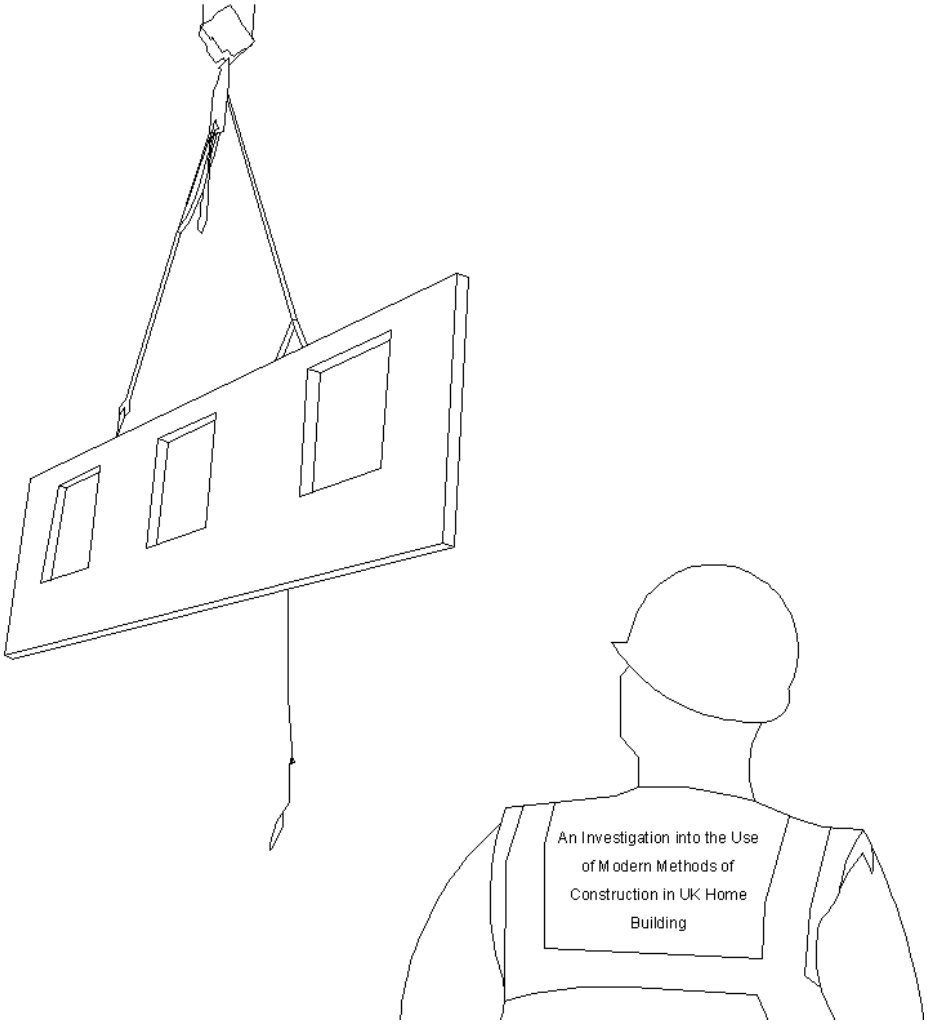
DISSERTATION TITLE

An Investigation into the Use of Modern Methods of Construction in UK Home Building



Submitted by:
Dean Jones (Student No. 2527428)
For the M.Sc. in Building Surveying
of London South Bank University
Faculty of Engineering, Science and the Built Environment
Department of Property, Surveying and Construction 2009.

Abstract

This dissertation analysis the perceived benefits of Modern Methods of Construction (MMC), which if viable could be said to provide the solution to more affordable, better quality, cost-effective and environmentally friendly housing in the UK.

The paper investigates the recent background to MMC home building, setting the historical and social context by identifying key relating papers, government's bodies and initiatives. The government's 60K home, Design for Manufacture Competition (DfMC) was regarded as fundamental milestone because, the government claimed that it succeeded in producing affordable, better quality, cost-effective and environmentally friendly housing using MMC. It was highlighted as a key driver for the start of the wider use of the term MMC.

Previous papers and projects, which addressed the benefits of MMC prior to the DfMC were analysed to establish the theoretical propositions made.

The study investigated and produced detailed case studies for three of the ten DfMC schemes and a questionnaire. It used the data from the case studies and collected from the surveys to make practical comparisons with the developed theoretical benefits of MMC.

Some of the case study and survey results are substantially different from the theoretical benefits and that of those reported by the government following the launch of their DfMC. Whilst only speed of construction was highlighted as a factual MMC benefit over traditional methods of house building, a number of steps are still required to realise this benefit in reality.

The results are shown in the conclusion of the work, which will hopefully enable future projects to consider MMC within their business case in a more unambiguous way.

2.9.1 Architects 53
2.9.3 Developers 63
2.9.3 Manufacturers 84
2.9.4 Other 85

CHAPTER 3 88

THE THEORETICAL BENEFITS OF MODERN METHODS OF CONSTRUCTION (MMC) HOME BUILDING 88
3.1 Scope of Chapter 89
3.2 Labour & Time Benefits 90
3.2.1 Process Plans 93
3.2.2 Planning & Early Commitment to a MMC System Type 94
3.2.3 Time Investment 95
3.3 Cost Benefits 95
3.3.1 MMC Developments Costs 97
3.3.2 MMC Construction Cost Estimates 98
3.4 Environmental Benefits 101
3.4.1 Maintenance 102
3.4.2 Waste 103
3.4.3 Energy Consumption 104
3.5 Quality & Accreditation 105
3.5.1 Durability 105
3.5.2 Whole Life Costs 107
3.5.3 Performance 108
3.6 Theoretical Framework 109
3.7 Enablers for the Application of MMC 111
3.8 Summary of Chapter 112

CHAPTER 4 114

RESEARCH DESIGN & METHODOLOGY 114
4.1 Scope of Chapter 115
4.2 Method of Data Collection 115
4.3 Review of Schemes 116
4.4 Design of Questionnaire 117
4.5 The Research Sample 119
4.6 The Assessment of Data 120

APPENDIX 2 - SAMPLE QUESTIONNAIRE 209
APPENDIX 3 - PREWETT HOSPITAL ADDITIONAL MATERIAL 212
d. Space 4 BBA Certificate 212
e. BRE Certification Certificate of Assessment 212
f. Bryant Homes new home warranty info 212
g. NHBC Warranty Approval 212
h. 2 Year Warranty Info 212
i. Zurich 10-year warranty info 212
j. Space 4 Technical Leaflet 212
k. Space 4 Cost Efficiency Brochure 212
l. Space 4 MMC on the March 212
m. Park Prewett Leaflet 212
n. Park Prewett Conservation Area Appraisal Site Plan 212
o. Park Prewett Master Plan 212
p. Park Prewett Site View 212
q. Park Prewett Article 212
Appendix 4 - Horns Cross Additional Material 213
r. Application – DA/06/00344/REM 213
s. Consultation Responses – Dee.Gold (06/00344/FUL) 213
t. Consultation Responses 56522 – Environmental Agency 213
u. Consultation Responses 561773 – Objection to Planning Department 213
v. Planning Decision Notice 578261 213
w. Drawing – 570209 (House Type A,A1 – Front Elevation) 213
x Drawing – 570210 (House Type A,A1 – Rear elevation) 213
y. Drawing – 0528 (House – First Floor Plan) 213
z. Drawing – 0628 (Site Plan) 213
aa. Drawing – 571924 (Development Plan Markup) 213
bb. Drawing – 573988 (Landscape Layout) 213
cc. Drawing – 573989 (Development Plan) 213
dd. Drawing – 570190 (Location Plan) 213
ee. Drawings – 622356 (Topographical Survey) 213
ff. Drawing – 570191 (View from Stone Place Road) 213
gg. Drawing – 570192 (Prospective 2) 213
hh. Drawing – 645960 (Plan Drawing Markup) 213
ii. Cut outs 213
APPENDIX 5 - RENNY LODGE ADDITIONAL MATERIAL 214

LIST OF FIGURES

Figure 1 - Sir John Egan ReThinking Construction targets 39

Figure 2 - Housing Market Supply and Demand, SMF: 2007 41

Figure 3 - State the main reason why MMC was chosen. CABE: 2004 (1= most important) 43

Figure 4 - MMC can halve on-site construction duration (NAO 2005). 90

Figure 5 - MMC provide weather tight conditions quickly (NAO 2005). 91

Figure 6 - Faster construction and reduced on-site work brings financial benefits. (NAO 2005) 92

Figure 7 - Process plans must match the construction method. (NAO 2005) 93

Figure 8 - Different project circumstances favour or work against MMC. 100

Figure 9 - MMC increases the amount of costs incurred off-site. (NAO 2005) 101

Figure 10 - Preventing heat loss by thermal Insulation and insulation. 2007 104

Figure 11 - Snagging as a percentage of build costs adapted from BCIS (2005) ... 108

Figure 12 - Theoretical Framework for the benefits of MMC. 110

Figure 13 - Viability of the established theoretical benefits of MMC. 112

Figure 14 - Outline methodology of the research adapted from Yin. 1994 116

Figure 15 - Statements taken from the questionnaire. 119

Figure 16 - Enablers for the application of MMC. 125

Figure 17 - Code for sustainable homes minimum standards. 129

Figure 18 - Quality and accreditation case study scheme analysis. 132

Figure 19 - MMC manufacturer key drivers 134

Figure 20 - Enablers for the application of MMC. 135

Figure 21 - Project triangle, Fast, Good and Cheap. 136

Figure 22 - Did the weather have any significant impact on the MMC scheme deadline? 137

Figure 23 - How much emphasis was put on tailoring the architectural plans of the home to fit the chosen MMC construction method? (1= most significant) 138

Figure 24 - Was the finial design complete before planning consent was sought? 139

LIST OF TABLES

Table 1 - Degree of off-site manufacture 37

Table 2 - Design for Manufacture Competition sites 46

Table 3 - MMC house building key players 52

Table 4 - Allerton Bywater DfMC scheme, key information 67

Table 5 - Oxley Park DfMC scheme, key information 70

Table 6 - Linton Hospital DfMC scheme, key information 76

Table 7 - Former TA site DfMC scheme, key information 79

Table 8 - Hastings DfMC scheme, key information 82

Table 9 - Different construction methods have different requirements. (NAO 2005) 91

Table 10 - MMC development costs. (BCIS 2005a) 97

Table 11 - brick and block cost estimate from survey of 50 recent schemes. (BCIS 2005) 97

Table 12 - Advanced panel cost estimate adapted from (BCIS 2005) 98

Table 13 - Hybrid cost estimate adapted from (BCIS 2005) 98

Table 14 - Volumetric cost estimate adapted from (BCIS 2005) 99

Table 15 - MMC construction range estimates 99

Table 16 - Snagging as a percentage of build costs adapted from BCIS (2005). ... 108

Table 17 - MMC Design for Manufacturer Competition (DfMC) chosen case study schemes. 119

Table 18 - Case studies house price comparison. 123

Table 19 - case study total project construction times 125

Table 20 - Quality and accreditation case study scheme analysis. 127

Photo 45 - Broadway Malyan 60K house artist's impressions. 2006 72

Photos 46 & 47 - Broadway Malyan 60K house artist's impressions. 2006 73

Photo 48 - Former Renny Lodge Hospital (prototype 60K home) bid image. Sheppard Robson: 2006 74

Photo 49 - Former Renny Lodge Hospital. SixtyK Consortium: 2006 75

Photos 50 & 51 - Former Linton Hospital (prototype 60K home). Crest Nicholson: 2006 77

Photos 52, 53 & 54 - Former Linton Hospital. SixtyK Consortium: 2006 77

Photos 55 & 56 - Aylesbury 60K house artist's impressions. ACD: 2006 80

Photo 57 - Hastings 60K house artist's impressions. Verry Construction: 2006 83

Photo 58 - Copod. Elements Europe: 2008 84

Photo 59 - Strucpod. Elements Europe: 2008 85

DEFINITIONS AND ABBREVIATIONS

AD	Approved Document.
Affordable housing	*'Affordable housing includes social rented and intermediate housing, provided to specified eligible households whose needs are not met by the market'* (DCLG 2006).
BBA	British Banker Association.
BCIS	Building Cost Information Service. A main supply of cost information for the construction industry.
BLP	Building LifePlans is a construction defects insurance specialist.
BM TRADA	BM TRADA offers a range of certification schemes under our Q-Mark brand for building products for over 20 years.
BRE	Building Research Establishment. A leading research, consultancy, training, testing and certification organisation delivering sustainability and innovation across the built environment and beyond.
BREEAM	Building Research Establishment Environmental Assessment Method. It is an environmental assessment method for buildings.
Brownfield site	A Brownfield site is largely land previously used for any purpose, but is no longer in use for that purpose.
BS	British Standard.
BSi	British Standards is the UK's National Standards Body.

Defra	Department for Environment, Food and Rural Affairs. The UK Government department tasked with issues, such as, the environment, rural development, the countryside, wildlife, animal welfare and sustainability.
DETR	Department of the Environment Transport and the Regions.
Development	Development is defined under the 1990 Town and Country Planning Act as '*the carrying out of building, engineering, mining or other operation in, on, over or under land, or the making of any material change in the use of any building or other land.'*
DfMC	Design for manufacturer competition. A CLG initiative aiming to demonstrate it was possible to build a more environmental friendly, affordable, high quality home, quickly for a construction cost of £60,000 using MMC. It was launched in April 2005 to address the major increases in housing costs in recent years.
DoE	Department of Environment.
DPDs	Development Plan Documents. They outline the key development goals of the Local Development Framework.
Dti	Department of Trade and Industry.
Eco-towns	'*Example "green developments". They designed to meet the highest standards of Sustainability, including low and zero carbon technologies and quality public transport Systems. They will make use of Brownfield land and surplus public sector land where Practical and lead the way in design, facilities and services, and community involvement.'* (Planning Portal 2009).

Housing association	Common term for the 2000 or so independent, not-for-profit organisations registered with and regulated by the Housing Corporation.
Housing corporation	The government agency who fund and regulate Registered Social Landlords (including housing associations) in England.
HSC	Health and Safety Executive.
IAB	Irish Agreement Board. It is designated by Government to issue European Technical Approvals.
IDeA	Improvement and Development Agency for local government. Body owned by the Local Government Association that works for local government so councils can serve people and places better.
IHS	The Source for Critical Information and Insight is a leading edge supplier of BSi British Standards, and other regulations.
Key worker	A 'key worker' is defined as public sector worker i.e. the police, nurses, possibly teachers and social workers etc.
Key worker living	A CLG scheme running since 2004 helping key workers in London, the South East and East of England to buy a home, upgrade to a family home or rent a home at an affordable price.
LHSC	Lifetime Homes Standards Criteria. Developed to help house builders produce new homes flexible enough to deal with changes in life situations of occupants e.g. caring for young children, temporary injuries, declining mobility with age.

NLUD	National Land Use Database.
ODPM	Office of the Deputy Prime Minister.
OGC	Office of Government Commerce.
OPD	Ozone Depletion Potential.
OSB	Oriented Strand Board. It is an engineered wood product.
OSM	Off Site Manufacturer. Refers to structures built at a different location than the location of use.
OSM Homes	OSM HOMES is a UK based house building company which uses the new concept of Modern Methods of Construction (MMC).
OSM - Hybrid	'*Combine both panellised and volumetric approaches. Typically, volumetric units (sometimes referred to as pods) are used for the highly serviced and more repeatable areas such as kitchens and bathrooms, with the remainder of the dwelling or building constructed using panels.'* (NAO 2005)
OSM – other MMC	*'Use floor or roof cassettes, pre-cast concrete foundation assemblies, pre-formed wiring looms, and mechanical engineering composites. They can also include innovative techniques such as tunnel form or thin-joint block work.'* (NAO 2005)
OSM - Panellised	*'Is produced in a factory and assembled on-site to produce a three dimensional structure. Open panels consist of a skeletal structure only, whereas more advanced panels may include lining material, insulation services, windows, doors, internal wall finishes and external claddings.'* (NAO 2005)

	consultant), Davis Langdon (cost planner) and MacFarlane Wilder (landscaping specialist). SIXTYK Consortium bids have been selected to develop two of ten publicly owned sites as part of the Design for Manufacture competition: Renny Lodge in Newport Pagnell and the former Linton Hospital in Coxheath, near Maidstone.
Standardised	Components/parts within the construction industry, normally 400mm, 600mm or 1200mm (centres) are used to create 'modules'.
Sustainable development	A development which meets the needs of the present without compromising the ability of future generations to meet their own needs.
TCPA	Town and Country Planning Association.
TRADA	Timber Research and Development Association.
Traditional build	A home that is 'traditional build' is constructed on the building site, piece by piece.
Zero-carbon	Zero-Carbon is a low carbon vision for the future.
Zulassung	A recognised Swiss Matriculation certificate.

