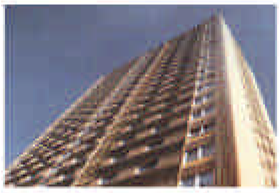
Non-traditional housing in the UK

– A brief review










COUNCIL of MORTGAGE LENDERS

BRE

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The Council of Mortgage Lenders

The Council of Mortgage Lenders (CML) is the trade association representing the mortgage industry. Its members comprise banks, building societies, insurance companies and other specialist residential mortgage lenders, which together represent around 98% of the UK mortgage assets.

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1. Introduction

Lenders are asked to lend money on different types of construction every day. It is probably true to say that there are more types of construction in the UK than in almost any other country in the world. And the number of different types is growing. The housebuilding industry is changing. Market forces are driving the industry to reconsider their approach to serving their customers. Government agendas on Rethinking Construction, planning policy and building regulations are forcing the industry to reconsider the way houses are built. These issues together with a construction skills shortage and a huge demand for new houses means that innovative construction types are being developed and used.

For lenders the issue is not only the new construction types but also the old ones which may not have performed as well as was intended. They need to protect their existing and their new book. Experiences in the past may well affect lenders' willingness to lend on new construction types which are unfamiliar and which may appear to exhibit some of the same characteristics as those they have had problems with in the past. It is critical that the dwelling holds its value in the medium to long term to offer suitable security for the loan. It is sometimes difficult to assess this with so many construction types on the market. This short report informs lenders about non-traditional construction both past and present.

Section 2 provides a brief review of non-traditional housing in the UK. It considers the development of UK systems through the First and Second World Wars and the advent of the system build high rise. It looks at particular problems associated with different types of construction.

Section 3 looks at current developments in non-traditional construction and more specifically the drive towards the use of offsite manufacturing techniques.

Finally, section 4 considers the pro's and con's of offsite production and looks at the technique from the various stakeholders' points of views – lenders, housing associations, housebuilders, surveyors, insurers, warranty providers and building control. For those who want more information about specific types of construction the report contains a comprehensive list of Building Research Establishment (BRE) publications relating to these.

This report does not attempt to provide all the answers in relation to non-traditional housing. What it does attempt to do is provide lenders with an overview of developments in the market and to raise awareness of the issues. It is clear that innovative construction techniques will continue to develop and lenders will be faced with borrowers wanting mortgages for these types of property. The Council of Mortgage Lenders (CML) intends to continue to work with BRE in development of a benefit realisation toolkit which will try to address the specific issues relevant to lenders with innovative housing. This will help to ensure that the developers and manufacturers of these new techniques consider the mortgageability of their products before they are launched to the consumer.

2. Origin and Development of UK Systems

First World War

Despite earlier examples, it was not until just after the First World War, when the replacement and renewal of housing was a big issue, that the use of pre-fabrication for house building in the UK developed in a serious or significant way. The building industry was seriously affected by a shortage of skilled labour and essential materials, industrial capacity and manpower having been diverted into the war effort. The result was an acute housing shortage and, in order to alleviate it, a number of new methods of construction were developed. This led, for example, to the production of more than twenty steel framed housing systems, an example of which is illustrated in figure 1.

The period between the First and Second World Wars also witnessed the development of various types of housing system based on pre-cast and in-situ concrete, timber, steel and occasionally of cast iron construction.

Figure 1 *Telford steel framed house -1920s - this was one of the steel clad systems*

However, of the total four and a half million houses erected in Great Britain between 1919 and 1939, the number built by new methods was comparatively small. It is difficult to say precisely how many non-traditional dwellings were built during this period, but the figure is probably less than 250,000, and the vast majority would be for local authority use. It is interesting to note that there was usually a reversion to masonry construction whenever the supply of labour adjusted itself to building demands although this took place only very slowly in some areas, and not always entirely.

In Scotland the need for the use of alternative methods was more acute. There was an extreme need for new homes that could not be met by traditional techniques and which was exacerbated by problems on the supply side. A shortage of good quality bricks, a lack of bricklayers and rising costs of traditional building stone and slates all contributed to a much greater need for alternative methods of construction in Scotland compared to the south. This was recognised by the formation of the Scottish Special Housing Association (SSHA) in 1937 with powers to assist the local authorities in 'special' or distressed areas with their housing programmes. The SSHA was authorised to build houses by non-traditional methods only, in order not to compete with local authorities for skilled labour.

