RIGHTSIZING (DRAFT July 2019)

Slim down and start up housing - new build

DRUw | Welsh School of Architecture
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Project Details

Title | RIGHTSIZING: Slim down and start up housing
Principal Investigator | Professor Wayne Forster, DRUw, Welsh School of Architecture, Cardiff University
Output No | XXXXX
Output Type | Physical output (new building)
Date of Output | 2016-2019
Client | Monmouthshire Housing Association
Function | Residential housing
Location | Locations across Monmouthshire, Wales
Funding | Award winning bid, Phase 1, Welsh Government’s Innovative Housing Programme, Contract Value £1.1m

in collaboration with the following design team

Project Management | Monmouthshire Housing Association (MHA)
Planning consultant | LRM
Structural consultant | Lodestone Cardiff
Services consultant | XXXXXXXX
Main contractor | MHA Construction Ltd.
Statement of Significance | AECOM Cardiff
STATEMENT ABOUT THE RESEARCH CONTENT AND PROCESS

Description
The Rightsizing project consists of two separate infill housing projects developed and designed to respond to, and meet, the needs of an older generation of people in Monmouthshire who wanted to ‘down-size’ from larger properties and a much younger generation who were looking for their first property. Both groups had been identified as requiring homes that Monmouthshire Housing Association were not able to provide from their extensive stock. The intention was also to demonstrate principles of good design on challenging backland sites that otherwise were prone to anti-social behaviour.

Two sites, one in Caldicot and one in Abergavenny, were selected from a number of blighted back-land garage sites for developments of 4 houses on each site; and funding was won in competition from Welsh Government as part of round 1 of the Innovative Housing Programme. Two different house single bedroom types - a terraced mews with patio and an ‘interlocking’ courtyard house were developed from precedent studies and market testing in response to needs for spaciousness and manageable private outside amenity spaces.
Questions
The research questions are framed within the overarching requirements for Welsh Governments Innovative Housing Programme, they are as follows:-
- How to design ‘loose-fit’ dwellings accommodating the potentially changing needs of a specific population type over time and integrate them into existing settlements.
- How to design for long life, but low maintenance buildings – ‘long-life’.
- How to design for an ‘active’ legible and ‘delightful’ energy strategy for residents – ‘low energy and comfort’.
- How to build an integrated collaborative procurement and construction framework using local supply chains.
- How to utilise a design process involving physical model-making to test out complex housing permutations and types involving a range of stakeholders, and to investigate construction technologies in order to meet the design objectives within an extremely tight budget and construction schedules.
- How to effectively disseminate all of the above.
Methods

- Literature review
- Precedent studies
- Collaborative design
- Design with emphasis on hand drawing and the use of physical models
- Market research – testing design proposals (house types)

Dissemination

- Open days on site
- WG Workshops on IHP
- Publication in Touchstone (Summer 2019)
Map showing the location of the two development sites in Monmouthshire - Caldicot and Abergavenny.
1. INTRODUCTION

The research fits within the Welsh Government Innovative Housing Programme which aimed to increase the supply of housing. However, within the aims and objectives set out in the Welsh Government Technical Guidance Notes, there was also an ambition to promote innovation that ‘facilitates greater use of active travel, consideration of innovative approach to the delivery of density for place-making benefits, the integration of different uses, tenures or unit sizes, and will involve consideration of the layout, mix of uses, connections beyond the site, green infrastructure and facilities as well as the design of individual homes’.

Additionally, ‘homes to be able to better recover from natural challenges (flood, fire, storm, cold, heat), human challenges (power failures, internet outages), and changing lifestyles (layout preferences, family sizes)’ were prescribed of interest.

In the ‘Rightsizing’ projects, questions about changing lifestyles, density, the life of homes and space, spaciousness and place are the spur for the aims and objectives. This had been prompted by a report commissioned from the Welsh School of Architecture (Green and Forster) entitled MORE:BETTER (2016) which promoted a diverse approach to procurement as means to alleviating the housing crisis.