1.1 Scope of Chapter

This chapter aims to provide a basic understanding of the issues surrounding the UK home building industry and the lack of affordable stock, together with the contentious benefits of using Modern Methods of Construction (MMC) for building these homes that provoked this research. The hypothesis, main aim and objectives are detailed, following with an explanation of the layout of the work and methodology of the research.

1.2 Introduction to the Research

The government wants to build three million new homes by 2020. Wilson & Anseau (2006) referred to (Barker 2004) who underlined the need for a long term strategy to be developed with regards to the supply of decent affordable housing for key workers and the homeless. ODPM (2005c) underlined the government's commitment to this strategy, in which they stated *'the opportunity for everyone to live in a decent home at a price they can afford was now one of the most fundamental goals of the government.'*

Therefore in order to promote their 'affordable housing' strategy, English Partnership (EP) the Government's national regeneration agency launched the Design for Manufacturer Competition (DfMC) in 2005, as primer to help the construction industry to achieve their goal.

Photo 1 - Design for Manufacturer Competition (DfMC) 60K house concept.

Photo 3 - English Partnership (EP) first Carbon Challenge site.

However, whilst the CLG & EP is now keen to encourage the building of more sustainable homes as shown in photos (*Photo 2 & Photo 3*) the questions still remain, 'are the benefits of MMC as outlined in (DCLG 2006b) actually achievable in reality? As such is MMC really more affordable, environmental friendly, quicker to build and better quality than traditionally built homes?

In (Mtech 2008) 'Off-site Directory' architects were asked to list problems with MMC house building. The question raised a serious of concerns with the main issue being the lack of technical information and shorter lead-in times. Other replies pertinent to this dissertation were:

- *'Lack of relevant cases studies',*
- *'Difficult to manage manufacturer's quality control',*
- *'Stigma attached to pre-fabs',*
- *'Lack of knowledge',*
- *'Client doubts',*
- *No perceived cost benefits',*
- *'Concern that aesthetics may be compromised',*
- *'Inability to deal with one-off solutions'*
- *'Not yet cost effective on small scale projects'*
- *Onerous design process not easily covered by fees'* (Mtech 2008)

1.4 Identification of Aims & Objectives

1.4.1 Aim

To assess whether the alleged benefits of using Modern Methods of Construction (MMC) for building houses is valid.

1.4.2 Objectives

In order to achieve the aim, the following four objectives will be implemented:

- ✓ To investigate current MMC house building in the UK.
- ✓ To investigate the theoretical benefits of MMC house building.
- ✓ To investigate the reality of MMC house building.
- ✓ To evaluate the impact of MMC house building.

Further sources included professional institutions, such as, RICS, CIOB and RIBA as well as, construction magazines & journals including Building (Off Site Directory 2008), Construction Manager, and Contract Journal. In addition a range of MMC industry player's websites including; housing associations, architectural practices and developers were used, before considering each of the proclaimed benefits of MMC in subsequent chapters.

The main field research will be case studies together with survey data based on primary information sources. The final chapter then draws conclusions from the analysis in each of the chapters in order to address specific issues raised in the introduction.

1.7 Summary of Chapter

It can be seen that there are a number of factors that have influenced the writing of this research, namely, governmental reports showing housing need and the failings of the construction industry. These reports along with CLG initiatives have offered a solution, that is the use of MMC to reduce construction time, waste, and offer more affordable and greener homes. These claims support the suggestion that MMC is the best way to provide modern architecture to the masses. It is understood not every MMC follower makes every one of these claims. However, they are universal enough that this dissertation is going to address them as the claims of the industry as a whole. From these issues the aims and objectives have provided the formation of the following chapters which will lead you through to the final conclusions and recommendations for additional research.

It is noted that this is largely a technical study, not really looking at the current climate.

2.1 Scope of Chapter

An empirical desk study of existing literature on MMC has been carried out to give an articulate insight and indeed a current historical context into the influencing documents that are available and have both provoked and driven this research. This has been composed to provide an insight into the industry change from using the term 'prefab' to using the phrase 'MMC' and then to illustrate the influencing factors and documentation surrounding MMC, in particular the governmental reports and the lack of affordable housing in the UK and resulting MMC government initiatives. This is followed by a breakdown of the key players within the UK MMC home building market and short reviews of their work. Other key players may be within the UK, however, research has not revealed any to date.

2.2 Prefabricated Homes

Prefabricated homes have been available for years and date back at least a century. The Sears Roebuck index made and offered prefab homes to the public as early as 1908, and Prefab was later explored by famous twentieth century architects, such as, Walter Gropius, Le Corbusier, Marcel Breuer, Frank Lloyd Wright, who saw the method as a likely solution to the dilemma of housing in modern society. Interest in Prefab grew in the first half of the twentieth-century, with the outburst of manufacturing expertise and the creation of the assembly line.

Historically the mention of prefabricated houses invokes memories of housing built to cover in the temporary a deficiency of housing in the UK following the World Wars.

The Government promised 'homes fit for heroes', however, negative public attitudes surfaced towards prefabricated housing because of substandard building materials used and poor workmanship. (See, for example, Crisp 1998)

A staggering 1 million of these homes were built during the 20th century and more than half a century on, many are still standing despite no foundations. A few are listed while others have been demolished.

Photo 6 - Catford prefab estate. Robin Bell: 2008

An example can be found by looking at the Catford estate. 62 years on and the prefabricated houses on Catford estate built by German and Italian prisoners of war in 1946 as shown in (*Photo 5* & *Photo 6*) is heritage listed.

> *'They were not built to last and need regular maintenance. They are just large sheds really and taking up a lot of space. They should really be demolished.'* (Drake 2008)

Over the years, Lewisham Council has tried to develop the site many times and a recent review (see *Photo 7*) found none of the dwellings met (DCLG 2006c, p. 4) Decent Homes Standard. (Drake 2008) further the estimated cost for refurbishment is a staggering £8.4 million, needed over the next 30 years. (See, for example, Flickr 2008).

Photo 7 - Prefabulous. Elisabeth Blanchet: Date unknown

Examples of each of the categories are included in 'definitions and abbreviations'.

The facts presented above would suggest that MMC is more broadly based than prefabrication, as it engages people and process to seek improvement in the delivery and performance of construction, not just a product.

Characteristically MMC is the fabrication of house parts off-site in a factory with panels & modules being the two main products. (See, for example, CIEF 2003, page 4; NAO 2005, page 3)

Panels comprise of complete walls, floors & roofs which are transported to site for assembly. Some panels also come complete with wiring and plumbing. Modules also known as 'pods' are complete rooms, which can be pieced together like puzzles to form homes. These are used mainly for bathrooms and kitchens where fittings are added in the factory. MMC can also include pioneering on site techniques, for example concrete moulds. A variety of materials are used for MMC, the most widespread being steel and concrete. It is important to understand that the fundamentals of MMC are common throughout various types of construction.

The table below has been extracted from BCIS (2005s) study in to MMC; it shows the degree of OSM in each MMC construction type over traditional brick & block.

Construction method	**Percentage off-offsite manufacture**
Advanced panel	25%
Hybrid	30%
Volumetric	65%

Table 1 - Degree of off-site manufacture

When you get down to the bare bones of it all the majority of material used in buildings are as stated above to some extent MMC as shown in (*Table 1*). However, it is arguably that it is amount of off site manufacturing that has increased over recent years that has re-triggered much interest in this area.

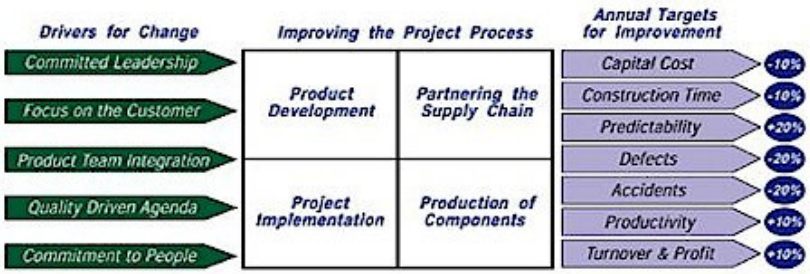


Figure 1 - Sir John Egan ReThinking Construction targets

Behind all of these initiatives lay the concept of assembling construction projects from standardised components made offsite. These are a number of items from the (Egan 1998) that support the use of MMC for house building applicable to this dissertation:

- *'Standardisation also has an important role to play in improving the design stage of construction. The average car contains about 3,000 components. A house, by comparison, has about 40,000. We see a useful way of dealing more efficiently with the complexity of construction is to make greater use of standardised components'* (Egan 1998, page 27). This again in looking at Lean Construction method. Breaking the house down into separate parts which can bf produced off-site and then brought to site and put together like a puzzle which is what MMC is all about.

- *'prefabricated units which can be incorporated in a variety of buildings, including Forte's Travelodge, speculative housing and housing association developments, military accommodation, private hospitals and top of the range self-build houses.' 'Advantages include speed of construction, lower cost, reduced need for skilled labour and achievement of zero defects'* (Egan 1998, page 10).

- *'McDonald's Restaurants have demonstrated an ability to construct a fully-functioning restaurant on site in 24 hours, using a very high degree of Prefab and modularisation. The design allows expansion or even relocation'* (Egan 1998, page 10)

Barker (2004) stated *'Demand for housing is increasing over time, driven primarily by demographic trends and rising incomes. Yet in 2001 the construction of new houses in the UK fell to its lowest level since the Second World War.'* In other words housing demand exceeds the current supply. Barker (2004) further stated that *'Affordability has worsened between cycles. In 2002 only 37 per cent of new households could afford to buy a property compared to 46 per cent in the late 1980s.'*

According to the Barker Review, every house would need to last over 200 years if the supply of new housing does not speed up to meet the current demand as portrayed in (*Figure 2*). However since there is no guarantee that the existing housing stock which includes fairly old houses will last quite this long, Baker is essentially saying that we need to build more homes, quickly other there will be an enormous housing deficit.

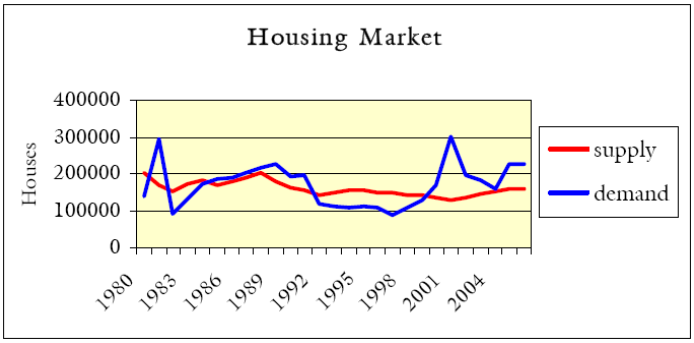


Figure 2 - Housing Market Supply and Demand, SMF: 2007

2004 also saw the publishing of the government's response to the Egan Report; amongst other papers, which in addition to (Barker 2004), made proposals for four new growth areas, and reforms to the planning framework. A number of recommendations were made in these reports, for instance: -

'We agree that high quality design standards are essential to deliver high quality development.' (ODPM, 2004a, page 4).

'We need to act now if we are to extend the opportunities and quality of life so many of us have enjoyed too future generations.' (ODPM 2005a)

Photo 8, 9, 10, 11 & 12 - MMC case studies. CABE: 2004

The project was led by HTA Architects Ltd, a company specialising in housing, supported by the Department of Architecture at Oxford Brookes University.

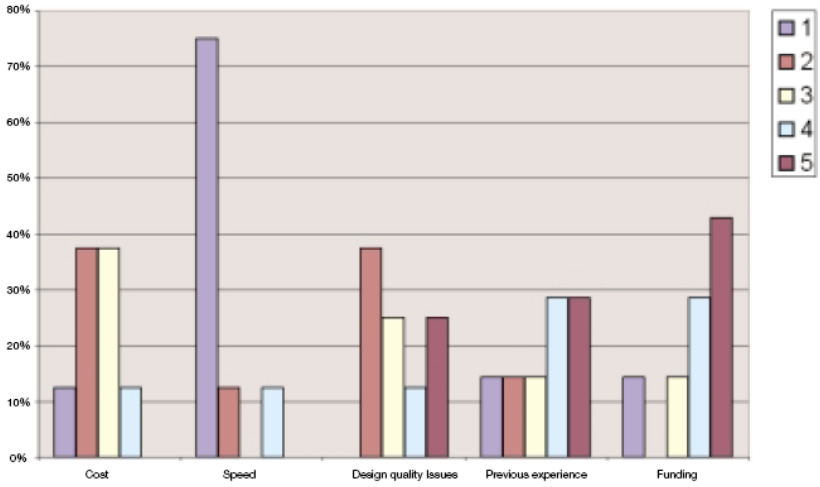


Figure 3 - State the main reason why MMC was chosen. CABE: 2004 (1= most important)

2.6 Government MMC Initiatives

In April 2005 the Deputy Prime Minister John Prescott pressed ahead and launched the, *'The Design for Manufacture competition'* it's aim was to prove undoubtedly, that it was possible to build good-quality, cost-effective homes across a range of housing types and solutions using MMC for a construction cost of only £60,000. As a minimum, all homes had to follow the principles of the Urban Design Compendium (EP & HC 2000). It's important the realize that none of the MMC schemes reviewed in (CABE 2004) had a strict benchmark of 60K, in fact no previous scheme involved the use of MMC in the UK ever attempted to achieve what the DfMC was now proposing.

It is important to note that although the phrase Modern Method of Construction (MMC) was coined in the post-Egan era, to describe work undertaken in a 'factory setting' as opposed to on site, that the launch of DfMC was almost certainly the starting point for the wider use of the phrase and consequently the demise of the term 'Prefab'. MMC now representing the ushering in of a new era of technological advances and possibilities in the public eye.

In total, the competition aimed to create in the region of 1,200 new homes for rent, sale and shared ownership with around 50% obtainable through HCA First time buyer initiative (FTBI). However, after just one year the prototype flagship £60,000 house had to be demolished and rebuilt with new materials, which casted doubts on the durability of MMC as CLG set this up as a primer to kick start the MMC house building industry.

The firms that entered the competition as list in (*Table 2*) were evaluated by looking at different aspects of the bid, including design, sustainability, cost, innovation, process, and health and safety. 220 companies entered, 9 winners were selected in August 2005, however only 6 were given sites. Building started in April 2006.

Construction report which was to improve the output, efficiency, quality, costs and waste.

As expected, the findings of the (DCLG 2006b) report resulted in a significant amount of media frenzy between the UK construction industry, as well as BCIS & CLG about the viability of the professed benefits of MMC.

2.7 The Apparent Benefits of MMC

2.7.1 Labour & Time Benefits

A faster building method is one of the claims made about MMC.

Grand Designs a popular reality TV program highlighted a distinct difference between the views of, for example manufacturers stating that a MMC building system is to be built in a specific way and will only take a specified amount of time to erect, to a contactors understanding of skills and time needed for the erection of the same MMC structure in reality.

Barker (2004) stated *'MMC time savings do not currently provide a compelling financial reason to switch from traditional brick & block.'* Nevertheless, MMC supporters, which include manufacturers, developers, RSL's and the government, declare that there are major savings because a lot of the work is undertaken off-site in factory conditions and complete building parts arrive onsite with electrics, pluming and fixtures installed and therefore *'when using MMC the amount of labour needed on-site is far less'* (SCRI 2008).

2.7.2 Cost Benefits

Some of the first homes to be built as a result of DfMC were on sale in the summer of 2008 at Oxley Woods, Milton Keynes. The first two bed properties went on sale for around £200,000, however, is this affordable?

Lovell (2003) also stated '*Construction and demolition waste comprises 25% of UK waste. The amount of waste produced using MMC is likely to be reduced because factory materials can be ordered to exact specifications.'* However, it has been alleged their core MMC structures, in fact use extra resources than traditional construction in order to endure transportation, if true, would this not be considered a form of waste?

The introduction of the DfMC was about three years ago and although some of the schemes are still far from complete EP has since launched the Carbon Challenge in 2008 as a successor to DfMC to promote environmental standards. This followed the publishing of (DCLG 2007) Green paper which committed the Government to executing a new energy related building regulations and set out their plans for three million new homes by 2020. These include more homes for social housing, building homes more quickly, more affordable homes and of course greener homes.

During a brief telephone conversation on 06 October 2008 Helen Stoddart of EP stated that their focus is now on building less energy-intensive and energy-hungry homes. This is in union with the Governments Code for Sustainable Homes (DCLG 2006e) which, states that all new homes should be low carbon neutral by 2016.