Second World War

The Second World War brought an even greater demand for the rapid construction of new dwellings. In addition to the need to rebuild homes damaged as a result of the war, the Government had other objectives that were set out in a white paper in 1945. These objectives were the provision of a separate dwelling for any family who wanted one, and to complete the slum clearance programme started before the war. Technical problems faced in an anticipated building programme of 3,500,000 – 4,500,000 houses in ten years differed in degree, rather than kind, from those faced by the building industry after the 1914-18 war. The problem of material shortages was thought to be less of an issue than the supply of trained building operatives. Initially, the emphasis was to supplement traditional building operations that relied on skilled labour with methods of construction that could use 'labour and industrial capacity normally outside the building industry'.

Government Initiatives

During the Second World War, the Interdepartmental Committee on House construction, commonly called 'the Burt Committee', was formed. This committee was in due course to draw on many of the testing procedures that had initially been developed at BRS (which later became BRE) for the evaluation of war-time buildings.

The Burt Committee looked at the efficiency, economy and speed of construction of all forms of building. Among the first research topics was an examination of possible economies in the use of steel and timber in factory building. With the exception of aircraft factories, it was found possible to standardise on a limited range of designs. 'Type designs' showing considerable economies were developed in relation to the use of steel, reinforced concrete structures and roofs.

Following the Second World War there was a surplus of steel and aluminium production, and an industry, until then geared up for the war effort, in need of diversification. These factors drove the move towards prefabrication. As a result, many new varieties of concrete (in both pre-cast and in-situ forms), timber framed and steel framed systems emerged (see figures 2 – 4).

While most systems were intended to provide permanent (or long term) housing a few were intended only as emergency or temporary solutions.

Figure 2 *Cornish Unit Type 1 – one of the many types of pre-cast reinforced concrete houses*

Figure 3 *Swedish Timber (As a result of a wartime purchasing commission visit to Sweden in 1945 Swedish Timber dwellings were imported in pre-fabricated sections for erection to English and Scottish designs)*

Figure 4 *The British Iron and Steel Federation House (BISF)*

Research and Development

With considerable attention focussed on productivity and new methods of production, it was appropriate that BRE looked at the maintenance issues relating to the new building systems even at an early stage (during the early 1950s). This was effectively recognition that the savings in the initial cost of building offered by some forms of construction might be offset by an increased cost of maintenance.

In practice the dwellings did not prove any cheaper to build, and when the subsidy (which was paid to defray the cost of promotion and development) was withdrawn in 1953, many manufacturers found the housing industry less profitable than elsewhere and thereafter non-traditional forms of construction began to lose ground. In terms of maintenance though, there appears to be little evidence that they were significantly more expensive to maintain – studies in the London area showed that the average cost of maintaining non-traditional dwellings was only 2.5% greater than that for traditional dwellings.

Industrialised Building

Throughout the 1940s, 50s and 60s important changes in house construction were taking place. The philosophy shifted towards that of Industrialised building.

Figure 5 *Large panel System – Balancy General view of estate*

Industrialised building

Industrialised building is based on the principle that as much of the work as possible is transferred from the site to the factory leaving only a simple assembly operation to be carried out on site. There are two generic forms of industrialised building, namely 'closed' and 'open'. With closed construction the bulk of the structure is produced from a fixed set of pre-fabricated parts, allowing very little scope to substitute products from other manufacturers. Open building on the other hand produces a shell from a relatively small number of parts, thus allowing the designer considerable scope to create a unique design.

Many Industrialised Building systems employed the large panel method of construction comprising factory-made pre-cast concrete floor and wall panels (see figure 5). These units arrived on site in their assembly sequence and were assembled with the aid of a crane.

From the mid 1950s with the redevelopment of city centres taking place, high rise construction was gathering pace and, because many of these systems tended to be used for high rise, the relevance of the various studies (e.g. use of cranes, production planning) mentioned above should be apparent.

There was a lot of enthusiasm for, and confidence in, industrialised building by those promoting it. However, a large section of the public remained suspicious about "modern building", particularly high rise construction (whether system built or not).