Two development sites in Monmouthshire were chosen to trial new house types and layouts that would provide potential solutions to the issues of downsizing and first time occupiers - ‘Rightsizing’.
2. AIMS AND OBJECTIVES

Aims and objectives are :-

• To conduct research into the housing needs and preferences of people who were either wanting to move from large houses that had become expensive and not fit for purpose (too big) and for those who could not afford a small dwelling but did not fit into a minimal space standard 1 bedroom apartment (first time occupiers). Monmouthshire Housing Association were already experiencing difficulties in letting to these groups from their existing stock.

• To establish a tectonic model in the context of design and construction of long life, low energy homes on small challenging infill sites. The presence of an allied in-house construction and maintenance organisation within Monmouthshire Housing Association would be key in this and the projects may also be seen as potential for apprenticeships, training and reinforcement of established local supply chains. It was envisaged that a close collaborative process through design as well as construction would be needed to support this.

• To achieve a model of settlement form and repeatable house types that meet the needs of a particular population that currently are not catered for in Monmouthshire. This would inevitably mean challenging prescribed space standards set out in the Welsh Design Quality standards, but also to attempt to draw out space and spaciousness.

• To conceive a way of looking at ‘sustainable’ architecture from a user and social perspective as well as the current one dimensional technological ‘measures’.

• To build on the established design process of design in DRUw which, while accepting the benefits of computer-aided-design, still locates the key decisions in the realm of the hand-made, through sketching and physical model-making.

• To test the central importance of particularly, physical models, in the evolution and dissemination to users and other stakeholders of innovative, spatially complex designs.
Acute need for housing for first time occupiers

Literature shows huge market for downsizers
3. QUESTIONS

The research questions are framed within the overarching requirements for Welsh Governments Innovative Housing Programme as follows:-

• How to design ‘loose-fit’ dwellings accommodating the potentially changing needs of a specific population type over time and integrate them in to existing settlements - to suit potential downsizers and first time occupiers.
• How to design for long life but low maintenance buildings – ‘long-life’ given only 1B homes can be developed.
• How to design for an ‘active’ legible and ‘delightful’ energy strategy for residents – ‘low energy and comfort’.
• How to build an integrated collaborative procurement and construction framework using local supply chains.
• How to utilise a design process involving physical model-making to test out complex housing permutations and types involving a range of stakeholders, and to investigate construction technologies in order to meet the design objectives within an extremely tight budget and construction schedules.
• How to effectively disseminate all of the above.
Initial brief (2017)

- MHA has seen a significant decline in the demand for its older person accommodation. Anecdotal evidence from other social landlords inform us that this is a sector wide problem.

- The research concluded that older persons renting preferences were for two bed bungalows in urban settings (due to restraints on benefits we can only develop a few of these, normally only 1 bed bungalows will stack up financially).

- MHA wish to research some small sites owned by MHA which are difficult to develop. The properties need to be built to a high density in a style than can be.
The needs identified by MHA, and in the DWELL report did not fall into any of the 'classified' house types
4. CONTEXT

The commission for the ‘Rightsizing’ projects was made following an initial viability study and a successful bid in Phase 1 of the Welsh Government IHP competition for ‘Innovation in Housing’. In 2016-2017, as part of the Welsh Government’s 20,000 additional affordable homes target, the Cabinet Secretary for Children and Communities asked Welsh Government officials to develop a new programme to support the development of new approaches to delivering housing in Wales. £90m has been set aside to support schemes in the programme. The Innovative Housing Programme (IHP) aims to:-

• increase the supply of affordable housing in Wales, as part of the 20,000 additional affordable homes target.
• align with the seven goals enshrined in the Wellbeing of Future Generations Act (WFGA).
• address cost and value in new homes and develop housing that meets specific current and future housing needs.
• provide support for those willing to innovate through the use of alternative approaches.
• demonstrate benefits associated with alternative approaches, to encourage their wider uptake.
• harness opportunities to deliver jobs, skills training, and develop local industry.
• publicly disseminate key findings and maximise learning.

IHP and innovation
The Innovative Housing Programme seeks to support innovation and impact in three different streams:

- **CONSTRUCTION TECHNIQUES**
  new and emerging forms of construction, materials or processes
- **DELIVERY PATHWAYS**
  alternative approaches to commissioning, procurement or collaborative working
- **HOUSING MODELS**
  dwelling types that respond to a specific need or promote increased applicability

As such the ‘Rightsizing’ projects met all of the above, but it was made clear that in terms of focus the need for new ‘Housing Models’ and appropriate delivery pathways were the main focus for innovation.