EP (2008) stated *'they no longer require Modern Methods of Construction'* EP and since replaced the MMC target with a condition for developers to give in a 'Statement of Construction Efficiency' covering all their projects.

Have EP forgotten the original aim?

2.7.4 Quality & Accreditation Benefits

Lovell (2003) stated '*The number of defects in traditionally built homes in the UK is considerable, with house builders allocating up to £2,000 per house to rectify problems. Greater use of factory production can reduce defects because there is less risk of weather damage during construction, and materials can more easily be standardised and tested.'*

The Government stated '*there '£60,000 home competition has proved wrong those critics who claimed you can't have both quality and quantity'* (Lovell 2003). However at a glance most would argue this was no more than another political stunt. After all it was a government run project and they have a lot more power to pull certain stings than say a small house building developer trying to achieve the same.

In (Mtech 2008) architects were asked to list in their words what would help MMC develop in the future. Some of the responses included the following:

- *'If costs equivalence can be demonstrated, other benefits will lead to widespread use.'*
- *There has to be a confidence in the quality of the supply chain and ability to produce consistence finishes.'*
- *Economies of scale will make it more viable for larger projects but for one-offs it may not be economically rewarding'*
- *'The current economically downturn may help'*

Hence MMC home building is experiencing a lot of new attention but as one developer puts it, *'I think the whole thing is a false promise'* (Smith 2008).

Nevertheless, the array of recent investigations into MMC by the government and industry has aroused a lot of interest in its possible advantages by leading architects, developers and contractors.

2.8.2 Key Players

Below are a number of UK key players within this section who are particularly interested in schemes for MMC:

List of key players within this section is given in the following table:

Many of the schemes featured below were selected to be 'Landmark' schemes incorporating a wide range of the Egan Principles. Most of the dwellings were required to achieve (at least) a very good rating under the BRE Eco-Homes Assessment Scheme.

It seemed appropriate to start with Murray Grove the first multi-storey modular housing scheme in the UK. This scheme designed for Peabody Housing Trust created 30 apartments targeted at young families.

2.9 Recent MMC Home Building Schemes

2.9.1 Architects

P&M: Proctor & Matthews

Photos 13 & 14 - Murray Grove. Peabody: 2004

Proctor & Matthews / Clancy Docwra

Barons Place (London)

Photo 15 - Barons Place. Clancy Docwra: 2004

Barons Place shown in *(Photo 15)* is a trial low-cost three-storey housing scheme in Southwark, London, for the Peabody Trust.

'Following early involvement with the client and his design team Clancy Docwra were appointed as principal contractor for the enabling works of this high profile project. Their client Spaceover Ltd was appointed by Peabody Trust to design and install modular key worker accommodation units on this small site close to Waterloo Station. The 15 units were constructed and internally fitted out off site, whilst Clancy Docwra undertook site preparation and the installation of services. The units were delivered to site, and under the supervision of Clancy Docwra, the three storey development was installed over one week-end. The installation was completed with access stairs and balconies complemented by hard and soft landscaping.' (Clancy Docwra 2008)

Photos 16 & 17 - Tim Pyne's M-house. Hugh Pearman

The M-house shown in (*Photos 16 & 17*) is a two-bedroom, single-storey house, a modernist bungalow, but on wheels. Architect Tim Pyne was refused planning permission to build a permanent structure on his land and decided to create the M-House as an alternative solution.

'The M-house (pronounced mouse) comes in two parts, which are transported by lorry and zipped together, on site and can be positioned on land, water or rooftops, and should, apparently, last for 100 years.' 'For a modular building, the M-house is rather roomy at 1,000 ft square. The interior even manages a loft-style feel with swish appliances and birch furniture. How much? £100,000.' (FANH 2006)

The prototype of the much-trailed M-house is located on a patch of waste land by a small industrial estate on the outskirts of Canterbury.

Quay2c

Projects: Fairmule House

If size matters, there is no comparison as Fairmule House as shown in (*Photos 21, 22& 23*). It is the largest solid timber construction in the UK. MMC solid timber panels were used for its walls, roof and floors, to create a scheme of 11 flats and four business units in east London. Built on a Brownfield site in Shoreditch, London.

Photos 21, 22 & 23 - The Fairmule House. Anthony Coleman & Quay 2c: 2008

'A design and build company specialising in solid timber construction, supplied the superstructure of the building. The sustainable laminated softwood panels are 115mm thick for the walls and 170mm thick for the floors and roof and made from sawmill offcuts. The first panel to be craned onto site was 2.7m wide, 14m long and 115mm thick. Even the lift shaft is created from timber panels.' (WFG 2008)

Allford Hall Monaghan

Projects: Raines Court (London)

Photo 26 – Construction of Raines Court. Allford Hall Monaghan, 2004

Peabody Trust commissioned Architect Allford Hall to create Raines Court in (*Photo 26*) which was in essence another experimentation project to see if it was achievable to building quality housing using MMC. Allford Hall worked with Wates and modular specialists Yorkon on the design and specification.

The apartments are clad in zinc panels and each apartment has a balcony and private entrance.

'The three project aims were all achieved: all the flats were sold on a shared and full ownership basis within weeks of being offered; the scheme increased the extent of works done off site and incorporated into the modules (which were increased in size and reduced in number); and the successes and difficulties were all openly discussed.' (BPB 2008)

'The key principles have been published and summarised in an 11-point plan and will be progressed in a new modular housing project the Momo being developed with a shipping container manufacturer.' (BPB 2008)

2.9.3 Developers

Peabody Trust

Projects: Murray Grove (London), Barons Place (London) and Raines Court (London).

Peabody is one of biggest & oldest housing Trusts in London and has been developing reasonably priced MMC housing for low key workers since 1999.

Photo 28 - Barons Place. Peabody: 2008

Barons Place, there latest development, has been built and temporary let to NHS key workers. This is because it has been uniquely designed so it could be taken apart and rebuilt somewhere else.

Developed in the UK by IKEA and BoKlok is Ikea's concept in MMC housing. They have designed a house that can be delivered flat packed and assembled onsite like a puzzle. *'They are high quality, simple to construct, affordable and encompass the latest technology, a project spokesman told the newspaper'* (Thelwell 2007). Drumchapel village is to become the first of many in the UK, the great news of that you will not have to put the house together yourself as they will send there own fitters to do this job.

'The house comes with the promise of being very energy efficient and environmentally sustainable. The homes were herald a "blueprint of the future". (Ikea 2008)

The Swedish furniture company is intending to firstly focus on Greater London, Kent, Surrey, Sussex, Hampshire, Yorkshire, Teeside, Tyneside and Central Scotland. The BoKlok flats are mostly built of local pine and have balconies overlooking joint gardens. However, if it's a house you desire, they have already developed flat-pack villas in Sweden, which in due course may well be introduced in the UK.

Barratt Developments plc

Project: Allerton Bywater, near Leeds Upton, Northampton: DfMC

Architect:

HTA

Main Supply Chain Partners:

Advance Housing Ltd (MMC supplier owned by Barratt)

Key information:	Key Dates:
No of Units - 151 Homes per Ha – 47.19 Number of Registered Social Landlord Affordable Homes - 30 First Time Buyer Initiative Units - 0	Last House Completion – September 2009 (Projected) First Occupation – May 2008 (Projected) First House Completion – April 2008 (Projected) Start on Dwellings – December 2006 Start of Infrastructure – April 2006 Planning Approval Granted – March 2006 Planning Application Submission – December 2005
Site Specific Information: Total number of homes to be built: 151 Total number of £60k homes to be built: 46 (equivalent to 30%) Total number of social housing: 30 mixed throughout the site and indistinguishable from other homes (16 for disabled and elderly) 3.2 ha (7.92 acres) site in a Millenium Community in a former Coalfields area Density: 47 homes per ha	

Table 4 - Allerton Bywater DfMC scheme, key information

Countryside Consortium – Developer

Projects: (DfMC) Horns Cross, Dartford - DfMC

Photo 37 - Horns Cross. Countryside Consortium: 2006

Countryside Consortium was selected as the preferred developer for this site by EP as part of the government 60K MMC DfMC.

The Countryside Consortium is one of the UK's leading homebuilders.

This scheme incorporated the use of both the BUMA volumetric system and The Homes Factory panellised timber frame system. The BUMA system is a light gauged steel frame, clad on the exterior with render-finished insulated OSB board or metal cladding with drained or ventilated cavity and internally lined with plasterboard.

Photo 38, 39, 40, 41, 42, 43 & 44 - Oxley Park. Roger Stirk Harbour: 2006

Taylor Wimpey plc were selected as preferred developer for this site by EP as part of the government 60K MMC DfMC. There houses come with three options (1) traditional brick & block, (2) light steel frame or timber frame with the steel or (3) timber frame options and similar to Ikeas Boklok solution, the components for this house are delivered as a 'flat-pack'.

The process was tightly controlled through a process map and supplier partnering arrangement which Wimpey alleged delivered major economies of scale.

The homes include a pre-fabricated eco-hat. The house has a central lantern through which all soil and vent pipes pass and allows light to enter the central area of the home, so heat can be managed and make maximum use of solar gain. The homes are designed for flexibility, allowing future bolt-on sections, balconies, study rooms and canopies.

Photos 46 & 47 - Broadway Malyan 60K house artist's impressions. 2006

Persimmon Homes (who recently acquired Westbury Homes) were selected as the favoured developer for this site. They used Space4's advanced timber-frame panel system with traditional masonry to create this house. Space4 is owned by Persimmon Homes. Space4 provides structural timber frame components for the building industry including external walls, cassette floors and internal/party walls, both load-bearing and non-load-bearing. Being based in the west midlands space4 is well situated to a ready supply of labour for its factory.

Photo 49 - Former Renny Lodge Hospital. SixtyK Consortium: 2006

The SIXTYK Consortium were selected as the approved developer for this site which used the SIP walled two bedroom house was designed by architects Sheppard Robson. The site was a former NHS hospital which EPs purchased as part of its surplus public sector land programme.

The team has fully maximised the potential of modern construction technology to create the new Former Renny Lodge Hospital.

Photos 50 & 51 - Former Linton Hospital (prototype 60K home). Crest Nicholson: 2006

Photos 52, 53 & 54 - Former Linton Hospital. SixtyK Consortium: 2006

A structural insulated panel method has been utilised for the construction of the walls and roofs for houses and flats. This form of construction supports the sustainable

William Verry

Projects: Former TA site, Aylesbury Vale: DfMC

Architect: ACD (landscape architects)

Registered Social Landlord: To be arranged

Main Supply Chain Partners: WeberHaus GmbH of Germany (manufacturing partner)

Key information:	**Key Dates:**
No of Units - 102 Homes per Ha – 70.34 Number of Registered Social Landlord (RSL) Affordable Homes - 30 First Time Buyer Initiative Units - 40 RSL - Genesis	Last House Completion – June 2009 (Projected) First Occupation - January 2009 (Projected) First House Completion – January 2009 (Projected) Start on Dwellings – September 2008 (Projected) Start of Infrastructure – August 2008 (Projected) Planning Approval Granted – May 2008 (Projected) Planning Application Submission – February 2008 (Projected)

Table 7 - Former TA site DfMC scheme, key information

William Verry is one of the UK's oldest companies and has been responsible for the construction of many well-known civic, commercial and arts projects. WeberHaus has been one of Germany's chief housing companies for the past 45 years and has built over 27,000 homes across Europe (mainly in Germany, Austria, France and Switzerland). It uses factory processes techniques used by the car industry which the company evolved with the support of Porsche Consulting to enable a quick production line otherwise known as lean manufacturing in the Egan Report.

The WeberHaus produce is a panellised timber-frame and walling system using floor and roof panels and wood exterior cladding all built in the factory and transported to the site for rapid assembly.

The WeberHaus system has full certified recognition to the high German construction standards and has had approval under the Zurich insurance housing warranty scheme. Their produce has already won the support of chief mortgage lenders. WeberHaus has now obtained BRE approval for compliance with UK Building Regulations. As the first complete housing development supplied by WeberHaus in the UK, this project is a major milestone in the use of highly developed construction techniques in this country.

Photo 57 - Hastings 60K house artist's impressions. Verry Construction: 2006

William Verry were selected as the preferred developer for this site.

The WeberHaus product is another panelised timber-frame and walling system incorporating floor and roof panels and wood exterior cladding all built in the factory and delivered to the site for quick assembly.

This is a 'combination' pod for the residential sector and comes in a series of different living areas, such as; bathroom, shower room, kitchen and staircase.

Project: Strucpod

Photo 59 - Strucpod. Elements Europe: 2008

This system optimizes MMC hybrid construction methods by being fully integrated into the structure of a building and provides a full load-bearing structure for buildings up to six story's high.

2.9.4 Other

Log cabins

Log cabins are fast becoming a popular choice in MMC homes because they provide a rural feel and are perfect for a small piece of privately owned land for a vacation getaway.

traditional style home. With MMC's individual designs and claimed benefits, it is clear the interest surrounding this type of house building in the UK is growing.

It is now widely accepted that MMC housing is the solution to cheaper, greener, and superior housing (Thelwell 2007). One could argue that we have reached the stage where MMC building methods need not hinder design flair or flexibility, and can potentially lead to improvements in construction. However, there conflicting anecdotal evidence and doubts as to whether the claimed benefits of MMC are really achievable in reality.

Chapter 3 explores these proclaimed benefits from a theoretical prospective before investigating the reality of MMC home building.

3.1 Scope of Chapter

This chapter takes a detailed look at the four main claims made by MMC proponents that support the idea that this method of house building is the best way to provide housing to the masses in order to discern the credibility of each proposition made. The claims are:

1. MMC takes less labour & time
2. MMC is more affordable
3. MMC is more environmentally friendly
4. MMC is of a better quality

This is accomplished by assessing the literature relating to the use of MMC on time, cost and the environment, the implication it has on the quality of housing schemes in the UK by various government bodies and other industry stakeholders including: - Communities and Local Government (CLG), Commission for Architecture and the Built Environment (CABE), Building Research Establishment (BRE), English Partnership (EP), Improvement and Development Agency for local government (IDeA), National Audit Office (NOA), Homes and Communities Agency (HCA), The National House-Building Council (NHBC), Zurich, Mtech, Building LifePlans Ltd Housing Cooperation and Building Cost Information Service (part of the Royal Institute of Chartered Surveyors).

The chapter takes a general view of MMC possibilities and some of their relative merits. It draws on the definition of MMC in Chapter 2 and refers to the categories of MMC as defined by the Housing Corporation as OSM volumetric, OSM panelised, OSM hybrid and OSM SUB Assemblies and components taking the established brick and block processes as a reference point to weigh against.

The established propositions for using MMC will be used later to make a practical comparison with the main field research.

A number of MMC enablers are derived from this chapter, which are deemed critical by their authors for the achievement of the four above benefits.

	Brick and Block	Open panel/ Advanced panel/Hybrid	Volumetric
Bricklayers on-site	44 days	20 days	20 days
Arrival of first following trades	16 weeks after groundbreak	7 weeks after groundbreak	Not used
Scaffolding in use	11 weeks	8 weeks	6 weeks

Source: Process plans prepared for the National Audit Office by the Salford Centre for Research and Innovation

Table 9 - Different construction methods have different requirements. (NAO 2005)

(*Table 9*) shows that with brick & block bricklayers are required to build both the internal & external skin of a building, which MMC are only required to build the external skin.

NAO (2005) concluded that MMC made it possible to build up to four times as much and halve time on-site using the same on site labour as brick and block

(*Figure 5*) shows the time taken to provide weather tight conditions for each MMC construction type. It was concluded that MMC provides faster weather tight conditions than brick and block. Yet again the Hybird building method had a comparable construction timescale to open panel.

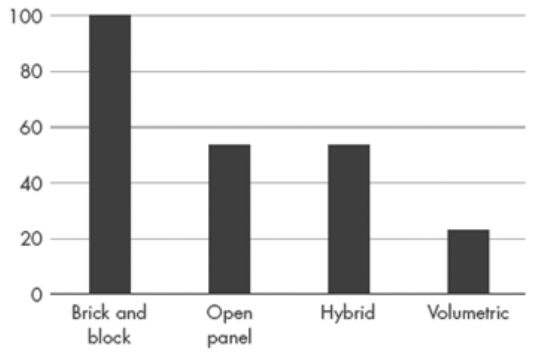


Figure 5 - MMC provide weather tight conditions quickly (NAO 2005).