Although high rise buildings became controversial for social reasons, the Ronan Point collapse (see box and figure 6), which involved large panel construction, also caused much concern with the public about some of the actual methods of construction being used. Other serious construction problems were later found to exist in some of the other large panel buildings.

Figure 6 *Ronan Point following collapse*

Ronan Point Collapse

Ronan Point was a 22-storey large panel building. The structure was inherently very strong, although it was not designed to withstand the forces generated during the large gas explosion that led to its collapse.

The explosion occurred in one of the corner flats on the18th floor and was sufficiently powerful to momentarily lift the four storeys above. Because there was very little tying between the floors and the walls the external walls were then unrestrained (once the vertical loading was removed) and were blown outwards by the force of the explosion. With nothing to support the upper floors progressive collapse ensued.

The absence of restraint ties was not due to poor workmanship. Rather, it was because at the time it was built the design codes did not require panels to be tied together vertically, and required only limited horizontal ties. As a result of the collapse design codes were tightened, and all remaining large panel structures of that type were required to have remedial work undertaken to tie panels together both horizontally and vertically.

Another generic type of construction used during the1960s and 1970s was volumetric construction, which involved producing buildings as a number of 'boxes' that are connected on site. This was used for a number of housing systems and usually involved lightweight frame constructions of either timber of metal. However, pre-cast volumetric concrete systems were also used.

Figure 7 *The Hawkesley BL8D Permanent Aluminium bungalow. Three thousand were erected in England and Wales*

The volumetric bungalows of the 1940s (B1 and B2) were made up from four units. The entire plumbing was contained in one of these four units with the result that no plumbing joints needed to be made on site. However, aluminium volumetric bungalows were soon superseded by aluminium panellised construction such as the Hawkesley bungalows illustrated in figure 7.

The 1960s also echoed another 1940s innovation. In 1944, the intention had been that all temporary houses of whatever type (and there were a number) should be fitted with pre-fabricated steel kitchen and bathroom cupboard sets designed by the Ministry of Works. A great number of sets were initially ordered (200,000) but other, wider issues impacted on these intentions. By 1948, only 28,500 of the former and 27,000 of the latter had been manufactured, but many dwellings were eventually fitted with them.

During the 1960s this sort of idea began to surface again with the use of various forms of 'pods'/heart units and service cores in house construction (see figure 8). These units contained most of the plumbing needed in a house. They were designed to be mass-produced and usable in more than one design of house. Service cores were produced by designing pods that were made to sit one above the other for the height of the dwelling.

Figure 8 *'Planimec' heart unit. The unit incorporates both kitchen and bathroom*

Although of questionable success, their use was at least logical considering that the prefabricated content in an appreciable number of housing systems had essentially been concerned with providing a frame or shell.

During the 1960s another approach to construction also gained popularity. Of the great variety of approaches taken, it was found that improvements in productivity could be realised by simplifying (or 'rationalising') the design and construction of traditional buildings to produce the so-called "Rat-Trads" (Rationalised Traditional Construction).

Rationalised Traditional Construction

This form of construction had masonry cross-walls* (separating walls and flank ends / gable walls) with the front and rear elevations in-filled with storey-height timber framed panels. Dimensions and details would be standardised. For example internal layouts might be arranged to allow all joists to be pre-cut to a standard length or eaves details might be designs to be used on a range of external wall designs.

**Note that certain timber frame systems also incorporated masonry cross-walls.*

Despite the use of Large Panel System (LPS), volumetric and Rat-Trad approaches, various other panel and frame-based constructions continued to emerge or remained in production. In 1964 a semi-independent government body was established in the form of the National Building Agency (NBA). The NBA was charged with spearheading the national housing effort. During the 1960s it encouraged and validated many housing systems by the issue of Appraisal Certificates.

Timber Frame takes the lead

Steel framed systems, timber framed systems and concrete systems of various types continued into the late 1970s and early 1980s. By then pre-fabricated housing had become dominated by timber framed construction of the modern platform frame variety (storey height timber wall panels to the inner leaf, timber floor panels and an outer leaf, or part of the outer leaf, of brick). The use of timber frame grew substantially, approaching one third of the market before a dramatic downturn that followed adverse TV coverage in the form of the now infamous World in Action programme.