**Affordable Housing in Monmouthshire**

Whilst the aims and objectives of the IHP programme are ‘generic’ and are part of a more concerted effort to increase housing supply nationally, it is important to set out the context of affordable housing in the geographic area that MHA operate in.

Monmouthshire has no real industrial urban centres. Housing supply in rural Wales is challenging but exacerbated in Monmouthshire where a local housing mark assessment (LHMA) found that average house prices in Monmouthshire increased by 28 percent between January 2010 and May 2018. House prices shot up by 12.86 per cent between July 2017 and September 2018, when the average house price was £307,600 – the highest in Wales. This coincides with the announcement that tolls on the Severn Crossings would be cut in early 2018 and scrapped altogether by the end of 2018. It puts Monmouthshire just behind Bristol (£334,600) and ahead of the second highest prices Welsh local authority, the Vale of Glamorgan (£278,800).
Despite average wages increasing, the high house prices still put owning a home beyond the reach of many families living and working in Monmouthshire. Analysis conducted between September 2016 and September 2017 also found that private rented properties was unaffordable for many households. Worst hit are the two groups targeted in the projects – first timers who have real problems with affordability and downsizers who have challenges in securing financial ‘headroom’ but crucially cannot find suitable housing models located close to vital amenities.

Monmouthshire County Council were looking for new ways to tackle the shortfall, including the allocation of small sites in rural areas which could deliver up to 60 per cent affordable housing.¹ Monmouthshire Housing Association had ‘inherited’ a number of blighted backland garage sites as part of a major stock transfer. The nature, location and condition of these sites lent themselves as almost perfect sites to address some of the issues identified above. A negative quality was the many and diverse physical constraints that hampered design - overlooking, rights of way, easement’s over existing services and undiscovered issues such as established rights of way and services.

The Welsh Government Innovative Housing Programme was framed within the Welsh Future generations Bill (above). Competing schemes were expected to meet all seven goals and provide innovation in up to 3 categories - bordered in green above.

## Potential benefits associated with housing, as they relate to WFGA

<table>
<thead>
<tr>
<th>WFGA goal:</th>
<th>short term benefit:</th>
<th>medium term benefit:</th>
<th>long term benefit:</th>
<th>focus:</th>
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<tr>
<td>globally responsible</td>
<td>low embodied CO₂ locking in carbon</td>
<td>reduced carbon footprint</td>
<td>decarbonising communities meeting international targets</td>
<td>CO₂</td>
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<tr>
<td>prosperous</td>
<td>addressing cost and value local resource use</td>
<td>more affordable housing supporting Welsh supply chain</td>
<td>affordability, local economy skills and community building</td>
<td>capital</td>
</tr>
<tr>
<td>resilient</td>
<td>robust, low maintenance changeable by the community</td>
<td>resilient to climate change accessible construction</td>
<td>adaptability and resilience reskilling and empowering</td>
<td>change</td>
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<tr>
<td>healthy</td>
<td>natural resource use breathable construction</td>
<td>healthy internal environment reduced impact on environment</td>
<td>positive health benefits reduced strain on health service</td>
<td>health</td>
</tr>
<tr>
<td>more equal</td>
<td>low embodied energy reduced heating bills</td>
<td>energy generation offsetting rental costs</td>
<td>affordable warmth for all energy positive homes</td>
<td>energy</td>
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<tr>
<td>cohesive communities</td>
<td>flexibility in layout constructable by end user</td>
<td>long life loose fit ‘other’ procurement pathways</td>
<td>meeting specific long term need flexible, high quality homes</td>
<td>space</td>
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<td>thriving culture</td>
<td>variety in form and materials suitability to different contexts</td>
<td>building strong neighbourhoods creating places with character</td>
<td>supporting people, communities and distinctive places</td>
<td>place</td>
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Elm Rd, Caldicot
Selected for the development of homes for first time occupiers.
St Teilo, Abergavenny
Selected for the development of homes for downsizers.
The geographical spread and size of Phase 1 of IHP. The Rightsizing projects are circled in red in the South East of the Country. They are also distinguished by being the only one focusing on space and place - the majority are focused on construction.
5. METHODS