All factors given above suggest that there are obvious time savings to be had with each MMC building method. It is also reasonable to assume that the time savings will bring added benefits, for example; bad weather cannot disturb trades. In addition

3.2.1 Process Plans

It can therefore be argued that speed is a plausible benefit for MMC, however, (NAO 2005) referred to process plans in (*Figure 7*) being integral & necessary to achieve this saving. Furthermore, that the process plan would need to be tailored to fit each MMC construction type according to a criterion, this being:

1. Foundations
2. Superstructure
3. Internal works
4. and completion

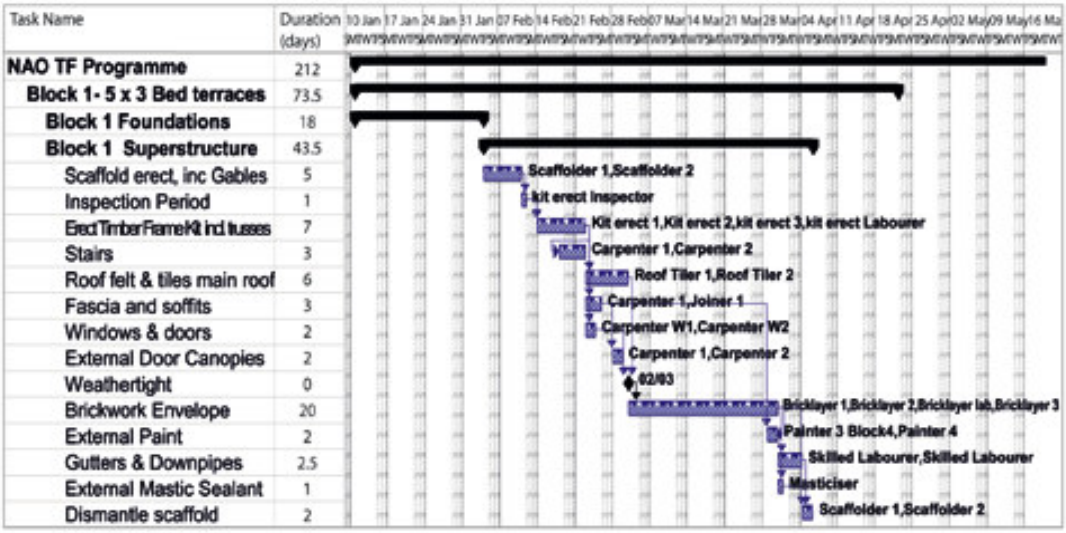


Figure 7 - Process plans must match the construction method. (NAO 2005)

In addition to the above (Fisher 2007) suggests that *'using a catalog of pre-selected materials increases supplier relationships and makes the design process more streamlined.'* In other words using ready made parts which can be brought literally of the shelve will speed up the building process.

Certainly this way of assessment allows for design and manufacturer to run almost simultaneously with jobs that need to be carried out regardless of the MMC product type.

3.2.3 Time Investment

Developers are reluctant to incorporate MMC from the outset of a project, for example. CABE (2004) stated *'there is a direct relationship between the scale and complexity of MMC component and the amount of time required to develop a design at an early stage.'* It is obvious that a considerable amount of study is required to investigate MMC systems; hence a time investment is required at the early stages of projects.

Furthermore, architects experienced in advanced MMC design reported in (CABE 2004) that it is necessary obtain extra funding for additional costs, which included verification of suppliers' credentials, for visiting previous sites, investigating mortgage and insurance issues, obtain technical performance information about a MMC building system, understanding junctions and interfaces, for talking to system suppliers, for coordinating other consultants, obtain building control input and so on.

Therefore the factors given above indicate that extra funding will be require in addition to a significant time investment for new scheme incorporating MMC.

3.3 Cost Benefits

DfMC (2006) stated that *'Off-site manufacturing, as product substitution, tends to be more expensive but does not necessarily result in more expensive schemes as savings are made from the increased speed'*

Manufacturers and resellers repeatedly tell us MMC is also cheaper because again parts of the house are assembled in a factory setting before being pieced together

3.3.1 MMC Developments Costs

Similar reasoning was established in BCIS (2005a) which identified that standard MMC components had almost no design cost in them as shown in (*Table 10*), nevertheless, that clients were consistently still incurring costs with the reason being that only a small number of consultants design for MMC. In addition BCIS (2005a) cited there was little reliability in the way that developers accounted for their development costs and overheads.

	Development cost Per unit £
Brick & Block	14,000
Advanced Panel	13,500
Hybrid	13,500
Volumetric	**12,500**

Table 10 - MMC development costs. (BCIS 2005a)

BCIS (2005a) used a scheme which reflected a 'typical' RSL shceme to evaluate costs. Though the cost of the MMC parts may be less incoherent than the traditional brick & block, labour costs on schemes create an array of results. (*Tables 11 - 16*) provides a range estimate of £/m2 construction costs for schemes from the (BCIS 2005a) assessment of average MMC costs in relation to brick and block.

	Cost per house	**Cost per m2 (£)**
Dwelling – Super and Sub	47764	646
External Works	12190	165
Prelims	14172	192

Table 11 - brick and block cost estimate from survey of 50 recent schemes. (BCIS 2005)

	Cost per house	Cost per m2 (£)
Dwelling – Super and Sub	£68,388.00	£925.00
External Works	£12,190.00	£165.00
Prelims	£9,113.00	£123.00

Table 14 - Volumetric cost estimate adapted from (BCIS 2005)

The cost estimates results for advanced panel, hybrid and volumetric MMC building methods have been combined in one table to make a practical comparison with traditional brick & block methods. The results are given in the following table:

No.	Construction system	Estimated range £/m2 dwelling with prelims apportioned by cost
1	Brick & block	599 - 999
2	Advanced panel	663 -1104
3	Hybrid	675 -1126
4	Volumetric	772 -1287

Table 15 - MMC construction range estimates

The results given above suggest that MMC is more expensive than traditional brick & block home building by a landslide. Volumetric being the most expensive by contrast and timber frame and panelised coming in close to traditional brick & block cost estimates.

BCIS (2005) stated, *that 'Manufactured products have a greater degree of price and cost certainty than on-site processes'* the reasoning behind this is that they are not subject to the same degree of site conditions, labour supply and weather as traditionally brick and block built homes. Therefore, it's arguable to say the amount of OSM will affect the cost & time certainty of a scheme.

The search for further cost reduction goes on and would perhaps depend on where most costs occur, which at this time seems to vary from each MMC construction method so far.

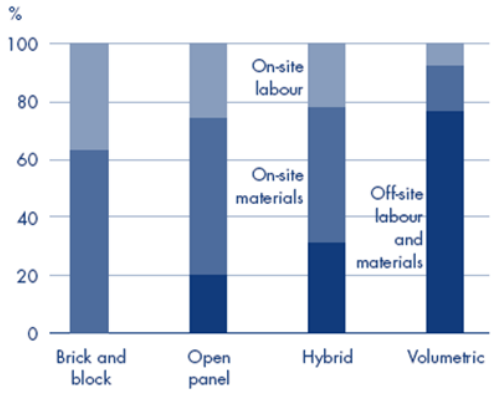


Figure 9 - MMC increases the amount of costs incurred off-site. (NAO 2005)

(*Figure 9*) shows that the percentage of MMC construction cost increases significantly with the amount of work undertaken. Cost is incurred mostly for volumetric approaches and mainly on-site for other MMC construction methods. As a consequence the volumetric method will perhaps become more economical if the cost of the MMC parts decreases; and open panel and hybrid approaches will become more economical if either the cost of the MMC parts decrease or if the MMC parts are designed better to decrease on-site labour.

3.4 Environmental Benefits

Beyond MMC's revival, or perhaps to facilitate it, supporters are pushing MMC's professed environmental advantages. 'Green' is a high priority agenda for the government at the moment, so MMC supporters are jumping in and claiming supremacy in this area, for example:

- *'Modular and panellised construction techniques have the potential of significantly reducing environmental impact'* (Quale 2008)

buildings expected life cycle and due to factory conditions requires less snagging and rework.' (SCRI 2008)

It has further been said, 'that sustainable MMC houses can cost about the same as a conventional home to construct' but the quality and efficiency of the finished product is typically better, because more investment is put into materials and technology rather than on-site construction crews. (Guardian 2008)

3.4.2 Waste

Since MMC is built in a factory it is claimed to create much less waste by setting and re-using scrap waste in other projects; for example. '*The re-use of timber off-cuts by finger jointing and the chipping of unusable timber for use as much'* (BCIS 2005a). However, the same could be said for traditional build homes as you can now easily hire a waste removal company who will recycle 90% of the onsite construction waste. Furthermore, the procedures outlined in (BRE 2008) Sustainable Construction, Simple ways to make it happen, paper can arguably be applied to both traditional build and off-site manufacture, as shown below:

1. *Finding a supplier who accepts returns or exchanges*
2. *take back and reuse packaging*
3. *Exchange material*
4. *Crush and reuse aggregates*
5. *Improved site conditions*

On the other hand, although, it is also possible for MMC builders to capture waste from their production line, just as it's possible for them to use economies of scale to buy environmentally friendly materials, it doesn't inevitably mean they do.

It has been said that MMC can help eliminate waste and animosity between trades. For example, traditional trades usually just manage the box work allocated to them, and don't usually step out side of their box to cater for others. Whiles it has be said that those individuals working in a MMC off-site factory would be more appreciative that the building is being prepared for final works to be undertaken on-site. This

3.5 Quality & Accreditation

CABE (2004) stated in their study of MMC that, *'There was no clear evidence of a relationship between design quality and the use of MMC'* and further that *'none of the schemes reviewed exhibited outstanding design quality. Performance standards likewise were generally not exceptional.'* In other words you can have fine buildings; well designed using MMC and you can have awful buildings using the same method.

CABE did not get the results they were after and it was generally decided that although, the schemes assessed were acceptable to clients & local planning authorities, none of them demonstrated extraordinary quality in design, which does not sit well with the proposition that MMC in better quality than traditionally building homes.

Similar reasoning can be found in (NAO 2005), which suggests that MMC can deliver at least as good quality traditional building methods, if appropriately specified.

However, we know there will be tensions when you prioritise time, cost and quality for example, if speed and cost come out first, unavoidably quality suffers as a result. So perhaps there needs to be a better evaluation of what we mean by better quality housing. Are we thinking about the whole life cost of a scheme rather than the initial outset costs?

Although, a seemingly simply starting point, there are certainly three quality questions that arise when you compare MMC to traditional build homes, will it last as long or longer?, will it cost more or less to keep?, and will it function as well or better? These questions are explored below: -

3.5.1 Durability

Issues have arisen concerning the durability of MMC building systems and as a result BLP were commissioned by the National Audit Office (NAO) to examine the specification details for a number of MMC schemes. The conclusion of the examination (NAO 2005) reported *'that the expected durability of the development*

3.5.2 Whole Life Costs

BICS (2005) reports that *'Any whole life cost assessment is based on a series of assumptions about the life of the components, their performance in use and the time horizon for the investment.'*

BICS (2005) cited that there are no maintenance issues with the core structures of the MMC methods and those materials will have the same durability, whole life costs and maintenance regimes regardless of the MMC system when compared with traditional methods of construction.

However, there is a flip side because if for example a part is defective, this will be repeated until it is reported.

It was stated at (SCRI 2008) that *'The only faults are those of human error in communication emphasising the need for better guidance on the installation processes. Manual labour is not as tiresome as it used to be due to technological improvements.'*

It was found that the present outlay for 'snagging', i.e. correcting faults once a home is complete, accepted by the industry is awful, traditional brick and block being the worst, which is arguably indicative of the lack of on site quality control, for example. A poll among house builders carried out by (BCIS 2005a) suggested the following levels of snagging in (*Figure 11*).

2. *Current Building Regulations, including Part L revision; and* (Mtech 2004)
3. *Housing Corporation scheme development standards compliant (*Mtech 2004)

All the MMC construction types were stated in Mtech (2007) The Callcutt Review, to meet the current energy and environmental requirements and will be capable of being developed to meet the proposed Part L of the Building Regulation.

Further, it was stated that *'Based on existing designs some of the off-site manufactured options already provide higher levels of insulation.'* (BCIS 2005)

Therefore, there are no real theoretical problems concerning performance. However, it was recommended to achieve better quality *'Improved dialogue at the outset of the project was seen as vital if design quality is to be maximised.'* (CABE 2004)

Constraints and opportunities within a particular MMC system are considered to be more easily included into design if partners communicate from the beginning of a project. (CABE 2004) suggested that this could be improved by long term partnering relationships.

There is no doubt distributing the investment throughout the duration of a project helps to ensure a higher standard of design and specification and thus superior quality.

3.6 Theoretical Framework

A number of theoretical benefits emerged for using MMC over traditional building methods from the literature research as outlined below:

Labour & time benefits	
'makes it possible to build up to four times as much.' (NAO 2005)	✓
'on-site construction time can be reduced by over a half.' (NAO 2005)	✓
Cost benefits	
'no cost saving was expected from using MMC.' (CABE 2004)	✗
'*can be at least as competitive as more established techniques.'* (NAO 2005)	✗

3.7 Enablers for the Application of MMC

However it is arguable that whiles MMC offers many benefits, it must be managed cautiously to capitalise on value and reduce risk amongst other things, for example:

- Improved communication with supply chain partners (CABE 2004)
- Time investment (NAO 2005)
- Tight liaison with planning authorities (NAO 2005) (DETR & CABE 2000)
- Process plans tailored to MMC construction method (NAO 2005)
- Early commitment to a MMC system (NAO 2005)
- Good risk management (NAO 2005)
- Using a catalog of pre-selected materials (Fisher 2007)
- Using proficiently skilled workforce for on-site assembly (BCIS 2005)
- Precise project planning (BCIS 2005a)
- Partnering relationships (CABE 2004)

The above has been expressed as being enablers for the application of MMC.

CABE (2004) concluded that, given the enormous range of systems that fall within the scope of Housing Cooperation's definition of MMC, that the conclusion must be that there are no inherent barriers to providing good design through their use and that the array of systems accessible potentially allows the any designer or developer enough choice and therefore the opportunity to avoid problems derived from any shortfalls posed by the use of any one MMC technique.

NAO (2004) concluded that, while MMC offers various benefits, they have to be managed carefully to maximise value and minimise risks.

from the onset. These are not proposed as obstacles to achieving good design in MMC schemes, but may hinder the use of more intricate types of MMC from, which better overall benefits may be realised perhaps because of the cost uncertainty, planning process, system, time outlay, inadequate communication, inexperience, supplier's role, available information, assumptions about the benefits of MMC and financial feasibility.

Consequently, we now understand that there are a number of 'Core Values' termed enablers to be adhered to in order to facilitate the potential benefits of MMC, in particular time and labour savings.

Now that we have established the theoretical benefits of MMC, the next chapter now aims to create a suitable methodology to investigate the reality of MMC home building.

4.1 Scope of Chapter

This chapter aimed to create a suitable methodology to investigate the reality of MMC.

4.2 Method of Data Collection

The main study of the work is to be based on the undertaking of three case studies and the analyses thereof, defined as primary information sources by Naoum. This is to be complemented with survey data from people directly involved in the MMC Housing schemes which will draw on the background knowledge and expertise of the architects, developers and RSL's. To give a much more focused view, as opposed to the random sending out of questionnaires which would instead give me a much boarder picture of what happening.

The use of case studies and survey data was found to be the most logical approach for this study, because this will enable the study to make a practical comparison with the literate based research data. It is a method that holds up well when compared to other methods in the range of research methodology.

The case study path is effective for generalising using the type of test that is called 'falsification', which will form part of the critical reflexivity where the previously developed theoretical propositions in the literature research will be used as a template to compare the results of each case study.

Lamnek (2005) *"The case study is a research approach, situated between concrete data taking techniques and methodologic paradigms."*

- Quality & accreditation (Three quality requirements)
  - Durability
  - Whole Life Costs
  - Performance standards
- Survey data

This has been designed to allow for the data to be directly interpreted and provide a fast effective method of data collection. Its structure has been developed to find out pertinent information regarding the chosen MMC construction projects in relation to the established theoretical MMC benefits.

4.4 Design of Questionnaire

The questionnaire was shaped from the theoretical research based on the four alleged benefits of MMC i.e. cost, labour and time, environmental and quality and accreditation. The fundamental design of the questionnaire was that of a postal type examination tool. The number of questions for each benefit was determined by a method of individually assessing the magnitude of the proclamation and the likely level of significance that could be derived. In general, there were a comparable number of questions relating to each alleged MMC benefit to give a relatively consistent examination.

Some of the questioning needed further explanation and therefore a space will inserted at the end of the questionnaire for further comments to ensure correct interpretation. Although there were many instances where extra information was added the majority of this information was not used in order to retain uniformity.