"World in Action" programme

In the early 1980s an episode of World in Action was broadcast which was severely critical of a small group of particular timber framed dwellings constructed in the West of England. The general gist of the programme was that the dwellings concerned were not watertight, and that the inevitable consequence had been early development of decay in some parts of the structure. The programme implied that these dwellings might be typical of all timber frame construction, and that many more owners of such homes could expect severe problems in the future. Accordingly, timber frame could not be considered a suitably robust means of construction.

The programme was broadcast at a time when the 'Right to Buy' scheme was being promoted. Much public sector housing at the time was built in timber frame and the government became very concerned about the negative impact that the programme would have on property values in general and the Right to Buy scheme in particular. BRE was commissioned to undertake a thorough review of the current moisture conditions prevailing at that time in existing and new timber frame dwellings, which it did during the late 1980s.

In all more than 400 dwellings were surveyed, many in areas of severe weather exposure. The surveys, which are reported in BRE reports BR283 and BR284, found no evidence of decay that supported the projections made during the programme, and the catalogue of failures predicted by the programme never materialised. Nevertheless, the programme is still quoted today as a justification for choosing a different form of construction.

Many in the construction and research community blame the media for this collapse in the market because of the highly selective nature of the programme. However, the approach it adopted resonated with some at the time because innovative uses of materials and construction were not common, in England at least. Some viewed the developments as comparable in some way to the temporary 'pre-fab' type of housing stock of the immediate post-war period.

Many people regarded dry lining with suspicion and extension of these factory production systems was seen as unwelcome and being forced on a reluctant market by the same forces that had driven the high rise building concept.

However, in Scotland, where, historically the vernacular is of "stone or timber", rather than "clay", and the timber frame tradition was in any case well established, favoured and respected, the timber frame market was hardly affected at all by the World in Action programme.

With the encouragement of Government and the Rethinking Construction Agenda, people are now once again beginning to experiment with alternative construction techniques. These are discussed in the next Chapter.

Few housing systems remain in production

The UK has considerable experience of prefabrication for house construction with approximately 1,000,000 dwellings constructed by such methods. The range of systems and construction techniques used has been extremely varied (see for example figure 9); BRE has over 500 systems listed between 1919 and 1976 excluding Rationalised Traditional Systems or post 1976 timber frame, (it does however include older timber framed systems, many of which were also of platform frame construction).

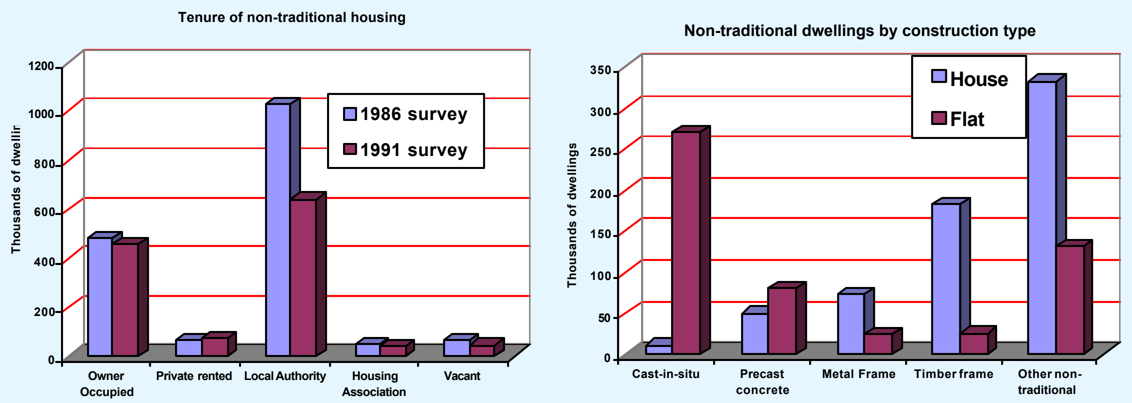
Figure 9 *Nissen-Petren steel framed house - The range of systems and construction techniques used has been extremely varied and includes some unusual-looking house types*

Few of these systems have remained in production for particularly long periods (ie twenty years) and/or have been used for the construction of more than 20,000 dwellings.

It is difficult to be sure of the number of dwellings built for the various systems or the length of their production period because different sources of information seem to contradict each other.