Collaborative design

Extensive discussions, and then design workshops were held with the client, MHA, and also the local planning officers, to determine appropriate house types, form and layout. Concurrently a variety of programmatic solutions and spatial permutations, as well as the detailed three-dimensional complexity of each of the candidate sites and its surroundings, were tested out through extensive physical model-making and other forms of visualisation. These analyses in turn allowed the refinement of the overall configuration of the building in terms of accessibility, circulation, lighting conditions, structural expression, housing typologies, and general functional viability. The many physical models were all constructed with the same logic as the real construction operations would be on site, being regularly and quickly updated throughout the whole process. Although the collaborative process was not entirely lineal the following illustrates the breadth of collaborative design studies.

Key dates:-

- November 2016–June 2017 - Design workshops with MHA (Initial viability study)
- May 31st 2017 - Design workshops focusing on house type and place-making with MCC Planners
- June 15th 2017 - Design Review with Design Commission for Wales, MHA and Monmouthshire County Council
- August/September - independent Market testing house type and form, including focus groups using models and drawings. (See below)
- October 3rd 2017 - Presentation of viability study to newly elected MCC Planning Committee
- January 19th 2018 - Pre-application meeting with MCC
Phase 1 and 2:

House type, form and place making. This was informed by a literature review, demographic surveys, and iterative design processes employing drawing and physical modelling.

Literature review

As the topic of provision of appropriate dwelling emerged prior to, and during the viability study, a review of design led research literature in particular was undertaken. The ‘DWELL’ report was published in 2016 as we commenced this study. The findings from the EPSRC funded 3 year research and co-design process with residents in Sheffield, developed a working definition for downsizer homes and proposed a series of co-designed typologies that respond to third-agers’ aspirations. These findings were in line with the findings from surveys conducted by MHA with the same tenant group and so they formed the basis of the initial precedent studies and space studies.

Key characteristics were as follows:-

- Demand for accessible single storey or two storey typologies, with a continuing appetite for bungalow typologies - despite their apparent unpopularity with planners and developers.
- A willingness to consider apartment living, as long as the offer feels secure, spacious and is in a good location, and potentially provides extra facilities such as allotments and shared space to host social events.
- Demand for fewer (bed) rooms but more space and adaptability to accommodate separate living, visiting friends and grand-children.
- Provision of manageable outdoor space for gardening and relaxation, such as courtyard gardens, roof terraces and generous balconies.
First steps prior to IHP 1

Process

2016 November /December 2017 January / May

Phase 1 Phase 2 Phase 3 Phase 4

Identify Sites Review Literature Test 4 sites through design 4 house types Select 2 house Types detail Complete Place studies

Site data Present and review Present and review Present to board

Initial contact and briefing
What is needed

- Demand for single storey
- Apartment living ok provided amenities
- Fewer bedrooms but more space and adaptability – visiting friends
- Manageable outdoor space
- Dedicated car parking
- Adaptable to future needs

Key spatial characteristics of an ideal house type were outlined in the DWELL report and found to be in line with the findings of the MHA tenant survey. (Note the demand for single storey.)
• The need for dedicated resident and visitor car parking provision in all but the most centrally-located sites.
• Above all, a home that continues to allow people to pursue the pleasures of life today, while feeling secure that their home can adapt to future needs.

**Loose fit**

The principles identified in both the Sheffield study (above) and during this one extend beyond ‘Lifetime Homes’. ‘The recommendations for Lifetime Homes, whilst absolutely sensible in their own right, do not go far enough to provide truly adaptable housing. They mainly deal with modifications to discrete elements of design (socket heights, door widths and so on) rather than taking a more holistic view of the potential of adaptation. These aspects are covered in the second approach to design for the lifetime of a home, namely recognising the demands of changing sizes and/or ages of family or individual groups. This ability to react to changing household circumstances is clearly not incompatible with the tenets of Lifetime Homes, but takes on board a wider set of parameters’.¹

Loose fit, or as Till and Schneider refer to it, ‘Flexible housing’ would mean that people do not have to move elsewhere should certain circumstances change. For example if somebody becomes physically less able, through age or illness to navigate their existing dwelling, an adaptable house could provide the continued interdependence to the dweller or should the dwelling need to accommodate an additional bedroom it has the capacity to do so.