The questionnaire comprised of a number of statements which required respondents to rate statements concerning their knowledge of the subject matter. Examples of statements included in the questionnaire are listed below (*Figure 15*).

the house over traditional methods of construction?
Quality and accreditation
17. Was there any constraints placed on the quality of the materials to be used?
18. Will the MMC system used hinder residents from adapting and modifying their homes reasonably straightforwardly, with particular reference to the skill level required and difficulty of an alteration?

Figure 15 - Statements taken from the questionnaire.

4.5 The Research Sample

The research consists of case studies and questionnaires.

Three projects were examined for the case studies (See Appendix 1) these were as follows.

	Site	MMC solution
A	Horns Cross (DfMC) in Basingstoke	Panellised & Volumetric & OSM
B	Park Prewett (DfMC) in Dartford	Panellised OSM
C	Renny Lodge (DfMC) in Maidstone	Panellised OSM

Table 17 - MMC Design for Manufacturer Competition (DfMC) chosen case study schemes.

Each project was part of the ODPM DfMC initiative, the first house building scheme in the UK to impose a benchmark construction cost of 60k, for building a 2-bedroom house using MMC. All projects formed consortiums and embraced a range of technologies involving MMC.

The main aims of the projects were two achieve cheaper, better quality, greener and more affordable homes using MMC for £60,000.00.

considered to be a reputable course of action for the cross case analysis of theoretical propositions as illustrated in (Figure 16).

It can be seen that the methodology adopted reflects the modest number of house building schemes for review in relation to the time available for this project and that it combines qualitative and quantitative approaches in one single for data analysis.

4.7 Methods of Analysis

The data in the following chapter is analysed by using both interpretative and positivist methods for the assessment. Literal duplication within data collected from the case studies and survey data was to a degree sought during examination to facilitate the testing of the theoretical propositions from the literature based research so that an assessment can be made. Replication was argued to be established if the results from each case constructively matched the theoretical propositions. However it is noted that statistical analysis was not the key goal as this study has not adopted a positivist stance.

5.1 Scope of Chapter

This chapter analysis data collected for three case studies and data received from questionnaires in (Appendix 1 & 2) respectively.

It seeks to breaks down the information gathered, so that the information can be used in part to assess the validity of the theoretical propositions established in the literate based research and help formulate the final outcomes of this research.

A number of tools have been used for this evaluation process including UK building regulations approved documents, BRE's Green Guide to Specification, ODPM Code for Sustainable Homes, Life Time Homes (LTH) requirements, SAP energy rating, National Statistics Online and Land Registry House Price Index.

A number of themes emerged which, whilst not necessarily statistically important, due to the small sample, are of importance and indicate areas for potential improvement or future research.

5.2 Analysis of the Case Study Data

The analysis of the case study data is broken down into four main sections, under the main headings of, labour & time, cost, environmental and quality and accreditation and other information.

5.2.1 Cost Benefits

Site	Construction Cost (£)	Actual selling price (£)	Average selling price in area (£)	Difference
Horns Cross	£60,000.00	unavailable	£176,000.00	unavailable
Park Prewett	£60,000.00	£219,950.00	£218,000.00	-£1,950.00
Renny Lodge	£60,000.00	£189,000.50	£114,000.00	-£75,000.50
*Based on a 2 bedroom house.				

Table 18 - Case studies house price comparison.

5.2.2 Labour & Time Benefits

Site	A. Horns Cross	B. Park Prewett	C. Renny Lodge	(Brinkley 2006)
Building method	MMC Volumetric & Panellised OSM	MMC Panellised OSM	MMC Panellised OSM	Brick and block
Total time to build (2 bedroom house)	8 months	4 months	13 months	8 to 15 months

Table 19 - case study total project construction times

The findings in (*Table 19*) demonstrate that improved speed is a viable benefit for using MMC for house building also found to be so in (NAO 2004) report. Whiles it is difficult to see increased speed as a great incentive to change if it does not encroach on for example, the financial position of first time buyers. Nevertheless RSLs and other organizations who wishing to complete schemes in a certain time, might it is thought, in the right circumstances, find 'increased speed of building' a reason to employ MMC.

Even though there is still little data about MMC labour costs, it seems reasonable to conclude that the way to reduce construction costs on site must be to eliminate as many unnecessary delays in the schedule both with each subcontractor and in between each sub's work on the site, by implementing the following as specified in chapter 3:

Improved communication with supply chain partners ✓
Time investment ✓
Tight liaison with planning authorities ✓
Process plans tailored to MMC construction method ✓
Early commitment to a MMC system ✓
Good risk management ✓
Using a catalog of pre-selected materials ✓
Using proficiently skilled workforce for on-site assembly ✓
Precise project planning ✓

Figure 16 - Enablers for the application of MMC.

The above may sound like common sense to many, but are factors that not always fall into place in the real world of house building which is why many construction sites

Quality & accreditation scheme analysis			
Site	A. Horns Cross	B. Park Prewett	C. Renny Lodge
MMC solution	MMC Volumetric & Panellised OSM	MMC Panellised OSM	MMC Panellised OSM
Durability			
On site assemblage by certified construction teams	Yes	Yes	Yes
Factory quality construction system	Yes	Yes	Yes
Life expectancy	60 years	60 years	60 years
Insulation / Thermal conductivity	Mineral wool (glass) [G 160kg/m3] / A rating	Injected Phenolic foam (PF) insulation / Not yet assessed	Polyurethane foam (PU) with CO2 / A rating
Performance			
10 year defects warranty	Yes	Yes	Yes
Building regulation endorsement	Yes	Yes	Yes
Housing corporation compliant	Yes	Yes	Yes
Whole life costs			
Future adaptability is in accordance with conventional engineering techniques.	No	No	No
General maintenance	unknown / not specified at this time	unknown / not specified at this time	unknown / not specified at this time
The environmental ratings of different types of insulation (with A being the best) have been taken from the latest assessments in BRE's Green Guide to Specification. (EST 2005)			

Table 20 - Quality and accreditation case study scheme analysis.

5.2.3.1 Whole Life Costs

The case studies revealed that there are obvious issues regarding whole life costs, specifically relating to future adaptability with the MMC. Two of the three schemes reviewed acknowledged that specific MMC suppliers would have to be involved in the elemental changes[5] such as modification to internal plan or the construction of an

[5] MMC suppliers would have to be involved in the fundamental changes to houses (New factor)

contrast traditional masonry, concrete and timber buildings still exist that have given good service for many hundreds of years and according to (RICS 1995a) traditional built houses have potential life spans in excess of 200 years, which raises some questions regarding the supplier's confidence in the MMC systems chosen.

5.2.3.3 Performance

In terms of future maintenance, this is difficult to prove since the houses are in there early years and the problems that might arise will almost certainly be for the generation to come. This fails to back up the proposition made by NAO (2005) that *'MMC lowers the risk of non-conformities and therefore consequent repairs.'*

The suppliers were all capable of supplying and meeting the production outputs needed for the schemes.

5.2.4 Environmental benefits

The three projects reviewed in this section exceeded the minimum standards in (*Figure 17*) for the government's new code for sustainable homes. The Code used a rating system indicated by one (*) to six (******) stars reflecting the success of a development in sustainability terms.

Minimum Standards					
	Energy		Water		
Code Level	Standard (Percentage better than Part L[1] 2006)	Points Awarded	Standard (litres per person per day)	Points Awarded	Other Points[4] Required
1(★)	10	1.2	120	1.5	33.3
2(★★)	18	3.5	120	1.5	43.0
3(★★★)	25	5.8	105	4.5	46.7
4(★★★★)	44	9.4	105	4.5	54.1
5(★★★★★)	100[2]	16.4	80	7.5	60.1
6(★★★★★★)	A zero carbon home[3]	17.6	80	7.5	64.9

Figure 17 - Code for sustainable homes minimum standards.

Sound Insultaion (Requirements of Building Regulation Part M)	Meets the minimum standard ✓	Meets the minimum standard ✓	Meets the minimum standard ✓
Private space For the provision of outside space that is at least partially private, and that is accessible to disabled people.	✓ Points awarded 1 - Code for Sustainable Homes	✓ Points awarded 1 - Code for Sustainable Homes	✓ Points awarded 1 - Code for Sustainable Homes
Lifetime Homes (LTH) 16 design criteria, and relevant requirements of Building Regulation Part M.	✓ Points awarded 4 - Code for Sustainable Homes	✓ Points awarded 4 - Code for Sustainable Homes	✓ Points awarded 4 - Code for Sustainable Homes
Ecology			
Ecological value of site (Where development land is of low ecological value as defined by either The BRE Ecological Value Checklist)	✓ Points awarded 1.2 - Code for Sustainable Homes	✓ Points awarded 1.2 - Code for Sustainable Homes	✓ Points awarded 1.2 - Code for Sustainable Homes
Ecological enhancement (Where ecological features have been designed for positive enhancement in accordance with the recommendations of a suitably qualified ecologist.)	✓ Points awarded 1.2 - Code for Sustainable Homes	✓ Points awarded 1.2 - Code for Sustainable Homes	✓ Points awarded 1.2 - Code for Sustainable Homes
Protection of ecological features (Where all existing features of ecological value are maintained and adequately protected from damage during site preparation and construction works.)	✓ Points awarded 1.2 - Code for Sustainable Homes	✓ Points awarded 1.2 - Code for Sustainable Homes	✓ Points awarded 1.2 - Code for Sustainable Homes
Change ecological value of the site	✓ Points awarded 1.2 - Code for Sustainable Homes	✓ Points awarded 1.2 - Code for Sustainable Homes	✓ Points awarded 1.2 - Code for Sustainable Homes
Building footprint	unknown	unknown	unknown

However, the over achievement in environmental criteria maybe one of the reasons the government along with English Partnership their regeneration agency are now focused on *'homes that respond to climate change, the pressures on energy cost, demographic change and work with the surrounding environments and ecology'*(DCLG & EP 2006b). However whiles this all sounds great, it is well known that other house building schemes built using traditional methods of construction are also achieving the high code for sustainable homes standards. It seem like the government been coy about the DfMC and have swiftly turned their eyes to environmental issues.

5.2.5 Other

The MMC systems were chosen at the beginning of each project. The early selection was understood to be necessary to enable each of the MMC solutions to become a central part of the design process. (DCLG & EP 2006b) which underpins (NAO 2005) proposition with regards to 'early commitment to a MMC system' being essential for MMC.

Interestingly, it was found that each (2 bedroom house) from the scheme assessed, utilised Panelised MMC building method, a new proposition, signifying that Panelised MMC leans itself to low level housing.[8]

All sites were noted to be generally level which supports the idea that MMC leans itself to level and accessible sites.[9] This is perhaps to allow cranes & trucks that transport building part to site to easily undertake their work.

It was found that all schemes analysed thought the cases studies chose to form consortiums and used fully integrated supply chain partnering supporting the proposition that MMC requires early attention to procurement issues through the whole supply chain to ensure efficient and timely delivery of components.[10]

---

[8] Panelised MMC leans itself to low level housing (New proposition)

[9] MMC leans itself to level and accessible sites (New proposition)

[10] MMC requires partnering relationships (CABE 2004) ✓

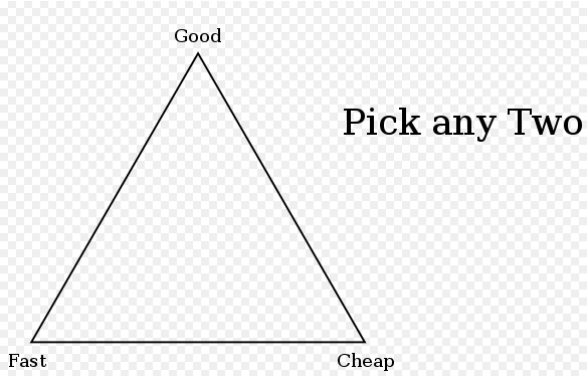
Improved communication with supply chain partners ✓	(CABE 2004)
Good time investment ✓	(NAO 2005)
Tight liaison with planning authorities ✓	(NAO 2005)
Process plans tailored to MMC construction method ✓	(NAO 2005)
Early commitment to a MMC system ✓	(NAO 2005)
Good risk management ✓	(NAO 2005)
Using a catalog of pre-selected materials ✓	(Fisher 2007)
Using proficiently skilled workforce for on-site assembly ✓	(BCIS 2005)
Precise project planning ✓	(BCIS 2005a)
Partnering relationships ✓	(CABE 2004)

Figure 20 - Enablers for the application of MMC.

Nevertheless, it was revealed that no cost saving was expected from using MMC and that the majority of schemes used MMC for reasons of speed. Further none of the schemes reviewed exhibited an exceptional design quality and there was no direct correlation between the use of MMC and improved environmental performance over traditional methods of construction.

DCLG & EP (2006b) stated *'the Design for Manufacture Competition has shown that the industry can meet the challenge of cost and innovation.'* Conversely, on a more careful examination of all the comparables in this section, it appears that the use of MMC to achieve enhanced environmental, quality, and faster building has affected the total costs of the projects; this is reflected in the results.

The triangle below represents the old conundrum (Bethke 2003). It has been said that you can have two of these, but only at the expenditure of the third. This is certainly true in this case.



5.3 Analysis of Survey Data

The survey data has in (appendix 2) has been broken-down into graph format under the headings of each question's posed in the questionnaire and then organised into four sections, under the main headings of, labour & time, cost, environmental and quality and accreditation and other as follows:

5.3.1 Labour & Time

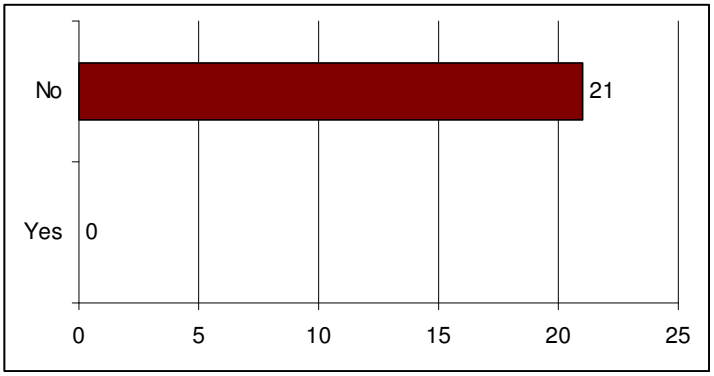


Figure 22 - Did the weather have any significant impact on the MMC scheme deadline?

(*Figure 22*) shows the percentage of schemes from the survey data, stating either yes or no. The data suggests that the weather did not have any significant impact on the MMC home building schemes.

Figure 24 - Was the finial design complete before planning consent was sought?

The majority of projects referred to in (*Figure 24*) had their final designs complete prior to submission of their planning applications. Nevertheless, a quarter of respondents still had to complete their designs after planning. This supports the proposition that early commitment to a MMC system is vital to ensure success[14]. It's interesting that those schemes which did not have there plans complete before submitting their planning applications didn't select speed as the primary reason to use MMC which also inversely supports the proposition that early commitment to MMC system is vital if speed of construction is the aim.

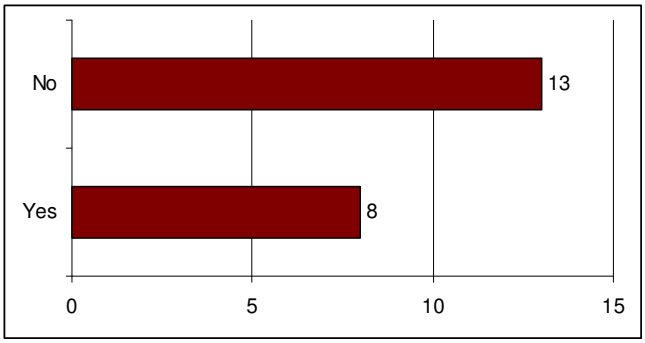


Figure 25 - Was there modifications to the process plans after planning permission was granted?

The majority of schemes in (*Figure 25*) did not change or modify their plans after planning permission was granted. This was highlighted as one of the *don'ts* in the previously established MMC enablers list as shown in (*Figure 20*) which supports the proposition that plans should not be modified after planning has been granted.

[14] Early commitment to MMC construction method (NAO 2005)

5.3.2 Cost

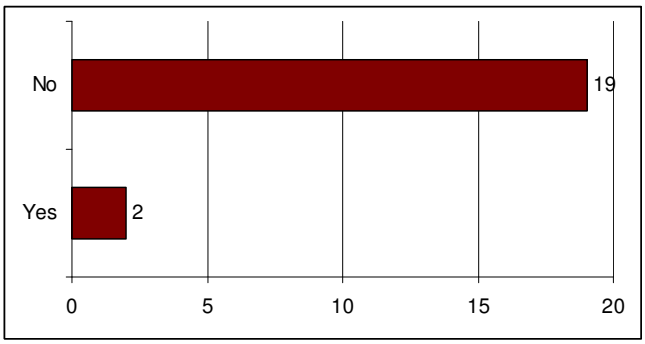


Figure 28 - Was there any construction material cost saving from using MMC?