However, the two charts below present data from the English House Condition Surveys carried out in 1986 and 1991, and the following table (compiled from sometimes contradictory data from a range of sources) attempts to list most of the systems that achieved notable production periods and/or numbers of dwellings built.

Chart 1: *Tenure of non-traditional housing and non-traditional dwellings by construction type*



Source: English House Condition Surveys 1986 and 1991

Table 1: *Non-traditional construction systems. Approximate number built and length of time in production*

System	Approx. number built	Length of time in production
Wimpey No-fines (cast in-situ concrete)	300,000	~30 yrs
Easiform (cast in-situ concrete)	90,000	50 – 60 yrs
The BISF (steel framed house) units over six years	35,000	6
B1 Aluminium bungalows	55,000	4
B2 Aluminium bungalows	14,000	4
Cornish Units (pre-cast concrete) Types 1 and 2	30,000	20
Airey (pre-cast concrete)	26,000 (England and Wales)	20
Reema Hollow Panel (pre-cast concrete)	17,600	20
Wates (pre-cast concrete)	22,000	10
Trusteel Mk II steel framed houses	20,000	20
Trusteel 3M steel framed houses	17,000	10
Unity (pre-cast concrete) - Types 1 and 2	19,000	10
Frameform (timber frame)	13,000	10
Quickbuild (timber frame)	12,000	10

Performance of non-traditional housing

Although age, wear, lack of maintenance and misuse take their toll and make buildings look rather poor, many non-traditional housing systems initially provided quite pleasant looking homes, and a good number remain so. In general most non-traditional housing systems have performed well from a structural point of view, although some problems developed with a number of system-built dwellings.

By the 1980s some fundamental problems affecting structural stability and durability began to emerge in some of the concrete system built houses. The problems occurred because of either carbonation or the presence of chlorides in the concrete and resulted in the corrosion of steel reinforcement and subsequent cracking and spalling of the concrete. The issue of carbonation was exacerbated in many of these systems by the slenderness of many of the components involved which offered comparatively little cover to the steel.

Carbonation of concrete

Concrete comprises a mixture of water, cement (usually Portland) and aggregates which sets to form a solid mass. When fresh, the hydrated products of cementitious materials in concrete normally provide a highly alkaline environment that protects any embedded steel reinforcement from corrosion.

Carbon dioxide (CO_2) in the atmosphere can react chemically with the hydration products of the cement to produce various carbonate minerals. This process is called carbonation, and usually begins at the surface and slowly advances inwards from the exposed surface over time. The outer layer in which carbonation has occurred is called the carbonated layer, and in this layer the alkalinity of the concrete is much reduced.

If embedded steel reinforcement is too near the surface then the advancing carbonated layer can reach the steel. The steel then no longer enjoys the protection provided by the alkaline environment and is able to corrode.

In the 1980s, the Government also introduced a policy of allowing and encouraging (by way of discounts) many public sector housing tenants to buy the property in which they lived. This "Right to Buy" policy ran into a number of problems when it came to Non-Traditional Housing. The release of prefabricated housing from the public sector to the housing market meant that surveyors acting on behalf of the lending institutions were confronted with forms of construction that were unfamiliar to them. The surveyors needed to know how to survey and assess these buildings, as without this, the properties would entail unknown risk to the lender and/or make it difficult for prospective owners to get a mortgage on their property.

This situation was exacerbated by the fact that, while some non-traditional houses looked obviously different to the norm (such as many of the concrete and metal clad houses) whereas others looked like typical 'traditionally' built homes of the period (see figure 10).

Figure 10 *Spooner timber framed house – looks traditional*

Thus identification of the particular system was often an issue in itself and local authority records were not always good. Consequently, BRE was commissioned to carry out a series of condition surveys for various systems of non-traditional housing and to produce a series of reports to help surveyors identify and survey the major and other important systems.

The problems of carbonation and the presence of detrimental chloride levels in reinforced concrete dwellings led to certain concrete housing systems being designated defective under the 1984 Housing Defects Legislation which was then incorporated into the Housing Act of 1985. A company named PRC Homes Ltd (a subsidiary of NHBC) was set up to licence repair schemes for housing systems designated as defective under the Act. The extent of works and costs involved in some of these repairs was very substantial. No steel or timber systems were designated as defective.

