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Cormac Flood
Technological University Dublin

Lloyd Scott
Technological University Dublin, lloyd.scott@tudublin.ie

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RESEARCH METHODOLOGY: A NOVICE RESEARCHER'S' APPROACH

Cormac Flood¹ and Prof. Lloyd Scott²

¹ *DIT School of Surveying and Construction Management*

² *DIT School of Surveying and Construction Management*

ABSTRACT

This research is a detailed study on the performance of external walls aimed at providing a guidance tool which will enable designers to determine the appropriate thermal upgrade system for a housing retrofit, particularly in Ireland; taking into account wall type, climatic conditions and orientation. This paper explains the steps taken to establish a research design and methodological approach suited to the topic at hand.

The choice of research methodology is a difficult step for the researcher to decide upon in the research process. When it comes down to an architectural technologist, the process becomes even more difficult. Throughout a college process of taught procedures for accurate building design, solutions do not delve into the world of methodological approaches. Research methodology is simply not a common concept or approach throughout the Architectural/Engineering and Construction (AEC) sector. This paper assesses the existing limited research in the AEC sector, while highlighting how this was interpreted by a novice researcher with a background of architectural technology, to allow accurate and precise research analysis.

Each research method has inherent strengths and weaknesses. Careful attention to the methodological approach of the design process, as discussed here, can enhance the validity and consistency of a given study. Combining quantitative and qualitative approaches in research design and data collection should be considered whenever possible. Such mixed methods research improves the validity and reliability of the resulting data and reinforces fundamental implications by providing the opportunity to observe data convergence or separation in the analysis of the theory.

Keywords: Research methods; Mixed methods; Data analysis;
Architecture/Engineering and Construction (AEC)

¹ cormac.flood1@gmail.com

² lloyd@dit.ie

INTRODUCTION

According to Abowitz & Toole (2010) construction is essentially a social process. In effect, construction can be considered to be the application by people of technology developed by people to achieve goals established by people involving the erection or retrofitting of infrastructure and buildings (Abowitz & Toole, 2010). The fact that people play key roles in virtually all aspects of the construction process proposes that conducive to understanding the human or social factors, effective construction research requires the proper application of social science research methods (Abowitz & Toole, 2010).

The focus of this paper is on various issues encountered in the application of social science methods to AEC research and on the practicality of applying a mixed methods approach to enhance the validity and consistency of potential results. A methodology refers to the philosophical framework and fundamental assumptions of the entire process of research. In any research project, it is imperative to illustrate an understanding of the research approach to increase the validity of the research. At the initiation of this research project, many questions arose in regards to the methodological approach which should be employed. Mixing qualitative and quantitative methodological techniques within the scope of a research project allows poise of the strengths and weaknesses of each approach. Using mixed methods affects not only measurement but all stages of research (Brewer & Hunter, 1989).

This research has followed a very heavily quantitative methodology in the explorative phases; however this should not be misconstrued as it has been designed around a mixed methods approach. As an AEC researcher, much disillusion and confusion surrounds the subject of methodology. It is a misunderstood area of research which remains unclear yet fundamental to all research. In this paper, I aim to highlight the journey which this research has taken, and the influence the chosen methodology has demonstrated.

The selected approach to this research has asserted the relevance of the research being carried out, and verifies its validity in within the current thinking of the AEC industry. Previously carried out research as recent as 2011, has found that software programs for U-values tend to overestimate U-values of traditional building elements. Moreover, current research recommends further research on the thermal properties of traditional building materials and construction components; improvements to the U-value calculations; and a standardised methodology for in-situ measurement of U-values (Baker, 2011; Künzle, 1998; Little, 2009, 2010, 2011). Correspondingly, it has been noted from alternative research in the area that:

‘Evidence suggests that the approach is often flawed because it is not based on any direct measurements or observations of buildings prior to retrofit work and frequently relies on modelled assessments to prove assertions of improvement.’

(Alliance, 2012)

The quantitative studies required to develop the hypothesis of this research can be compared with previous methods which have been carried out in differing climates and populations. This previous research has projected methods of data collection, analysis, and interpretation which can be compared with, improved, added to and used as a verification tool.