In the DWELL report as well as ‘Downsizing’, the concept of ‘Rightsizing’ is introduced. This suggests the opportunity to provide housing for another group of the population who also appeared not to be catered for but

¹ Tatjana Schneider and Jeremy Till, Flexible Housing (Routledge, 2007).
that had some similar attributes to the needs of the downsizer. ‘First-time occupiers’ also had many of the needs that matched those listed above, but perhaps with nuanced differences – enhanced affordability for example. It was decided to include this group within the scope of the study.

**Precedent studies**

Another crucial aspect of the research involved not just looking at general housing design, but also an in-depth analysis of highly regarded practitioners, of which - as noted - the most influential on the final project was the work of Jørn Utzon at Fredensborg and the Kingo Houses just outside Copenhagen. Both schemes had been regularly visited with Richard Weston, the authority on Utzon. This source however was reinforced by Forster’s ongoing interest in the courtyard form and the idea of additive architecture, with the testing of various design options always being tied back what makes a place successful, or not, in generating a sense of privacy and neighbourhood. Initially four house types were chosen and tested against four sites (16 in all) for massing and potential fit and estimation of numbers of potential new dwellings. (see above)

Studies underpinned MHA’s initial thoughts on downsizers. Design studies demonstrate the potential that the ‘infill’ candidate sites provide for appropriate infill neighbourhoods for both downsizers and possibly start-ups in line with WG ambitions.
Courtyard dwellings and additive form

The courtyard dwelling has been a subject of interest in DRUw for some time and were referenced as potentially suitable for downsizers in the literature review. The integration of inside and outside and the addition of spatial hierarchy from public to private provided by the private court is considered of great value in the design of the dwelling.

The detached or semi-detached house has emerged, in the late 20th.c as the ideal form of dwelling. This may be for a number of reasons – not least the efficiencies of cash flow for developers in uncertain times – build one, sell one - and perhaps the cultural demand for autonomy and perceived ideas of privacy and ownership.

However, given the nature of infill brownfield sites in particular, the courtyard form with its introverted nature has the potential to solve a number of issues. Peter Barber, in particular has demonstrated this on a number of dense, low rise infill schemes in London typified by the use of the notched terrace type at Donnybrook.

Here, the courtyards are used as private secluded spaces providing daylight and ventilation. Used in this way in combination with one another the type allows for very dense urban developments, as it can be linked to other units on three sides. In the research presented here the small infill sites did not provide much opportunity for this, but the secluded court did provide the potential to alleviate overlooking on hemmed in sites. Living and sleeping places adjacent to the private court can ‘borrow’ space to add to feelings of spaciousness.
Additionally, the courtyard itself may be considered to be the energy garden enabling higher levels of glazing and daylighting and also catching useful solar gains. They also provide areas for activity (gardening and growing) and amenity – with privacy as a key quality. The modern urban courtyard house has little or no association with the ancient precedents as it has been re-worked throughout northern Europe through the 20th c.

**Typology**

‘Typology is an approach that isolates the attributes of the architectural coherence, identifies them as characteristics in order to compare them with similar abstracted attributes from other contexts and define similarities or differences’ ³. In the design of residential architecture, in particular, the use of type as a platform on which the dependencies between occupants, culture, social environment and topography and geography was thought to be a relevant approach on these projects.

The two main types selected by MHA for further development from a range of four, are described in this study as a single storey L shaped courtyard and a Mews garden court. These both feature in Utzon’s Fredensborg scheme although the L shaped courtyards invariably have two bedrooms on a wider plot. According to Macintosh, the modern atrium house in Europe is not really similar to ancient precedent. ‘Mass courtyard housing, ….. never had anything to do with earlier courtyard houses. It was created afresh during the search for a new, functional, low rise housing from for the urban working class.’ ⁴

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The courtyard plan was developed to achieve privacy in the garden and allow light to penetrate the surrounding rooms. The first modern courtyard housing was detached and looked south over its private garden. This single aspect courtyard house, designed by Hugo Häring in 1928 was then developed into an L shaped plan by Hannes Meyer and Ludwig Hilbersheimer at the Bauhaus. In 1931 Hilbersheimer produced an improved L shaped courtyard house, with sleeping and living rooms grouped in two wings of the block. It is this ‘binuclear’ plan which is most used today.\(^5\)

According to Macintosh the Mews ‘patio’ or garden type may have some roots in Spanish Colonial Revival in Southern California\(^6\) but it was the efficiency of the terraced combination at Fredensborg that appealed here. Some confidence was gained through reference to the relatively small courts in the Barber schemes and the one-bedroom courtyard unit used by Patel Taylor at Barking. Here the external finish was a darkish stock brick.