The ownership of these properties by their former tenants was further complicated by these defects, and procedures were put in place to give the new owners rights of repair or, in certain specific circumstances, an obligation for the former landlord to buy back the property.

There were also problems with the cladding panels to some properties. As these panels were no longer in production they could not easily be replaced, and even if they could have, it may have been unwise to do so because of the potential for further problems. Therefore, it was not unusual for the local authorities to replace such cladding with, for example, a brick skin. Although it is unlikely that the brickwork would ever need to be replaced during the life of the buildings, this would be easy to accomplish should the need ever arise.

Condition surveys undertaken by BRE in the 1980s and early 1990s, revealed serious corrosion to parts of the steel frame to some steel framed houses in certain locations. Corrosion was particularly common on the lower sections of stanchions (see figure 11), setting out jigs, etc. and sometimes around window and door openings. The corrosion was such that on some occasions the replacement of lower sections of the stanchions was necessary. However, many steel houses remain in good condition.

Some of the steel clad systems have experienced condensation problems, where the steel forms a vapour control layer on the wrong (cold) side of the construction. Problems with steel frame systems are documented in a number of BRE reports on individual systems. In 1987 BRE published a report (BR113 Steel framed and steel clad houses: inspection and assessment) giving guidance on the inspection and condition assessment of steel framed housing, which was based on site investigations of a number of systems. Despite the obvious problems observed by the research team the report concludes that

"…the vast majority of steel framed dwellings have given levels of performance not very different from many traditionally built dwellings of the same age …"

and that, provided the appropriate repairs are carried out

"…there is no reason why steel framed and steel clad dwellings and cast iron dwellings should not give good performance into the foreseeable future, and certainly on a par with the life conventionally assumed for rehabilitated dwellings built in conventional construction."

Figure 11 *Corroded steel stanchion*

Similar conclusions were reached in a sister report (BR282 Timber frame housing 1920 – 1975: inspection and assessment) with timber housing. It concludes that:

*"…the performance of timber frame dwellings built between 1920 and 1975 is generally similar to that of traditionally built dwellings of the same age. Provided that regular maintenance is carried out…
a performance comparable with traditionally constructed dwellings of the same period should be maintained into the foreseeable future."*

The Large Panel Systems of construction also had weaknesses which, as noted earlier, contributed to progressive collapse (Ronan Point 1968). Following this, other LPS buildings had to be appraised with a view to carrying out strengthening works if shown to be necessary.

Although no longer a major news issue, the consequential effects of Ronan Point are still being felt and a quite demanding set of appraisal recommendations exist. Periodic appraisals are likely to be an ongoing process for many LPS buildings – fuller details are provided in BRE Report: The Structural adequacy and durability of large panel system dwellings Part 2 Guidance on appraisal 1987. Part 1 of the same report deals with investigations into construction problems, an example of which is illustrated in figure 12.

Figure 12 *Shepard Spacemaker LPS building with extensive cracking and spalling in exposed ends of cross walls*

Many LPS buildings have also had problems related to deterioration in the sealant/baffles to the joints between panels with implications for weather tightness (this is one of the reasons why many have now been over clad at significant cost). Although condensation, lack of thermal insulation and expensive heating systems are by no means exclusive to Large Panel Systems, they were significant problems for some buildings which also strengthened the argument for over cladding. An example of over cladding is illustrated in figure 13.

Figure 13 *One of many different approaches to over cladding in this case to a Reema block. Timber battens carrying colour coated aluminium sheets. A combination of vertical and horizontal ribbing. Panels fixed back through a neoprene gasket. Insulation: 25 mm of polystyrene board*

Keeping things in perspective

When considering off-site assembled housing it is important to take a balanced view. The terms 'non-traditional' and 'prefabricated' have become very emotive, conjuring up a sense of all that is bad about a wide range of construction systems. On the other hand the phrase 'traditional construction' is now widely used to describe brick/block or rendered block/block cavity constructions whose supporters would have us believe that cavity masonry construction is by far the best and most reliable way of building houses. The term also implies that non-traditional forms of construction were an attempt to displace it from an established position. An objective review of construction practice over the last century would paint a somewhat different picture.