REVIEW OF RESEARCH METHODOLOGICAL TYPES

The initial step for this research (which is in constant development) was to understand the different aspects to each type of methodology, their application and usefulness to the project. A methodology refers to the philosophical framework and fundamental assumptions of the entire process of research. In any research project, it is important to illustrate an understanding of the research approach to increase the validity of the research. The philosophical framework will influence the procedures of the research process. Within this research process are four stages; epistemology, theoretical perspective, methodology and methods (Crotty, 1998). The starting point of this research was to develop an ontological view on the area of study. This means the researcher embraced the idea of multiple realities and developed a personal epistemology. Epistemology refers to what should be regarded as acceptable knowledge, and is concerned with theories of knowledge. These theories attempt to answer questions surrounding the nature of knowledge, its limits and how we acquire it (Bryman, 2008; Knight, 2008). In validating the research, the aim is to contribute to social knowledge as a function of the researcher understanding their relationship with that being researched (Knight, 2008).

Quantitative research represents the dominant methodology for conducting social research (Bryman, 2008). This methodology is typically characterised by collecting numerical data, using deductive reasoning to link theory and research, a preference for a natural science approach (positivism) to explain social phenomena, and having an objectivist conception of social reality (Bryman, 2008). According to Creswell (2009), there are two primary research designs for conducting quantitative research:

1. Surveys –provide a numeric description of trends, attitudes, or opinions of a population by studying a sample of that population.
2. Experiments –determine if a specific treatment influences an outcome.

In a quantitative methodology, the data collected is hard, objective and standardized (Corbetta, 2003). Quantitative research is structured and theory precedes observation. In a qualitative study, the activities of collecting and analysing data, developing and modifying theory, elaborating or refocusing the research question, and identifying and dealing with validity threats are usually going on more or less simultaneously, each influencing all of the others. In addition, the researcher may need to reconsider or modify any design decision during the study in response to new developments or to changes in some other aspect of the design (Maxwell, 1998, 2012).

In a qualitative methodology, the data collected is soft, rich and deep while stressing 'ecological validity' and the applicability of social research findings to those that exist within the social situation studied (Corbetta, 2003). Contemporary qualitative research is characterised by its diversity (Punch, 2005). There are five popular research designs to conduct qualitative research (Creswell, 2009) :

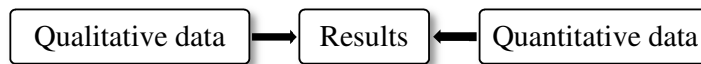
1. Ethnography is about telling a credible, rigorous, and authentic story (Fetterman, 2010).
2. Grounded theory is the systematic development of theory from the data through inductive and deductive (Phelps & Horman, 2010).
3. A case study is an idiographic examination of a single individual, family, group, organization, community or society (Rubin & Babbie, 2013).
4. Phenomenology is a research design which aims to understand people's perceptions, perspectives, and understanding of a particular situation. A lengthy interview with people who have had direct experience with the phenomenon being studied is a typical method adopted in a phenomenology study (Leedy & Ormrod, 2005).
5. Narrative is a study of the lives of individuals (Zou, Sunindijo, & Dainty, 2014).

Mixed methods research is a new approach as a distinct research design with philosophical assumptions that guide the direction of the collection and analysis of data. Many researchers believe that both methodologies complement rather than rival each other, and quantitative research may subsequently compensate for the weaknesses of qualitative research and vice versa (Cooper & Schindler, 2008; Neuman, 2010). Bryman (2008) refers to three approaches to mixed methods research:

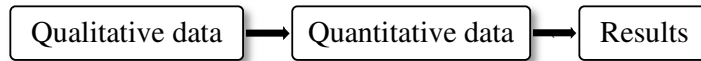
1. Complementary: two research methodologies are employed so that different aspects of an investigation can be merged.
2. Facilitation: one research methodology is employed to aid research using the other research methodology.
3. Triangulation: the use of quantitative research to corroborate qualitative research findings or vice versa.

