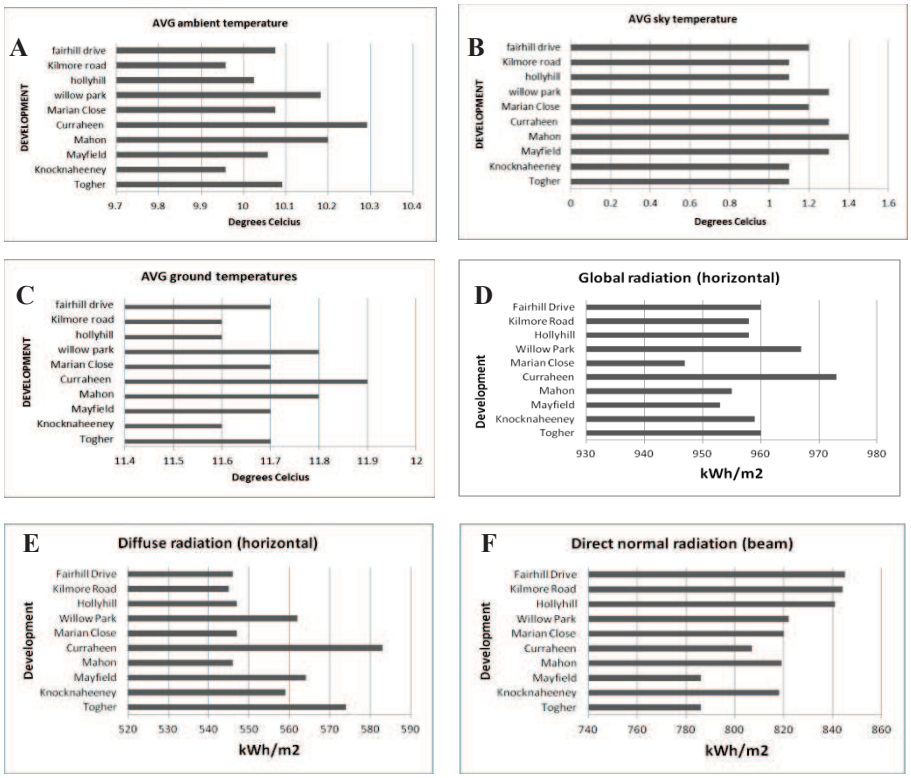

Figure 1.4; Variations within weather data for the 10 chosen locations. The 3 weather stations used by Meteonorn to interpolate weather data are Cork Airport, Valencia and Shannon.

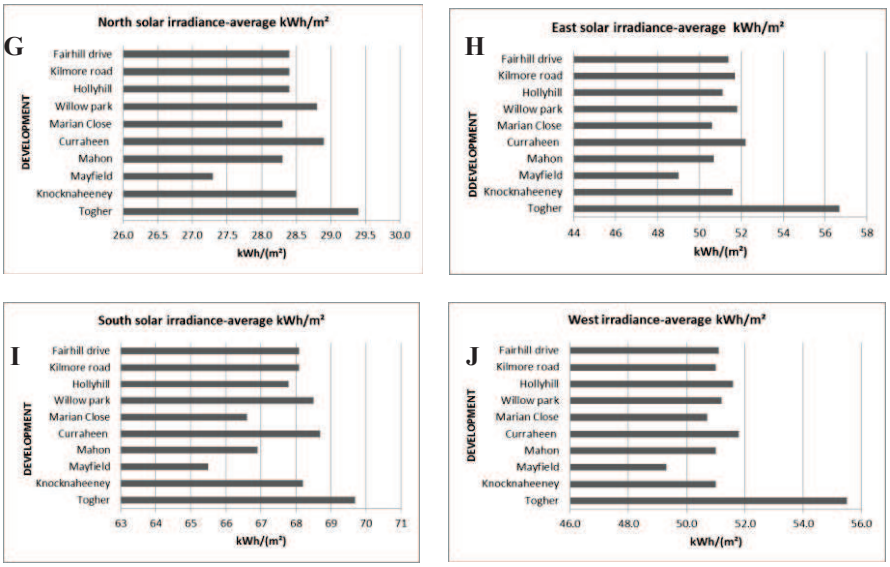

Figure 1.4; Variations within weather data for the 10 chosen locations. The 3 weather stations used by Meteonorn to interpolate weather data are Cork Airport, Valencia and Shannon.

4. Conclusion

From initial cataloguing of LAH it has become evident that patterns exist between different building typologies. Results from sectional study conclude that there is little variation in structure between traditional LAH. Most common structures are block on flat, block on flat with Cork lining and cavity wall with 60mm cavity. These initial findings support the need for a systematic retro-fit methodology as patterns in structure support a modular application. There are challenges faced in reducing typical cold bridging elements, these areas will require further design solutions.

Through extrapolation of elements in the 10 weather files generated, variations were found between locations. Variations in solar irradiance suggest further study in this area as this will have an important influence on glazing specifications, overheating and passive solar gains. Average ground and sky temperatures were minor; it is probable that one opaque retro-fit solution be adequate. Further research in this area is necessary. This would however support the focus of this research, which is to design a large scale modular retro-fit application for terraced LAH. The maximum distance between any 2 weather files produced is 7km. The variations found at such small topographical distances and elevations prove the importance to support this method for use in retro-fit nationally. The current work is not definitive and is subject to further analysis.

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