In practice cavity masonry construction was not widely used in the UK until the 1930s, making its widespread introduction later than some, and contemporary with many, of the so-called non-traditional systems. There have also been many developments and innovations in cavity construction which have been readily taken up by the 'traditionalists', but innovation in other forms of construction is treated with extreme scepticism.

Two examples of this inconsistent approach would be in the areas of blocks and lintels. The concrete block itself was an innovation that was developed shortly after the introduction of cavity construction as a means of reducing the number of bricks needed for the wall and increasing the speed of construction, both factors leading to a reduction in cost. Cost was further reduced by the use of breeze (a waste product from coal-fired power stations) as the aggregate.

Since the second world war progressively higher standards of thermal insulation required by building regulations have stimulated the development of a whole range of aircrete block products to replace the less thermally efficient concrete and breeze blocks. Aircrete itself was a real innovation in the sense that, unlike concrete, the material contains no coarse aggregate and might be better described as an aerated mortar.

Lintels too have seen a number of significant changes. Stone and timber gave way to reinforced concrete, which in turn has been partially replaced by steel. Initially steel lintels were manufactured from quite thick sections, the ubiquitous RSJ (Rolled Steel Joist) I section being the most common, although other profiles were also used. More recently we have witnessed the introduction of relatively thin section folded steel lintels. These too have been accepted almost without question in safety critical areas to support quite substantial weights of masonry. However the same material is looked upon by many as unsuitable as a structural material with which to build the walls and other elements of houses despite its widespread use in non-domestic buildings.

Many critics of system built housing will point to problems that have been encountered in order to justify the continued use of cavity masonry construction. It is true that a number of problems emerged with some system built housing, but in the main these were no more serious than those that emerged in some cavity constructions. During the 1980s and 1990s BRE conducted investigations into a large number of different non-traditional housing systems, the results of which are available in numerous BRE reports on individual systems (see list in appendix 1). The majority of problems resulted from poor workmanship, poor quality materials or lack of maintenance – but these issues are equally relevant to all forms of construction including cavity masonry.

Problems with masonry construction

During the same period that BRE was undertaking investigations into problems with non-traditional systems other investigations were also being undertaken on 'traditional' masonry dwellings. The range of problems being investigated was broad and included the following:

- Lack of lateral bracing to trussed rafters leading to the collapse of roofs. When trussed rafters were first introduced too much reliance was placed on the gable walls and purlins to resist racking movement on trussed rafter roofs. In some non-domestic buildings the roof eventually collapsed. Subsequently it was noted that some domestic properties were showing the early signs of trouble necessitating remedial action to prevent eventual structural failure. The regulations have since been modified to require lateral bracing.
- Corrosion of gang nails used in the manufacture of trussed rafters due to interaction with certain timber preservatives. With wood preserved with Copper Chrome Arsenic (CCA) formulations if the fixings are inserted into the wood before the recommended curing and drying times had elapsed then accelerated corrosion could take place, with possible structural failure of the joint as a result. Moisture exacerbates the problem and, since condensation in a loft space is not uncommon, fixings on trussed rafters were particularly vulnerable.
- Sulphate attack of mortars in brickwork leading to expansion of brickwork and detachment of renders. Sulphate attack can occur in situations where there is a source of sulphate salts and the brickwork is kept relatively damp. The source of the sulphates could be the bricks themselves, from some soils where the damp proof course is missing, bridged or damaged or from the inappropriate inclusion of gypsum plaster in the mortar mix. Moisture sources include ground water, construction defects (such as improperly constructed or maintained parapets and rainwater systems), or by entrapment behind renders which are too strong. Remedial treatments require the removal of the moisture source to prevent the situation from getting worse or, in severe cases, demolishing and re-building the affected area.
- Problems with concrete blocks manufactured with low-grade aggregates. Some low grade aggregates contain minerals or substances which undergo chemical changes when used in concrete. This chemical change can be accompanied by a physical change such as an expansion, which in turn can lead to a weakening of the concrete and structural damage. An example of this problem was seen in the west country, particularly Cornwall, where concrete blocks made from 'mundic' aggregates (the waste from tin mining) can suffer sever failure. These aggregates contained deleterious metalliferous minerals which led to the problem.