Its central premise is that the use of quantitative and qualitative approaches in combination provides a better understanding of research problems than either approach alone. Fig. 1 is an illustration further enhancing the methods fielded by Bryman (2008) highlighting how Creswell (2009) believes mixed methods research may be approached:

Merge the data:



Connect the data:



Embed the data:

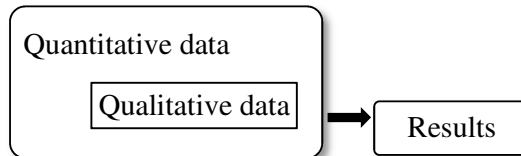


Fig. 1. Three Ways of Mixing Quantitative and Qualitative Data: after Creswell (2009).

Following Fig. 1, the author has connected the data through facilitation or connecting the data. Using the literature review, the author could relate to previous research performed in the area which would point towards the necessities and pitfalls within the current thinking within the context of thermal design research in the AEC sector. The information could be connected by findings to those that exist within the area studied, whilst the preceding data collection would be hard, objective and standardized. To verify the suitability of mixed methods approach, a review of alternate research in the AEC sector was carried out.

REVIEW OF EXISTING LITERATURE ON AEC RESEARCH METHODS

Researchers use the literature review to identify a rationale for the need for their own study. Some of the specific rationales for the research that might emerge from a literature review include:

- A lack of consistency in reported results across the studies.
- A flaw in previous research based on its design, data collection instruments, sampling, or interpretation.
- Research may have been conducted on a different population than the one in which you are interested.
- Uncertainty about the interpretation of previous studies' findings.

The literature available regarding AEC research methods is rather sparse. Fellows & Liu (2009) does however contribute in focusing upon the sequential methodological processes that should be followed to ensure effective research. Furthermore, Fellows & Liu (2009) concentrate on the philosophical issues of research methodologies. Raftery et al. (1997); Runeson (1997) and Seymour et al. (1997) discussed research

methods, challenging the relative benefits of theoretical versus experimental papers and qualitative versus quantitative research. Cultural sensitivities including communication, were recognised by Loosemore (1999) rendering one method of research method more appropriate than another in differing circumstances. Walker (1997) explained his doctoral research process as a case study on the challenges of obtaining data from thirty-three projects and analysing them using linear regression. Similarly, El-Diraby & O'Connor (2004) used the collection and analysis of bridge construction data as a case study to establish significant methodological issues as extracted from Cook & Campbell (1979), which according to Abowitz & Toole (2010) is one of the major works on experimental design in the social sciences along with Campbell & Stanley (1963). Four types of validity concern Cook & Campbell in particular. They are briefly summarized in the Table 1:

Table 1

Four Types of Validity in Social Science Research. Source: Based on Cook & Campbell (1979)

Type of validity	Key Issue
Construct Validity	Do the indicators capture the expected relationships among the concepts being researched?
Statistical conclusiveness validity	Are the relationships between hypothesized independent and dependant variables statistically significant?
Internal validity	Has the research truly demonstrated a causal link between hypothesized variables, or are there plausible alternative explanations for the statistical association between the independent and dependant variables?
External validity	Are the apparent relationships found within the sample's experimental subjects generalizable to the larger population assumed in the hypothesis?

In both the social sciences and AEC research, a clear understanding of experimental design issues is crucial not only to the soundness of any experimental data collected but for a deeper understanding of basic research processes and problems (Fellows & Liu, 2009). Careful analysis of experimental design texts, such as Cook & Campbell (1979) can improve other research exertions including surveys and ethnographic observation. Ultimately, understanding issues of internal and external validity in experiments, as well as measurement and statistical significance, helps in understanding the problems of interpretation, consistency and validity, and statistical interpretation in the AEC sector (Abowitz & Toole, 2010). Correspondingly, the author utilised this information and employed the understanding towards literature review. Alternative and similar analyses were, and still are being researched and analysed to aid current research methodologies.

THE RESEARCH APPROACH

This is a preliminary part of the research process which describes the general path / cycle of the research. The research includes five broad components; Mind map, Literature Review, Research Design, Calculations and Results, as shown in Fig. 2:



Fig. 2. Approach to research

RESEARCH DESIGN PARAMETERS

According to Babbie (2008), “Research design involves a set of decisions regarding what topic is to be studied among what population, with what research methods, for what purpose.” Proper research planning and design therefore encompass numerous distinctive issues. For example, if the topic is thermal upgrade in the construction industry and its effect on external wall performance, we have to determine which subjects to include from among external wall performance; the sampling technique and sample size and the methods of data collection an experiment, survey, observational study, and so on. Each of these decisions affects the quality and quantity of data collected.