In the design of both house types for MHA window and patio door opening sizes have an increased head height and the courts are white to increase the internally reflected component.

Long life, loose fit

In the literature review and in the focus group meetings of the subsequent market testing; the ability for some adaptation and flexibility in the use of the dwellings was emphasised as a preference. Given the funding structures and prescribed space standards this would prove challenging. The desire for spaciousness over multiple rooms provided some possibilities to accomplish both requirements. ‘Oversized’ or at least generously sized living spaces, in volume and area, were analysed to enable spaciousness, but also any subsequent adaptability and to maintain

\(^5\) Ibid
\(^6\) Ibid
minimum space standards. This was to done without having to ‘break’ or ‘add to’ the building envelope as it was envisaged that dwellings would be on constrained sites.

It is acknowledged that this is a limited form of flexibility however total flexibility is nigh impossible to achieve without huge overcapacity in plot size and building form. The standard 1 bedroom apartment that was being ‘rejected’ by potential tenants is around 50m2 GIA with no external amenity space. The ‘First time occupier’ mews unit was sized at 75m2 with the additional area being provided with spacious lounge and dining space almost twice the area of the minimum set out in the London Housing Design Guide.7

The ‘Downsizer’ courtyard bungalow similarly was nearly 50% bigger at 67m2 GIA. These areas are commensurate with the recommendations from the DWELL report (above) and in addition the volume of the dwellings is expanded by the ‘open’ roof arrangement. Each dwelling then has two separate private amenity spaces. The use of floor to ceiling glazing then allowed these outside spaces to be ‘borrowed’ as part of the interior, adding again to feelings of spaciousness and optimised daylight.

Low Energy

Whilst low energy and sustainability was an explicit goal, MHA were suspicious of the value of Passivhaus in use. They had reason to suspect that the downsizer group in particular would find the passivhaus regime too restrictive and difficult to live with. Initially a SAP rating of 100+ was set. This was modelled for the house types under different orientations. Initially the School’s own SAP calculator was used to set strategic parameters and then SAP calculations

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were made. The parameters were Passivhaus standard thermal performance for opaque parts of the fabric, a U value of 1.2W/m² for windows and doors. This was supplemented by a 4kW photovoltaic array.

**Drawing and modelling**

A range of models and particular drawing types were used to test out complex housing permutations and types involving a range of stakeholders, and to investigate construction technologies. For the initial design workshops site models at a scale of 1:200 were made showing the site contexts. These were helpful as they provided an immediacy for others in the design process and for planners and the client to observe the effect of physical constraints. Overlooking, rights of way and the impact of existing services could be quickly understood and different layout and massing studies were made by inserting (and removing) dwelling types. These were followed by hand drawn studies of the streetscape which were intended to not only convey character of place but also to be comprehensible to all stakeholders. These drawings, whilst three dimensionally accurate, convey impressionistic ideas of space and place without being to explicit about materials and architectural detail. These techniques were used in the first phases of design.

**Market research – testing design proposals – model houses**

Independent market research was commissioned by MHA and took place through August and September of 2017 following the Design Review with the Design Commission for Wales. Part of this research was conducted with 4 focus groups with a semi-structured interview around the proposed drawings and models. DRUw were present at the focus groups to answer questions and queries. The models were frequently picked up and studied in detail as
Early place and townscape studies drawn for discussion at client and tenant design workshops and market research focus groups
The use of physical models in the design research process.

1:200 Scale ‘loose’ models were used in design workshops with clients and local authority planners (above) to illustrate layout options. Larger scale 1:50 ‘dolls’ type houses were used in market research processes and also to explain spatial configurations to clients and users.
Modelling and testing of space and place - planning stage

RIGHTSIZING
respondents analysed room size and configuration. The results of this phase of research confirmed that both house types would be popular with the corresponding population – courtyard bungalows for downsizers and mews houses for first time occupiers.