The majority of respondents in (*Figure 28*) anticipated increased expenditure on projects rather than savings, which supports the proposition that MMC is more expensive than traditional methods of construction and may indeed require early investment for latter gain.[15] Only 2 respondents indicated potential cost savings.

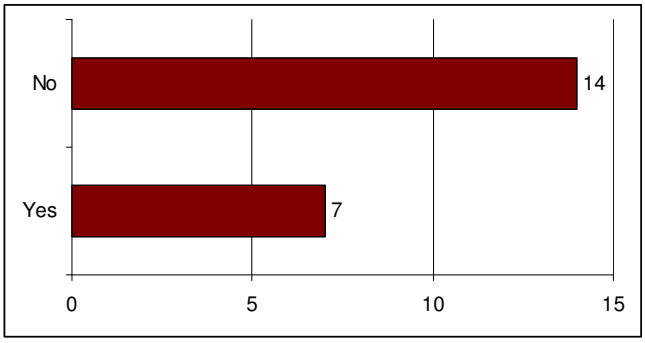


Figure 29 - Was accurate cost information available from the start for the MMC system chosen?

(*Figure 29*) suggests that the amount of accurate cost information available from the start of a project involving MMC is low. This is a good reason to ensure that adequate time investment allowed for gathering all necessary information about a MMC system before committing oneself.

[15] No cost saving was expected from using MMC (CABE 2004)

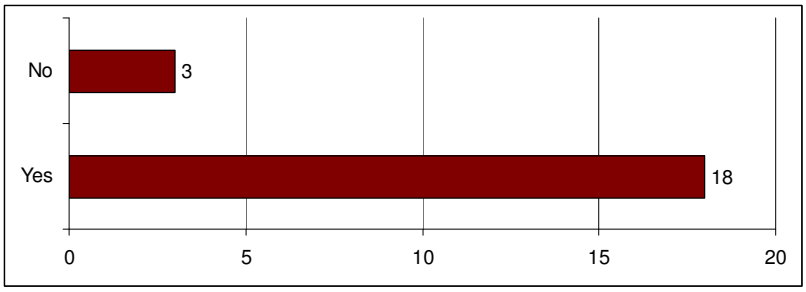


Figure 32 - Was there any on-site waste?

(*Figure 32*) suggest even though the MMC system parts are produced off-site, that there is still a small amount of on-site wastage.

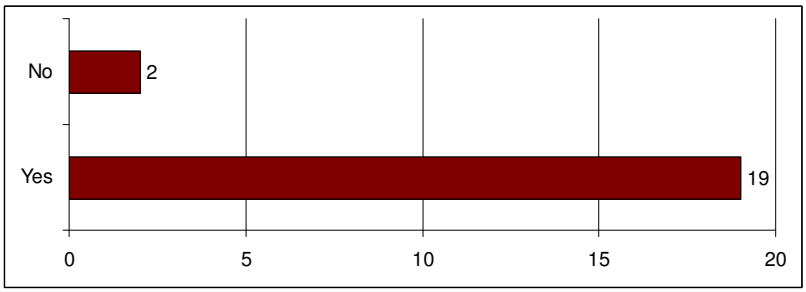


Figure 33 - Was more than 90% of the waste reused?

The data shown in (*Figure 33*) suggest that in the majority of cases more than 90% of the waste was recycled, suggestive that there were waste management systems in place.

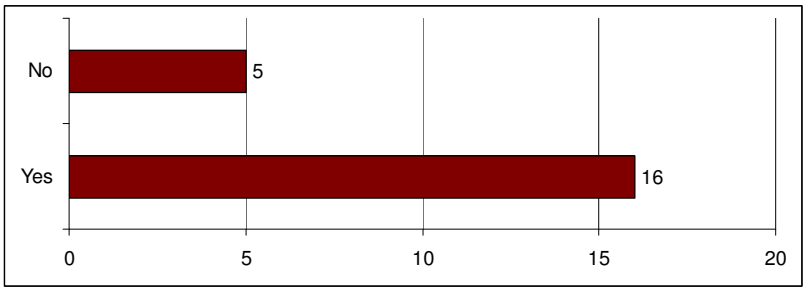


Figure 34 - Was there any over engineering carried out to facilitate the movement of MMC parts to site?

The data in (*Figure 36*) suggests that where MMC is used constraints are placed on the materials used. This could be because MMC materials were found to be generally more expensive than traditional materials?

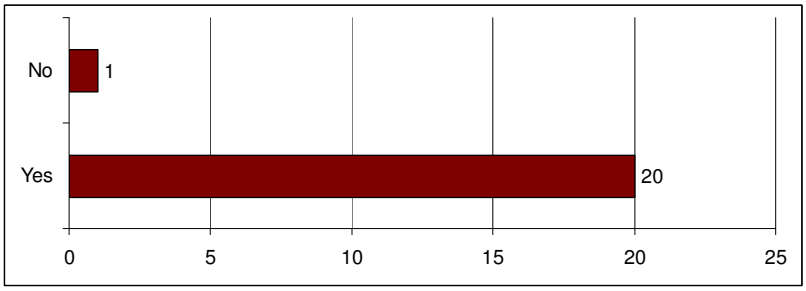


Figure 37 - Will the MMC system used hinder residents from adapting and modifying their homes reasonably straightforwardly, with particular reference to the skill level required and difficulty of an alteration?

(*Figure 37*) suggests there are issues regarding future adaptability with MMC and supporting the case study findings that suggest that MMC suppliers would have to be involved in the fundamental changes to houses.

5.3.5 Other

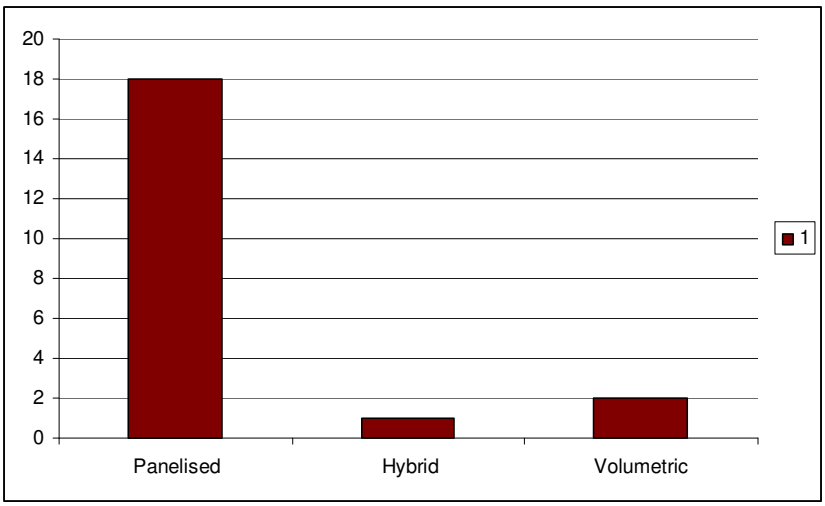


Figure 38 - State the MMC category used? (Based on 2-bedroom house)

The final chapter draws on the analysis in this chapter and makes final conclusions and recommendations for additional research.

6.1 Introduction to Chapter

The objective of this chapter is to gather all the items from proceeding chapters and create conclusive facts with regards to the claims made by MMC proponents that support the idea that MMC is the best way to provide faster, more affordable, environmentally friendly and better quality housing in the UK.

6.2 Review of Research Aim

The aim of this work was to assess the alleged benefits of using MMC for home building that, if true, could be said to enable better quality, environmental, quicker and more affordable homes to be built using MMC in UK. In general terms the aim has been achieved.

Early research enabled the four alleged benefits to be established and developed. From this, the alleged benefits were analysed, assessing the magnitude of each proclamation and the likely level of significance that could be derived to provide a number of established propositions and a number of questions. This provided a tool for examining the impact of MMC's alleged benefits on three house building projects using case studies supported by a general questionnaire.

The case studies are enclosed in Appendix 1 and the list of questions is contained in a sample questionnaire enclosed in Appendix 2. The analysis of the results of the case studies and questionnaires and the subsequent comparison with the established theoretical propositions showed a number of inconsistencies in the perception of the alleged benefits of MMC.

The enablers for the application of MMC in (figure x) are shown to be adhered to in the three schemes assessed. However, the results of the research show clearly that a number of enablers deemed to be critical to MMC house building project success from (authors such as CABE (2004), DCLG & EP (2006b) and NAO (2005) amongst others) whiles being practical in sense, do not automatically guarantee the achievement of the four perceived benefits of MMC.

Uncertainties were identified concerning environmental benefits of which, MMC is purported to have over traditional build housing. However, since there was limited data found to support the environmental proposition, this is going to require further research since so few MMC homes have been tested in the marketplace to date in this new area.

The investigation identified good practice by illustrating how leading sector specialists are using MMC. These were termed MMC 'enablers' which reinforced the importance of improved communication with supply chain partners, sensible time investment, importance of tight liaison with planning authorities, tailoring the process plans to fit the MMC construction method, early commitment to a MMC system, the importance of good risk management, where possible using a catalog of pre-selected materials, the importance of using proficiently skilled workforce for on-site assembly of MMC structures, the necessity for precise project planning and partnering.

The results of this investigation revealed that MMC will only give at least as good quality of more established building techniques and identified that MMC had little effect on the quality, environmental of house building schemes. Furthermore that main conjectural reason for the choice of MMC would almost certainly be the prospect of improved speed of delivery. However, the bulk of data forecasted increased costs on projects, with none of the data indicating possible cost savings in construction. The results of the case studies and questionnaire exemplified these factors.

To this extent it is believed the objective was met.

- ✓ **To investigate the reality of MMC house building.**

The data from case studies and questionnaires respondents was used to investigate the reality of MMC house building in the UK. This data was broken down in collaboration with the literature research to allow for easy interpretation which was then used to assess the validity of the previous developed theoretical propositions.

Consequently, there is still a lack of information pertaining to the construction of MMC homes, and it seems reasonable to suggest that we are no closer to producing affordable, better quality and environmental homes using MMC than we were before the DfMC competition was lunched in 2005.

It would seem as though the reality of Fast, Good and Cheap is meth representative of the old conundrum that you can have two of these, but only at the expenditure of the third.

To this degree it is thought the objective was met as the case study and questionnaire data, it is thought, contributed to the dependability of the findings.

6.4 Conclusion of the Research

Guidance received from the industry MMC specialists' in terms of informing the study has been limited. However, the case studies including the use of the questionnaires were effective in producing results with regards to the benefits of using MMC for house building.

The responses exhibiting the most correlations from the survey data and from the investigate of development of case studies suggest that there is no direct relationship between the use of MMC and better quality of design over traditional house building method. It seems reasonable to conclude that consultants with prior experience of MMC will almost always be necessary to advise on structural alteration work to homes built using MMC.

Despite the small sample, it seems reasonable to conclude that MMC homes are more expensive than established techniques of house building. Therefore, at the present time, traditional brick and block methods of construction remain the cheaper option.

It is concluded that MMC is a faster home building method than traditional brick and block house building. Furthermore, the survey findings demonstrate that the principal rationale for anyone using MMC is the prospect of improved speed of construction. Therefore it is also true to say that MMC provides weather tight

- Developers should consider guaranteeing the durability of MMC structures for a longer period of time which would arguably give purchasers more faith in new MMC home building.

- Studies into further steps that can be taken to help planning authorities appreciate the need to get firm planning decisions quicker in order for developers and alike to commit early on to the design and manufacture of MMC parts.

- Research into the environmental benefits of MMC in relation to energy saving.

- Find ways for the design team to work with manufacturers to decrease the cost of off-site parts involved in MMC.

- To continue financial support and encourage the use of MMC to keep it on the agenda?

BPB. (2008) *Raines Court, London N16: about the project,* http://www.betterpublicbuil dings.gov.uk/finalists/2004/rainescourt/, Date accessed 03/11/08.

BRE. (2008a) *Building new & better homes*, http://www.bre.co.uk/page.jsp?id=346, Date accessed 26/10/07.

BRE. (2008) *Sustainable Construction, Simple ways to make it happen.* Watford: Building research Establishment.

Brinkley, M. (2006) *The housebuilders bible*, Cambridgeshire: Ovolo Publishing.

Bryant. (2008) *Search results,* http://www.bryant.co.uk/main/search/searchResults.asp, Date accessed 18/01/2008.

Burnett, J. (1986) *A Social History of Housing*, London: Methuen.

CABE. (2008) *Murray Grove, Hackney, London,* http://www.cabe.org.uk/default.aspx?contentitemid=211, Date accessed 03/11/08.

CABE. (2004) *Design and modern methods of construction.* London: the Commission for Architecture and the Built Environment.

CABE. (2007) *Assessing the design quality of new housing in the East Midlands, West Midlands and the South Wes.* London: the Commission for Architecture and the Built Environment.

C&LG (2006) *Delivering affordable housing,* London: Department of Communities and Local Government.

C&LG (2008) *Homes for the Future: more affordable, more sustainable, Summary of Responses to the Housing Green Paper,* London: Department of Communities and Local Government.

C&LG (2008a) *Innovative Construction Products and Techniques.* London: Department of Communities and Local Government.

Chapman, T. & Hockey, J. (1999), *Ideal homes*: *social change and domestic life,* London: Routledge.

DCLG (2006d) *DFM Ten Lessons Learnt.* London: Department for Communities and Local Government.

DCLG (2006e) Code for Sustainable Homes: A step-change in sustainable home building practice. London: The Department for Communities and Local Government.

DCLG. (2007) *Homes for the future: more affordable, more sustainable - Housing Green Paper.* London: Department for Communities and Local Government.

DCLG (2007a) *Carbon challenge standard brief.* London: The Department for Communities and Local Government.

DCLG. (2008) *Homes for the future: more affordable, more sustainable.* London: Department of Communities and Local Government.

DfMC. (2004) *The countryside consortium,* http://www.designformanufacture.info/countryside, Date accessed 02.01.2008.

DfMC. (2005) *Design for manufacture competition stage 3 brief*, http://www.designform anufacture.info/images/Stage1brief.pdf, Accessed 06/02/09.

Drake, M. (2008) *Saved for the nation, the South London prefab estate built by German and Italian PoWs,* http://www.dailymail.co.uk/news/article-1061037/Saved-nation-South-London-prefab-estate-built-German-Italian-PoWs.html, Date accessed 30/10/08.

DTi. (2006) *Sustainable construction strategy report*. London: Department of Trade and Industry.

Egan, J. (1998) *Rethinking construction.* London: Her Majesty's Stationery Office (HMSO).

EP. (1996) *Time for design.* London: English Partnerships.

EP. (1996) *Time for design II.* London: English Partnerships.

EP. (1999) *Allerton Bywater Development Brief.* London: English Partnerships.

EP & HC (2000) *Urban design compendium 1.* London: English Partnerships and Housing Corporation.

FOE. (2005) *Implementing the baker report,* http://www.foe.co.uk/resource/briefings/implement_barker.pdf, Date accessed 30/10/08.

FOE. (2005a) *The baker report, destroying sustainable communities,* http://www.foe.co.uk/resource/briefings/the_barker_report_destroyi.pdf, Date accessed 30/10/08.

Gardiner,J. (2009) Safer skyline victory. *Building Magazine*. Issue 05, pp.20.

Google. (2007) *The UK carbon footprint project,* http://www.google.co.uk/carbonfootprint/index.html, Date accessed 13.11.07.

Grant, M. (1991). The resource-based theory of competitive advantage: implications for strategy formulation. *Management Review*. 33 (3), pp114-22.

Guardian. (2008) *Prefab's empty promise,* http://www.guardian.co.uk/commentisfree/2008/jan/16/prefabsemptypromise, Date accessed 29.12.08.

Hanson. (Date unknown) *Hason EcoHouse,* http://www.ribaproductselector.com/Document.aspx?ac=&t=8&f=COL704729.pdf, Date accessed 29.12.08.

Hawthorne, C. (2006) *Such a deal?,* http://www.independent.co.uk/environment/climate-change/solar-panels-take-100-years-to-pay-back-installation-costs-917202.pdf, Date accessed 20.01.08.

Hayward, R. (1993) *Rationales and the practice of everyday urban design in 'making better places*. United States: MIT Press.

HMOS. (2008) *Strategy for Sustainable Construction.* London: Her Majesty's Government.

Housing Corporation. (1998) *Scheme development standards*. London: Housing Corporation.

Housing Forum. (2003) *National Customer Satisfaction Survey*. http://www.dwp.gov.u k/asd/asd5/rports2005-2006/rrep282.pdf, Date accessed 22/10/08.