Building on the theoretical mind map processes of Buzan from the 1960’s (Buzan, 2015), Fig. 3 is an initial brainstorming process carried out to identify the parameters which needed to be considered for investigation. The parameters were identified through literature, both academic and specialist identifying connected issues to the central question:

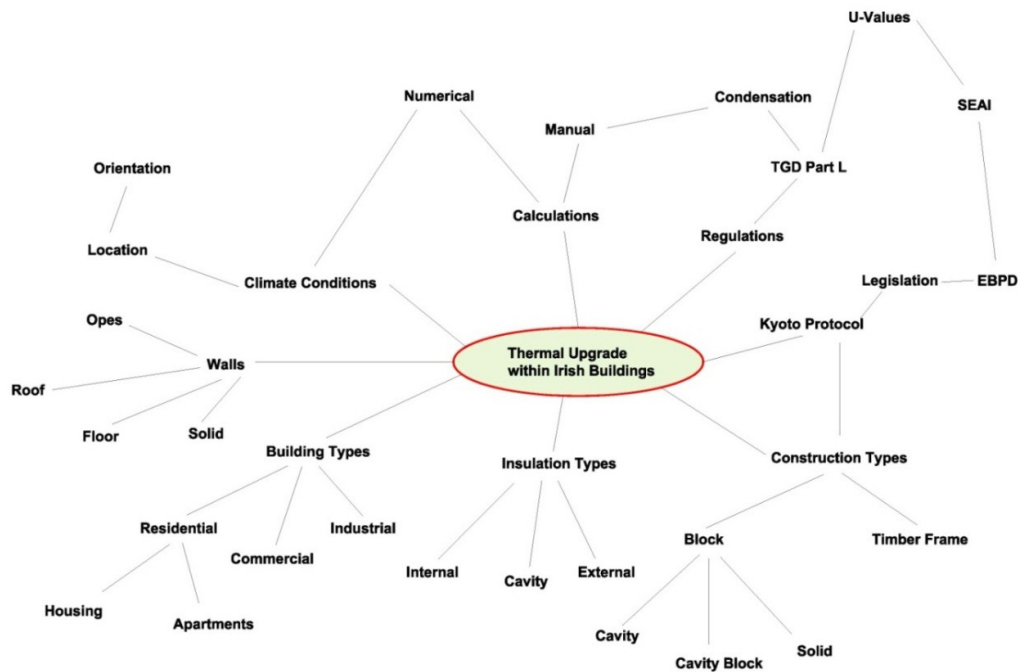


Fig. 3. Mind Mapping

According to Eppler (2006) and mindmapping.com (2015) a mind map is a multi-coloured, image centred radial diagram that represents semantic or other connections between portions of learned material hierarchically. An online tool is available; however these maps were composed through AutoCAD due to a pre-established proficiency already gained through previous experience both academically and professionally. This mind mapping process allowed the initial focus of the aim and objectives but also, allows continual update and focusing of these. The key areas are addressed and explored thus; these parameters are a work in progress always progressing towards refinement as may be witnessed in the transition between Fig. 3 and Fig. 4. It is highlighted in Fig. 4, that the fundamental aspects of the research parameters were refined and outlined after exploring all other branches of the mind map. The items not circled still have an impact on the research however their influence was not as crucial at the point in the process.

Upon approaching the current mind map (Fig. 4), a clear indication of the research had emerged. Literature, previous studies, papers, articles and reports had all led the research to a refined central question (centred in Fig. 4), with the most applicable influences which should be applied to this study. The result of the current mind map circles the broad area information most crucial to the research at this point, whilst the extended branches house the refined area information crucial to the study outlined in red.