Phase 3 and 4 Design in Detail

February through till June 2017.

Low energy and environmental delight - environmental modelling

The potential of the houses to meet a SAP rating of 100 plus was further modelled on an iterative basis as the precise means of construction was investigated with the Housing Association’s direct labour organisation. The SAP sensitivity tool developed by the school’s Architectural Science Group was of particular use during this phase as effects of variations in fabric performance and or systems could be immediately seen. Whilst environmental efficiency was key environmental delight was also tested although not as explicitly reported upon.

The following were also observed through the use of physical and computer models:-

- Adaptability, a house whose space and occupants can adapt to changing conditions (daily and seasonal) and needs.
- Variation, the focus on nature’s cycles implies that the indoor environment should vary in time and space rather than target uniformity or non-variability –one of the reasons for the early rejection of Passivhaus.
- Outdoor and semi-outdoor areas to be easily accessible; and occupants are able to follow (changes in)
outdoor conditions in all main living areas of the house.

- Light/darkness: Exposure to high levels of daylight is needed in the main living areas of the house during daytime, with special attention to the rooms that are mainly used in the morning, whereas the bedrooms need to provide complete darkness at night time.
- Cool/warm: The house should provide temporal and spatial variations in the thermal environment that are logical and follow, to a certain extent, outside temperature variations.
- Flexibility related to the seasons: The use of outdoor and semi-outdoor spaces should be stimulated outside the heating season.
- The occupants should be able to control the systems that influence parameters that can be sensed, e.g. lighting level, air quality and indoor temperature.
- Electrical lighting should follow, support and supplement change and variation in the light. It was the intention to design for this and again solar and lighting studies were undertaken using physical and computer models to support these factors.

Fabric performance, construction and buildability

These aspects of construction were tested mainly through an iterative drawing process during which detail design workshops involved the whole construction team. The initial physical models were used to ‘benchmark’ changes as they arose.
Carrowbeck Passivhaus, Norwich was used as precedent and base performance indicator for the construction of the building fabric.
**Environmental sustainability : Solution**

The design provides for a SAP rating of 100 plus. This entails providing a building envelope to Passivhaus standards PLUS 4kW renewables but with the addition of comprehensible and user friendly controls. The intention is to ensure that high levels of environmental comfort can be achieved with minimum reliance on fossil fuels and maximum user control. Additionally the environmental system is integrated with occupancy factors. We will therefore combine underfloor systems in the main living spaces with high thermal mass. In summer the buildings are designed to maintain coolness through openable windows and natural cross and stack ventilation allied to the high thermal mass. The buildings achieved the 100 plus SAP rating as built providing an energy plus solution.
6. DISSEMINATION

As et evenist incil moluptiant abo. Em ditatum reptate ctorrov itiaeru mendit vid utemque sitas sum verspe eos digni ut es volupiet venis ut eicienis raectentiae. Et moluptis perum ut dunda dolorepudio volendia quas esti quid quas doluptaque dolorro min pedigent volenda eperum conseque optatur aut que et qui re non porerferitio bea-quassimus con nonse poritaque cum vende et dendust, eos molore dolendamus rectotatia velignimin nonem duci dolorepe experferes qui quid ut qui bea nobit quo vel ilia quod maios ipsunt, soluptatur, occabor antore, ne et od quam quae sae net optate non culluptur, solut doloreperi cone eos magniihit, que ma consect usaerov itibusdanis veliquam im verestorem resciene non comnimus que ipsae est expel eatat por reicabore voluptae iunt re conserc itasper natist, optatquis est eseque lab im aliquundi ullah maio moluptatia porestr uptaqudestti autest, quos dolupta ssinventiae sitis essi consequi dolorio sandic tectur?
Voluptios sit quid quisim comnime nimincte porio ilique as maion nus rerum ute corpori as es ea parupti aecabori-bus sincta quam, sandandipsus eos im que voluptaest, opta saperit atendae endandit, consectur sequod que lam eatiorro voluptur aut hicidun diosam fuga. Ut volecer natur? Nam, si occaern atiur?
7. BIBLIOGRAPHY


Schneider, Tatjana, and Jeremy Till, Flexible Housing (Routledge, 2007)