Keeps, D. (2008) *The prefab gets a makeover,* sandbox3.planbgroup.com/CCCFCSWEB/uploads/ARCHITECTURE-Prefab.pdf, Date accessed 29.03.09.

Mtech. (2008) *Offsite Directory,* http://www.mtech-group.com/media/6, Date accessed 05/09/2008.

McLinden, S. (2005) *Manufactured homes improving, but still different,* http://www.bankrate.com/brm/news/real-estate/20050409a1.asp, Date accessed 30/10/08.

NAO. (2005) *Using modern methods of construction to build homes quickly and efficiently*. London: National Audit Office.

Naoum, S. G. (1998) *Dissertation writing for construction students*. Oxford: Butterworth, Heinemann.

Nasar, J.L. (1999) *Design by competition: making design competition work.* Cambridge. Cambridge University Press.

NHDA. (2005) *Homes Design Awards, Barling Court, Larkhall Lane, Stockwell, London SW4 6RN*, http://www.homedesignawards.com/homebuilder/homebuilder_2005/Category7/barling/barling.htm, Date accessed 03/01/2009.

Nicholson, C. (2005) *Corporate responsibility report: Striking the balance between economic, social and environmental responsibilities,* http://www.crestnicholson.com/as sets/pdfs/reports/CRReport2006.pdf, Accessed 29.01.2009.

Nicholson, C. (2006) *Corporate responsibility report: Striking the balance between economic, social and environmental responsibilities,* http://www.crestnicholson.com/assets/pdfs/reports/CRReport2006.pdf, Accessed 29.01.2009.

Nicholson, C. (2008) *Crest Nicholson's Action on Climate Change Annual Review*, http://www.crestnicholson.com/assets/pdfs/climate_change_review_052008.pdf, Accessed 29.01.2009.

ODPM. (2000a) *Approved Document A – Structure*: 1992 Edition, fourth impression (with amendments) 1994, further amended 2000. London: Office of the Deputy Prime Minister.

ODPM. (2003) *Housing Statistics*, http://www.statistics.gov.uk/STATBASE/Product.asp?vlnk=86558, Date accessed 19/10/08.

Persimmon. (2009) *Limes Park Basingstoke,* http://www.persimmonhomes.com/detail.aspx?development_id=2812, Date accessed 27/1/009.

Planning Portal. (2008) *Approval pocess,* http://www.planningportal.gov.uk/wales/professionals/en/1115313971469.html, Date accessed 05/05/08.

Planning Portal. (2009) *Planning Portal – Glossary, E,* http://www.planningportal.gov.uk/england/government/en/1115310689108.html, Accessed 06/02/09

POST. (2003a) *Government response to ODPM select committee report on planning for Sustainable communities in the south east*. London: Parliamentary Office of Science and Technology.

PRP. (2005) *Summit House*, http://www.prparchitects.co.uk/skills/skill/Sustainability/SummitHouse, Accessed 03/11/08.

Quale, J. (2008) *Finding the potential in prefab,* http://www.oscmagazine.com/OSC%20web%20pdf/sample2.pdf, Date accessed 22/11/08

RIBA. (2008) Building a new Britain. London: Royal Institute of British Architects.

RICS (1995) *How 'green' are residential prefabricated building systems?,* http://www.r ics.org/NR/rdonlyres/8DA17BED-858E-4199-ADC7.../how_green_are_residential_prefabricated_building_systems_19950901.pdf, Date accessed 27/10/08.

RICS (1995a) *Life span assessment of building components*, http://www.rics.org/NR/rdonlyres/67C67EAF-11CC-4B3C-8AB2-BCD1683D37CE/0/life_span_assessment_of_building_components_19950901.pdf, Accessed 04/04/09.3

RICS. (2007) The construction and building research conference of the Royal Institution of Chartered Surveyors. London: The Royal Institute of Chartered Surveyors.

Ross. K. (2002) *National-traditional housing in the UK: a brief review*. Watford: Building Research Establishment (BRE).

SCRI. (2008) *Modernising construction methods; emerging issues for modern methods of construction (MMC) for house building*. The Salford Centre for Research & Innovation. Workshop report 13.

Thisismoney. (2007) *Affordable housing schemes,* http://www.thisismoney.co.uk/mortgages/article.html?in_article_id=420482&in_page_id=678, Date accessed 19/10/08.

WFG. (2008) *Fairmule house, Shoreditch, wood for good,* www.woodforgood.com/.../housing/fairmule-house/, Date accessed 03/11/08.

Whittington, R. (1993) *What is strategy: does it matter?.* London: Routledge.

Wilson, W., & Anseau, J. (2006) *Affordable housing in England.* London: House of Commons Library.

Yin, R. (1984) *Case study research: design and methods* (1st ed.). Beverly Hills, CA: Sage Publishing.

Yin, R. (1989a) *Case study research: design and methods* (Rev. ed.). Beverly Hills, CA: Sage Publishing.

Yin, R. (1989b) *Interorganizational partnerships in local job creation and job training efforts.* Washington, DC: COSMOS Corp.

Yin, R. (1993) *Applications of case study research.* Beverly Hills, CA: Sage Publishing.

Yin, R. (1994) *Case study research: Design and methods* (2nd ed). Beverly Hills, CA: Sage Publishing.

Yin, R., & Moore, G. (1987) *The use of advanced technologies in special education*, Journal of Learning Disabilities, 20(1), 60.

Zhang, X. (2001) *Application of benchmarking as a managerial tool in prefabricated building construction*. Cambridge, Massachusetts: Harvard University.

Appendix 1 - Case Studies

a. Former Park Prewett Hospital, Basingstoke

b. Horns Cross, Dartford

c. Former Renny Lodge Hospital, Maidstone

	buildings.
Project status	Work on Phase 2 has commenced and is expected to be completed in 2009. This site is part of a much larger scheme which is included in EPs' Hospital Sites Programme.
Developer	Persimmon Homes – (using the bid by Westbury) Note: Westbury Homes is now owned by Persimmon Homes
Architect	Broadway Malyn
RSL	Sovereign Housing Group
Employer's agent:	Philip Pank Partnership
Local authority	t.b.c.
MMC system supplier(s) / Main supply chain partner	Space4 Ltd (timber frame closed panel) Stewart Milne as a back-up pre-fabricated supplier (open panel, structural insulated panels - SIPs) Thermalite use for (thin joint blockwork)
MMC category	Panellised category
MMC system depiction	Space 4 Uses CAD/CAM production techniques from the automotive industry and a unique patented injection technology to produce closed panel MMC structures for homes and apartments.
Other MMC system supplier(s) / partner	1. Entec UK Ltd (environmental and engineering consultants) 2. Salford Centre for Research and Innovation (project measurement) 3. Trench Farrow (project managers)
Contract type	Fully integrated supply chain partnering
Total No. of homes	137
Total No. of £60k homes	42 (equivalent to 31%)
Total No. of social housing	47 (equivalent to 64%)
Density	36 homes per ha

	and a number of housing associations. **2. High volume output:** Space4 has an annual output capacity of more than 6,000 plus units. They can produce units at an engaged rate to suit a project plan and to match the speed of follow-on trades. [[[This increases the cost benefits of the preliminary site costs]]]] **3. Flexible design:** Space4 portfolio contains hundreds of house designs.
Land gradient	The site is generally level.
Scheme Design	
Layout	The property has a well conceived internal layout, designed to permit occupiers to adapt them as there families grow in size and then reduce them as necessary, eliminating the need for people to move home, flexible living. The house tries to make the most of space, light together in a MMC version of a typical terraced house. Each home has an extraordinary double-height glazed galleried atrium space, essentially the core to the home, cleverly designed to act as a circulation space & central light source. In addition the home also includes a service wall, The house has recessed atria, large areas of glazing and good-quality architectural detailing. Car-parking is tucked away, but however observed by adjacent homes. There is a shared central courtyard, which reduces the impact of car parking and seemed to fit well into the existing environment. As is customary in Poland bathrooms have been tiled from floor to ceiling, , pre-loaded with wall-hung toilet basins & concealed cisterns. Interestingly contrary to its modern, advanced form, the building comes with standard, traditional interiors fitted out in accordance with the developer's requirements.
No. of houses	7
No. of flats	30
Proportion of MMC as a percentage %	t.b.c
Key building parts procured off-site	1. External and internal load-bearing walls and floors 2. Floors 3. Roof structures 4. Staircases, including stairs

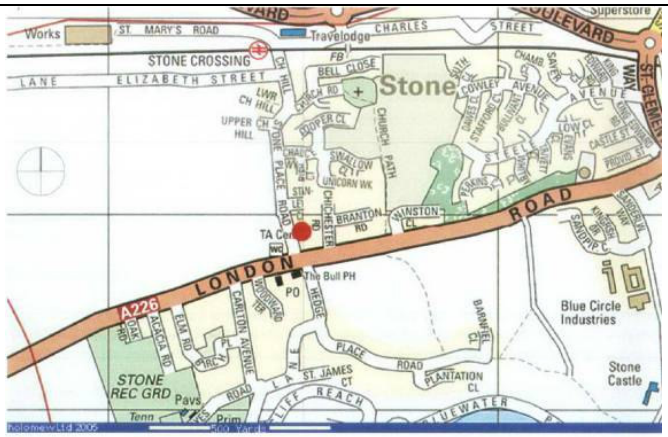
Developer/architect selected by employer	unknown / not specified at this time
Planning submission	Nov 2006 The LA did not impose any design codes explicitly to the site. The layout was designed to comply with the councils SPG 'Urban Design guidance for residential schemes.
Planning approval granted	April 2007 A reserved matters application was approved For phase 1 (279 dwellings) and now been built out.
Start on infrastructure (projected)	Jan 2006
Start on infrastructure (actual)	April 2007
Start on dwellings (projected)	Oct 2007
Start on dwellings (actual)	Oct 2007
To provide weather tight conditions (actual)	unknown / not specified at this time
Scheduled first house completion (projected)	Feb 2008
Scheduled first house completion (actual)	Feb 2008
Scheduled first occupation (projected)	t.b.c
Scheduled first occupation (actual)	t.b.c
Last House completion date (Projected)	t.b.c
Last House completion date (Actual)	t.b.c
Total construction period (projected)	Based on feedback received from the developer, once an order is place the house will be erected in four months, whiles the paperwork is being sorted out. This is to save having empty homes.

Construction cost per unit	£60K (according to the DfMC guidelines)
Manufacturing overheads	unknown / not specified at this time
Manufacturing profits	unknown / not specified at this time
Delivery, setting, & crane fees	unknown / not specified at this time
Architect & reseller fees	unknown / not specified at this time
MMC impact on cost?	Waiting for architect response *"Space4 are achieving a real cost benefit' 'However, it does depend very much on the way projects are set-up and how they are managed throughout the whole construction process'.* (Space4, 2008) In other words, it's all down to the strength of the partnership.
Environmental	
Maintenance	(Sub-heading)
Life cycle costs include	unknown / not specified at this time
Capital costs	unknown / not specified at this time
Opportunity costs	unknown / not specified at this time
Operation	unknown / not specified at this time
Eco-homes rating	Very Good
U-Value	unknown / not specified at this time
Building waste	(Sub-heading)
Waste	unknown / not specified at this time
Energy consumption	(Sub-heading)
Green features	unknown / not specified at this time

Performance Standards	(Sub-heading)
Building warranty information	1. One-month inspection to take care of any snags. 2. 2-year defect cover. 3. National House-Building Council (NHBC) 10-year guarantee.
Certification	1. Independent structural certification is provided for all structures by Space4. 2. ISO 9000 Quality Control System 3. BRE certificate No: 098/02. 4. Satisfies Q Mark+ Certification (Timber Frame) Standard 5. Zurich and Lantac (Local Authority National Type Approval Confederation) 6. The MMC system is endorsed by the Council of Mortgage Lenders (CML) and Housing corporation scheme.
Building regulations	The Space4 system has been tested to conform with all applicable current building regulations, and is compliant with the updated Part L as follows: <u>Air testing</u> Regulation 20B - maximum allowable air leakage is <u>10m3/hr/m2</u> Space4 system achieved between <u>5-7m3/hr/m2</u> <u>Wall Thickness</u> Typically timber frame or brick & block use between 140 & 150 mm of wall structure to pass Part L 2006. The Space4 standard product can use 89mm studs and pass Part L 2006.

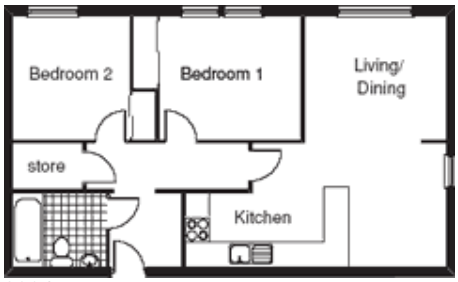
Horns Cross - Phase 2. 2008

1. Key Information	
Address of site	Ex Territorial Army Centre Stone Place Road Stone Greenhithe Kent DA9 9BN
Location	Former Greenhithe TA Centre Horns Cross is part of the C&LG DfMC initiative. The development falls within London and the Thames Gateway one of Europe's largest regeneration areas. This area has been identified by the Government as one of Englands major growth areas in the Sustainable Communities Plan. The site is located off the A226 which links to Dartford and the M25 approx. 1.5 miles away.
Project status	Work is now well under way on the Former Greenhithe Territorial Army Centre at Horns Cross, Stone scheme in Dartford which is part of C&LG DfMC initiative.
Developer	Countryside Consortium / Countryside Properties plc
Architect	PCKO Architects
RSL	Hyde Housing Association Ltd & Inplace (Member of the Hyde Housing Association)
Employer's agent:	Walker Management
Local authority	Dartford Borough Council
MMC system supplier(s) / Main supply chain partner	BUMA Free-dom SA The Homes Factory
MMC category	Panellised & volumetric Categories
MMC system depiction	The BUMA system is a light gauged steel frame clad outwardly with either render-finished insulated OSB board or metal cladding with drained or ventilated cavity; internally lined with plasterboard.



Horns Cross location map: 2009

Horns Cross, The Stone (site) - Phase 2. PCKO Architects: 2004

	 Barling Court, Larkhall Lane, Stockwell, London SW4 6RN. 2008  Barling Court plans. 2004 **2. High volume output:** • Buma has a high annual output capacity **3. Flexible design:** • An assortment of finishing including mineral or acrylic render, wooden siding or a system cladding can be applied. The apartments can be unbolted, transported to another site and re-erected. Buildings are assembled without scaffolding.
Land gradient	The site is generally level.
Scheme Design	
Layout	A model home as a mass-produced product. The house tries to utilise space, light together with flexible living in a MMC elucidation of the typical terraced house. Each home has an impressive double-height glazed galleried atrium space that is essentially the heart to the home. Cleverly designed to act as a circulation space & central light source. The home also includes a service wall. The house-plans present a similarly attractive appearance with recessed atria, large areas of glazing and good-quality architectural detailing. Car-parking is tucked away however unobserved by adjacent homes. The shared central courtyard reduces the impact of car parking and seems to fit well into the existing environment of Dartford.

SIDE ELEVATION (East)

FRONT ELEVATION

16.05.06 Rev.B: Amendments to facade materials.
17.03.05 Rev.A: Elvations redesigned.

PCKO

ARCHITECTS URBAN DESIGNERS MASTER PLANNERS INTERIOR DESIGNERS

Horns Cross

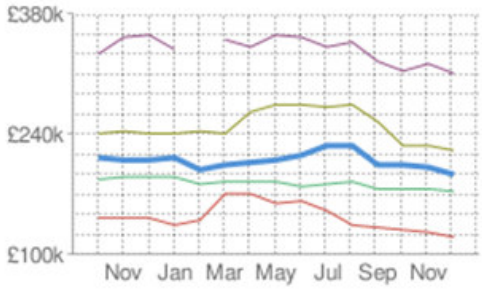
Flat type 2 (Block C) Front & Side Elevations

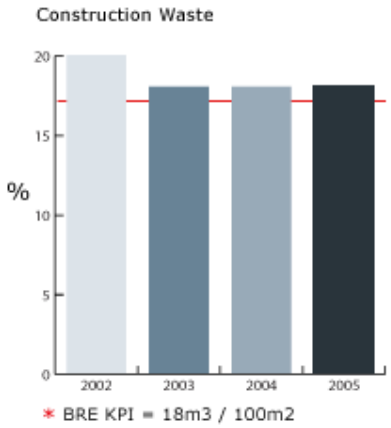
MIDDLESEX HOUSE 130 COLLEGE ROAD HARROW MIDDX HA1 1BQ TEL 020 88611444

DATE 16.05.06 SCALE 1:100/A3
FILENAME 0528_pl220.dgn
DRWG No 0528_pl220
REV B DRN

Horns Cross site plan. PCKO Architects: 2006

Labour & Time	
Land assessment	2001
Pre-planning / outline planning permission	Apr 2003 The Brownfield site was purchased from the Defence Estates with ooutline planning permission for 30 flats and 7 houses was granted on 1st April 2003. Pre-planning advice was sought from Dartford planning department before submission of application.
Developer/architect selected by employer	May 2003
Planning submission	Mar 2006 There was letter's received from nearby residents about the height of the flats on the north side in (Appendix 3) which will enable the occupants of the new development to oversea their rear gardens.
Planning approval granted	Jun 2006 Although a land assessment was carried out in 2001 a further contaminated land assessment will be required as a condition of planning.