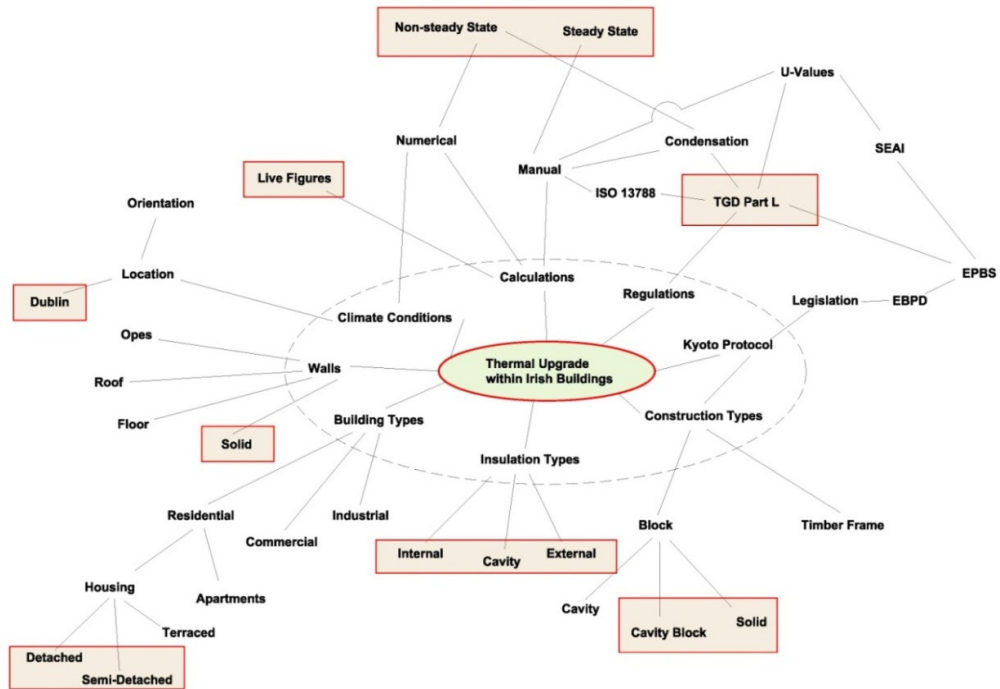


Fig. 4. Mind Map Further Development

From this developing mind map, the research parameters have evolved. The established and finalised milestones to date are presented below in bold, while the outstanding and changing parameters are written below in grey;

1. Literature Review.
2. **Identification of problem.**
 - a. **Residential.**
 - b. **Housing.**
 - c. **Detached & Semi-detached.**
 - d. **Walls- Opaque Element.**
 - e. **Solid Block & Cavity Block.**
3. **Policy constraints and values.**
4. **Current Practice.**
5. **Calculation Methods.**
 - a. **Manual Calculation – Steady State – ISO 13788, BS 6946**
 - b. Simulation Calculation – Non Steady State - Thermal Decrement - PhD
 - c. Simulation Calculation – Non Steady State (WUFI) - PhD
6. Live Building Analysis – PhD
7. Questionnaire - PhD

Upon forming the research parameters, the research design was then asserted. Research design stems from the chosen methodology, referring to the ways in which the data will be collected and analysed in order to answer the research questions posed and so provide a framework for undertaking the research. For the purpose of selecting the correct methodology, it is vital to understand the various practiced methods which are described in the following sections.

A mixed methodology is practical in the sense that the researcher is free to use all methods possible to address a research problem and individuals tend to solve problems by combining inductive and deductive thinking making the argument more persuasive than either words or numbers in isolation (Creswell, 2009).

CURRENT METHODOLOGICAL APPROACH

The methodology used in this research to date is modelled around multi-methodological design. Data collection and analysis through past and present research by others, along with policy design standards, recorded climate data, housing figures, common external wall constructions, standard design calculation methodologies and non-standard yet required design calculation methodologies corresponds well with and suits the theory of a quantitative methodological approach (Corbetta, 2003; Maxwell, 1998, 2012). Furthermore, suiting the quantitative approach as alluded to by Maxwell (1998, 2012), the research is structured, performing a series of calculation methodologies and recording performance data to produce results which clarify the question. The early phase of the research followed a mixed methods approach and developed using mind mapping and literature review as explained earlier. As the research transitions into the PhD it will remain heavily quantitative while encompassing a mixed methods approach, incorporating some qualitative research to allow a fuller piece of research as suggested by Creswell (2009). This will be in questionnaire format which will require interpretation and discussion suiting a qualitative stance using both numbers and words to combine inductive and deductive thinking (Maxwell, 1998, 2012).