2 bed house selling price	£ unknown / not specified at this time. During a telephone conversation with the housing association it was stated that actual house selling prices are only available to social housing tenants who qualify under the housing associations criteria.
Average 2 bed house selling price in area	£176,000.00 – £172,000.00 (25.01.2008) **Buy prices in Bluewater**  **Average House Prices in Bluewater** beds / Nov 2008 / Dec 2008 all: £200,000 / £193,000 / -3.5% 1: £124,000 / £119,000 / -4.0% 2: £176,000 / £172,000 / -2.3% 3: £226,000 / £220,000 / -2.7% 4: £322,000 / £310,000 / -3.7% Average house prices in Bluewater. nestoria.co.uk: 2008 / Land Registry House Price Index Next index.
Total land cost	£0.00 (Land cost excluded)
Development cost per unit	unknown / not specified at this time
Construction cost per unit	£60K (according to the DfMC guidelines)
Manufacturing overheads	unknown / not specified at this time
Manufacturing profits	unknown / not specified at this time
Delivery, setting, & crane fees	unknown / not specified at this time
Architect & reseller fees	unknown / not specified at this time
MMC impact in cost?	0 – 5% increase in cost *'There is costs saving to be had, for example the Barlinf Court development rose from the ground in just four days, instead of what could have been 18 Months by traditional methods of construction'.* (Buma, 2009)

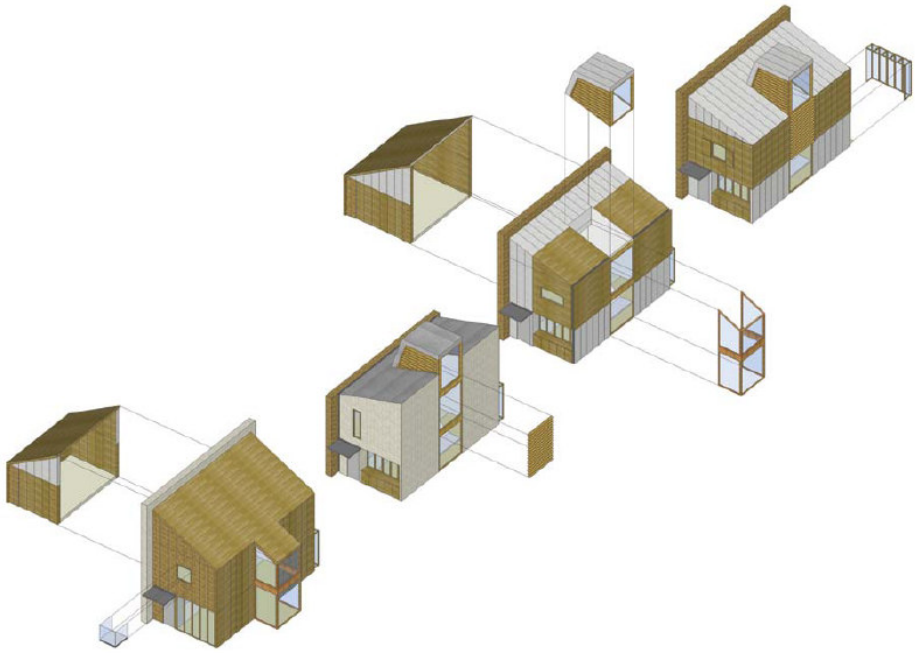
	 Horns Cross, construction waste. BLP: 2008
Energy consumption	(Sub-heading)
Green features	unknown / not specified at this time
Emission	unknown / not specified at this time
Thermal performance	unknown / not specified at this time
Air leakage rate	unknown / not specified at this time
Quality & Accreditation	
Durability	(Sub-heading)
MMC basic structure	The internal load-bearing walls are made of keramzyt light-aggregate concrete, with a mineral-wool layer applied to obtain proper acoustic insulation. The partition walls are made of plasterboard fixed on light steel frames, and filled with mineral wool. The floor structure consists of reinforced keramzyt mass slab, cast within a light steel frame and filled with mineral wool. BUMA offered to build the prototype on its land at its own expense so that it could be viewed and tested. BLP undertook a durability assessment for Hyde Housing Association who needed to fast-track the adoption of there Bupa system. *'There are one or two small hitches relating to the alignment of the foundations but the block is completed.'* (Buma, 2009)

	Note: A structural engineer must verify major alterations.
Performance Standards	(Sub-heading)
Building warranty information	1. BLP 10 year latent defects warranty
Certification	1. The systems are endorsed by the Council of Mortgage Lenders (CML) and 2. Housing corporation scheme.
Building regulations	The systems have been tested to satisfy or conform with all applicable current building regulations, and is compliant with the updated Part L.

RSL	Affinity Sutton
Employer's agent:	t.b.c.
Local authority	t.b.c.
MMC system supplier(s) / Main supply chain partner	Kingspan TEK
MMC category	Panellised
MMC system depiction	A structural insulated panel system which can be used for walls and roofs, based on insulated core timber wall and roof panels.
Other MMC system supplier(s) / partner	ARUP (Structural engineer, highways and M&E) Davis Langdon (Quantity surveyor) Macfarlane Wilder (Landscape Architects)
Contract type	Fully integrated supply chain partnering
Total No. of homes	68
Total No. of £60k homes	21 (equivalent to 14%)
Total No. of social housing	8 (equivalent to 5%)
Density	68 homes per ha
Min unit area	t.b.c.
Area of site	t.b.c.
Green field / Brownfield	Brownfield
Land ownership	The land was allocated by EP as part of the DfMC.
Land gradient	The site is generally level.

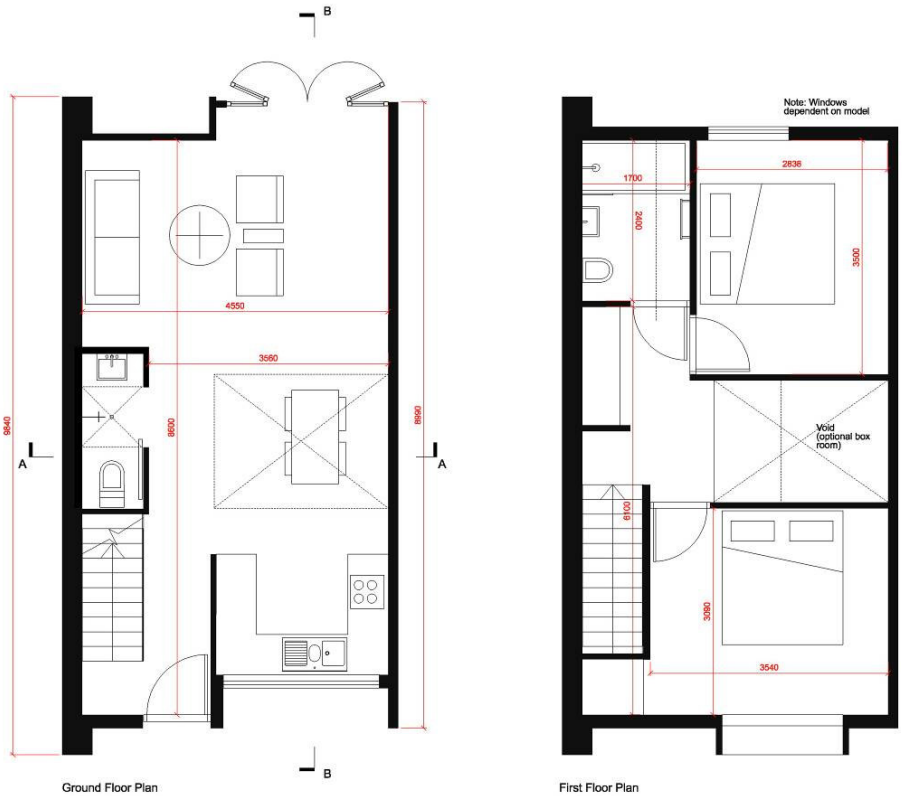
SIXTYK Consortium - Renny Lodge, Newport Pagnell Master Plan. 2006

Why OSM?	**1. Previous experience:** • First SIPs building system in the UK & Ireland to receive BBA and IAB certification. • Building Homes Innovation Awards - Runner-up 2001. • Plan Expo Best Innovation Class - Winner 2001. • Plan Expo Best Environmental Creation Category - Highly Commended 2001. • BBA Innovation Award winner 2002. • Design for Manufacturer (60K Competition) - Winner 2006. • Used on the UK's first house to achieve Code for Sustainable Homes - Level 6 (BRE Innovation Centre 2007). **2. High volume output:** • Kingspan has a high annual output capacity **3. Flexible design:** • The units required no on site work other than joint sealing and nailing.



Renny Lodge 2 bedroom 3D Image. SIXTYK Consortium: 2006

The above illustration shows a variety of extra components for bays, bin, stores, winter gardens and a garage/ alternate living extension.



Renny Lodge 2 bedroom flat plan. SIXTYK Consortium: 2006

Start on infrastructure (actual)	Aug 2006 Construction of link road with associated footpaths, roundabout and landscaping (See Appendix 4 document ref(s): 05/01122/FUL, 00/01512/OUT, 00/01513/OUT, 98/00853/MK for move information)
Start on dwellings (projected)	
Start on dwellings (actual)	Sep 2006
To provide weather tight conditions (actual)	unknown / not specified at this time
Scheduled first house completion (projected)	unknown / not specified at this time
Scheduled first house completion (actual)	Oct 2007
Scheduled first occupation (projected)	unknown / not specified at this time
Scheduled first occupation (actual)	Oct 2007
Last House completion date (Projected)	Jun 2008
Last House completion date (Actual)	unknown / not specified at this time
Total construction period (projected)	unknown / not specified at this time
Total construction period (actual)	unknown / not specified at this time
Handover	unknown / not specified at this time
MMC impact on time?	0-10% reduction in programme
Costs	
2 bed house selling price	The first homes have gone on sale in Renny Lodge, Newport Pagnell – for £189,500.00 (25.01.2008)
Average 2 bed house selling price in area	£114,000.00 – 110,000.00 (25.01.2008)

Capital costs	unknown / not specified at this time
Opportunity costs	unknown / not specified at this time.
Operation	unknown / not specified at this time
Eco-homes rating	Excellent
U-Value	0.20W/m2K. (U-value range between 0.10 W/m²·K and 0.23 W/m²·K.)
Building waste	(Sub-heading)
Waste	No surplus construction material delivered to site. The core of the building system including panels and ancillaries came from a single source. **Note:** The developer claimed that this reduced the impact on the surrounding environment, with reductions in noise, traffic congestion and pollution from lorries.
Energy consumption	(Sub-heading)
Green features	Six green features noted including: **1. Reduced heat loss**: As glazing was noted to be minimised in bedrooms and maximised in living areas. **2. Improve solar gain:** A central lantern in the terraced homes floods the house with natural daylight. **3. Passive ventilation & heat recovery system:** From central lantern. **4. Solar shading:** The units have uncovered soffits, cantilevered walls and pitched roofs. **5. Solar water heating:** Comes as an option with all the 60K homes. **6. Less CFCs/HCFCs:** MMC System is manufactured without the use of CFCs/HCFCs and have zero ODP.
Emission	unknown / not specified at this time
Thermal performance	4% thermal bridging
Air leakage rate	Air seepage rates 8m3/hr/m2 air changes per hour at normal pressures. Note: The Kingspan Air Recovery System as illustrated below recycles up to 91% of the heat normally lost with conventional extractors. The system filters dust, pollen & smoke, providing better air quality in addition to maintaining steady internal temperature & humidity levels.

MMC Build quality	Kingspan TEK panels are produced to the uppermost standard under a documented internal factory production quality control management system. Vapour resistivity of Kingspan TEK Building System panel components is: • the rigid urethane core – 300 MN.s/g.m; and • the OSB/3 facing – 500 MN.s/g.m.
Whole life costs	(Sub-heading)
Life expectancy	60 years may be expected.
Future adaptability	Alterations following completion of the building are possible but trickier and should, where possible as stated by the manufacturer and developer, be carried out by a registered Kingspan TEK contractor who has access to the original plans. <u>Note: A structural engineer must verify all alterations.</u> • Cabinets • Cabinets can be fixed anywhere along the surface of KingspanTEK system wall panels using suitable screw fixings. • Boilers/Radiators • Boilers/radiators can be fixed wherever along the surface of an external Kingspan TEK Building System wall using correctly sized fixings. • Plumbing • Plumbing is done in a usual way
Performance Standards	(Sub-heading)
Building warranty information	1. BLP 10 year latent defects warranty Kingspan TEK Building System is accepted by the chief building warranty providers such as: • Building Life Plans, • Homebond, • HAPM, • NHBC • Zurich Municipal. It also holds BBA, IAB, BM Trada and Zulassung Certification
Certification	1. The system's use is covered by BBA certificate 02/S029. 2. IAB certificate 02/0158 3. Zulassung certificate 2-9.1-315. CERTIFICATE No. 02/0158 4. BM TRADA Q-Mark product certification. Q-Mark is the ideal tool for independently proving that products are properly tested and appraised in the first instance; manufactured under an appropriate quality management system; and consistently manufactured to the same high standard, day after day.

Appendix 2 - Sample Questionnaire & Results

Modern Methods of Construction (MMC) Survey

Thank you for taking the time to complete this questionnaire which is part of an MSc research project, currently being undertaken at London South Bank University on the impact of Modern Methods of Construction (MMC) in the UK. (Where multiple answers have been provided please tick the appropriate answer.)

(Criteria= Based on a 2-bedroom House)

Scheme name:

No.	Questions	Yes	No
Q1	What MMC system was used? • Panelised • Hybrid • Volumetric	☐ ☐ ☐	☐ ☐ ☐
Q2	State the main reason why MMC was chosen (1= most important)? • Cost • Speed • Quality • Environmental • Other	1 2 3 4 5 ☐	
Q3	Was there any construction material cost saving expected from using MMC over traditional built homes?	☐	☐
Q4	Was accurate cost information available form the onsite for the MMC	☐	☐

	• Obtain building control input etc?	☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐
Q15	Was partnering considered vital to the success of the scheme? If applicable	☐	☐
Q16	Was there any constraints placed on the quality of the materials to be used?	☐	☐
Q17	Will the MMC system used hinder residents from adapting and modifying their homes reasonably straightforwardly, with particular reference to the skill level required and difficulty of an alteration?	☐	☐
Q18	Was there any off-site waste?	☐	☐
Q19	Was there any onsite waste?	☐	☐
Q20	Was more than 90% of the waste reused? If applicable	☐	☐
Q21	Was there any over engineering carried out to facilitate the movement of MMC parts to site.	☐	☐
Q22	Has the MMC system used improved the energy consumption of the house over traditional methods of construction?	☐	☐

If you have any general comments about this MMC scheme or MMC in particular please type them below.

Please save the survey and email it to Dean Jones at:

dean.jones@scottwilson.com

Appendix 4 - Horns Cross Additional Material

r. Application – DA/06/00344/REM

s. Consultation Responses – Dee.Gold (06/00344/FUL)

t. Consultation Responses 56522 – Environmental Agency

u. Consultation Responses 561773 – Objection to Planning Department

v. Planning Decision Notice 578261

w. Drawing – 570209 (House Type A,A1 – Front Elevation)

x Drawing – 570210 (House Type A,A1 – Rear elevation)

y. Drawing – 0528 (House – First Floor Plan)

z. Drawing – 0628 (Site Plan)

aa. Drawing – 571924 (Development Plan Markup)

bb. Drawing – 573988 (Landscape Layout)

cc. Drawing – 573989 (Development Plan)

dd. Drawing – 570190 (Location Plan)

ee. Drawings – 622356 (Topographical Survey)

ff. Drawing – 570191 (View from Stone Place Road)

gg. Drawing – 570192 (Prospective 2)

hh. Drawing – 645960 (Plan Drawing Markup)

ii. Cut outs

Appendix 6 - Other

nn. Insulation Materials Chart

oo. MMC out of site not out of mind (Article)

pp. House Prices to High - Prescott (Article)

qq. Emails, Letters & New Prints