METHODS

This section explains the process of identifying the research field including contributors, institutions, references; a literature review of the pertinent research material, papers, articles, reports etc.; calculation methodology identification, breakdown, and application, further research projection, explanation and the final output proposal of the research.

Searches were undertaken of recognised relevant academic and specialist building conservation literature databases and used a variety of search fields including the

terms; buildings, existing, old, conservation, energy, efficiency, refurbish, retrofit, upgrade, performance, thermal, moisture, steady state, non-steady state. A number of journals were established as principle sources of evidence including: the Association for Preservation Technology (APT); Building & Environment; Energy & Buildings; Intelligent Buildings International, International Journal of Sustainable Engineering, Journal of Information Technology in Construction and Energy Policy. A series of technical indices were then identified as paramount sources of calculation methodology and procedure literature including: Technical Guidance Documents (TGD's), British Standards (BS), The Chartered Institution of Building Services Engineers (CIBSE) Guides and The International Organization for Standardization (ISO) documents.

Websites of the statutory bodies responsible for the protection of the Irish, UK and European environment were also searched; Department of the Environment, Community and Local Government, Sustainable Energy Authority of Ireland (SEAI), National Standards Authority of Ireland (NSAI), British Research Establishment Ireland (BRE), Environmental Protection Agency (EPA), Historic Scotland, British Research Establishment (BRE), United Nations (UN) Documents, and Intelligent Energy Europe.

The searches uncovered a range of documents, some of which had more direct relevance to the research question than others. Those judged to be of some relevance were collected into an EndNote database of relevant references. Decisions on this were based on degree of relevance to the research question; if a paper was concerned specifically with the performance of residential buildings via an analysis based on measured or theoretical data it was deemed highly relevant.

Once the literature was reviewed, the problems could be identified: namely the lack of research into the separation between theoretical and practical analysis. Using the technical indices, namely current Technical Guidance Document Part L 2011, the standard calculation methodology for thermal wall design was identified as the U-value. This document then references alternative sources of calculation methodologies to dissect and improve the accuracy of this calculation methodology and material classification: BS 6946, EN ISO 13788 and CIBSE Guide A.

Through analysing these documents the U-value calculation was explained, gaps in the process established, and solutions to these gaps identified. The process was documented using techniques acquired from previous research at undergraduate level including steady state analysis of condensation risk analysis, and two-dimensional conduction heat-transfer analysis through THERM software and methods acquired (Department of Environment Community and Local Government, 2011; Hens, 2010, 2012; Künzle, 1995; Little, 2009; McMullan, 2012). The results of all of this work have been translated through peer reviewed papers, reports, posters and oral presentations.

The next phase of this research encompasses a progression from the quantitative to qualitative through application. Thermal decrement analyses will be completed as per CIBSE Design Guide A using a Dynamic Thermal Properties Calculator (DTP) developed by ARUP along with Ecotect building analyses software developed by Autodesk.

A series of hygrothermal simulations of the wall types identified through the literature review will be carried out illustrating the impact of heat, vapour & moisture transfer through the building fabric following examples set out by F. IBP, (2013), Künzel (1995, 1998) and Little (2009, 2011).

This phase will also consist of case studies which will be acquired and sensors will document the in-situ U-value performance of a selection of the identified wall types versus the theoretical values identified. This process will follow standards as set out in prEN 12494:1997, EN ISO 7345:1987 and I.S. EN ISO 8990:2007 as referred to by Department of Environment Community and Local Government (2011) and Rhee-Duverne & Baker (2013). The U-value readings will be monitored in accordance with procedures outlined in similar research by Baker (2011), Rhee-Duverne & Baker (2013) and Little (2010).

The analysis of preferred methods of thermal upgrade amongst homeowners will be documented through the composition and distribution of a questionnaire. The questionnaire will be an online survey using tools acquired from previous research. The results of this survey will be presented in a table formatted in excel highlighting key findings.

The final thesis and analysis will be compiled using a combination of excel data sheets and charts to compare and contrast the differences / similarities between all of the data. Following this, the results will be interpreted and documented, resulting in a framework design tool. Results from the survey will accompany the framework as an indicator of the sociological thinking which will need to be addressed for advancement of thermal upgrade viability.

RESEARCH DESIGN MODEL

Fig. 5 is the research process model developed to illustrate the path in which the research has progressed to date and shall progress through the PhD in accordance with the multi-methodological research design to expand the data:

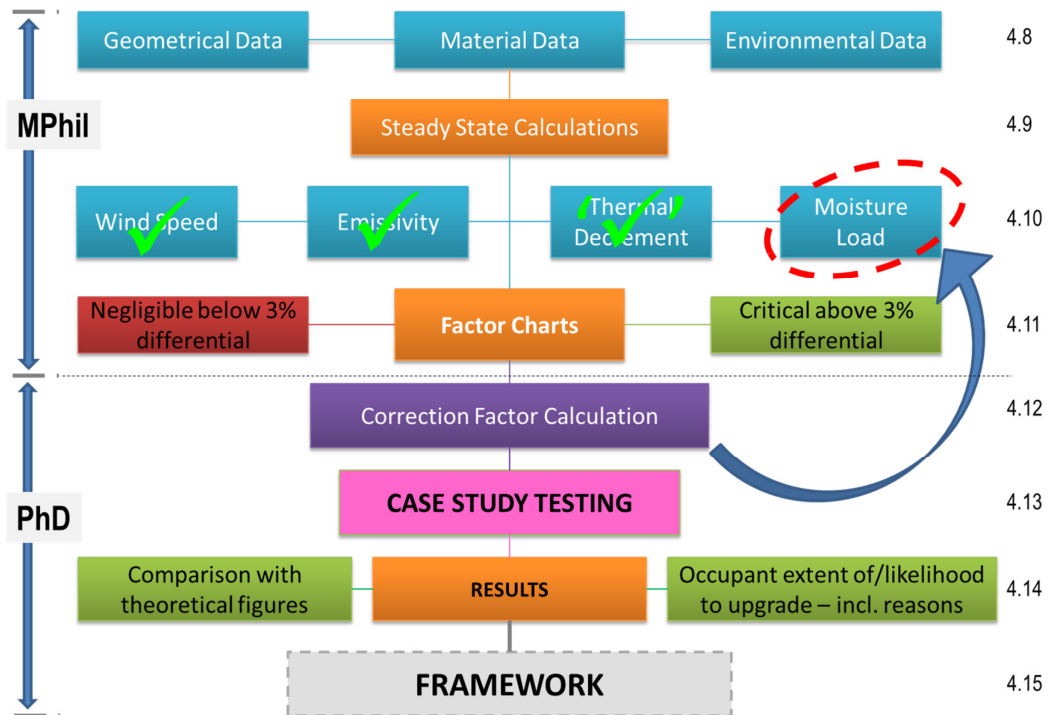


Fig. 5. Research Process

CONCLUSIONS

This paper has reviewed the process of methodological approach followed in this research along with a mixed methods approach to research design, in order to increase credibility and validity of conclusions resulting from experimental research. This paper is intended to serve as an introduction to issues and sources of enlightenment in effective research methods in AEC research in order to encourage researchers to more fully study the topic.

The realm of philosophy and research theory is something of an enigma throughout the AEC sector, particularly within architectural technology. This has been confirmed through an examination of previous research in the field, accompanied by personal experience. The understanding gained regarding the influence of an informed methodological approach has already, and continues to enhance the product of this research. Adopting a mixed methods approach has allowed a more concise and defined format of information to be assessed. Through the trawling through previous literature available on AEC research, comparable precedent has been established to set a benchmark for results generated from this research. Previously however, the approach would have been to think of an area of interest and simply carry out the proposed research with a view to gathering results expected or hoped for.

Effective research on topics in construction is difficult and necessitates skill and knowledge that is rarely provided in AEC research programmes. To understand the full range of methodological challenges faced when doing research, graduate AEC students should take at least one course on social science research methods, preferably one that covers both qualitative and quantitative approaches, and one course.

The number of references explored to explain what is still being understood by the author really is arduous. Including social science research methods courses in a graduate curriculum in the AEC sector is uncommon. Nonetheless, integrating the knowledge consequential from such a course would prove advantageous to allow effective research within AEC research.

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