- Weak mortar mixes resulting from either the use of unsuitable sands or from low cement content. The use of an overly weak mortar can result in rapid erosion of the mortar from the brickwork and structural instability. Depending on the extent of the problem remedial action varied from some re-pointing to total rebuilding the outer leaf of a cavity wall.
- Wall tie corrosion. This affected a large number of dwellings, and as a direct result of that the requirements for the thickness of galvanised coatings on wall ties was increased. Remedial action depends on the extent of the damage and the type of tie involved. Ties with thicker cross sections were potentially more damaging than wire ties, and in severe cases complete rebuilding of the outer leaf of brickwork was the only sensible option.

Many of the problems were due to either ignorance or poor quality workmanship. Few people would argue with the fact that there is now no reason for those problems with masonry construction to be repeated, yet they are. Despite that the problems are rarely reported widely, and are accepted almost without question as part and parcel of the construction industry, rather than the fault of masonry construction. When such problems arise with non-traditional construction, however, it is usually perceived as a fault with the system.

3. Current developments

Drivers for off site manufacture

There are a number of reasons for the current shift towards prefabrication. Some are political, while others are the result of circumstances that prevail in the building industry.

The most obvious political driver at the moment is “Rethinking Construction”, the report of the Construction Task Force (published in 1998, also known as the Egan Report) and the subsequent launch of the Movement for Innovation (M4I) and the Housing Forum.

In the social housing sector the Housing Corporation (HC) have strongly supported both the activities of the Task Force and the Housing Forum and have let it be known that within the coming two or three years they will expect any schemes that they fund will need to be ‘Egan compliant’. They launched the ‘Kick-start’ initiative for which £80 million of their Assisted Development Programme (ADP) funding over the 2001/2002 and 2002/2003 financial years was ring-fenced specifically for factory produced housing.

Many private sector house-builders are also looking seriously at prefabrication. One of the main drivers for their interest is the skill shortage, coupled with an ageing workforce. These two factors mean that it is becoming increasingly difficult for builders to get reliable, skilled workers for conventional sites. Younger people no longer regard the construction industry as being able to offer suitable career opportunities - this is in part because of a poor image, namely that of having a muddy field as a place of work.

Another factor pertinent to builders is the latest round of reviews for different parts of the building regulations. In particular the requirements for both thermal and acoustic performance are becoming more onerous, not least because of the threat of performance testing of the finished dwelling.

M^4I and the Housing Forum

The Movement for Innovation was launched in November 1998 to facilitate the cultural change within the construction industry identified as necessary in the Egan Report. M^4I identified four priorities for innovation and change. These were product development; project implementation; partnering the supply chain and production of components. These are now known as the four ‘Ps’.

Five drivers for change were also identified which were customer focus; a quality driven agenda; committed leadership; integration of processes and teams around the product and commitment to people. In order to be able to measure the extent to which companies were achieving objectives set by the Task Force, a series of annual targets have been set out which are:

- A 10% reduction in capital costs
- A 10% reduction in construction time
- A 20% reduction in defects
- A 20% reduction in accidents
- A 20% increase in predictability
- A 10% increase in productivity
- A 10% increase in turnover and profits

In December 1998 the Housing Forum was launched to promote innovation in the housing sector via a number of mechanisms including the development of industry key performance indicators, seminars, demonstration projects and the Off-Site Manufacturing Working Group.

From the thermal performance viewpoint there is a penalty to be paid in terms of increased wall thickness as the required U-value decreases. Framed solutions, which lend themselves more readily to prefabrication, can in general offer the same U-value for a thinner construction.

Good acoustic performance needs good quality workmanship if it is to be achieved. While both masonry and prefabricated constructions are able to meet the proposed standards, many builders feel that off-site manufacture offers a better prospect of achieving consistently high standards compared to site-based masonry construction. As regulations become more onerous and clients see the improvement in quality available from prefabrication it is likely that an increasing proportion of houses will be built this way.

Technical developments

There have been a number of significant technical developments that make today's manufactured housing different from that of the past. Materials have improved, standards have been tightened, and building physics is much better understood. These factors mean that there is no reason why historic problems related to the corrosion of steel frames, cracking of concrete and condensation should be repeated.

In parallel with these improvements new products have evolved to deal with particular problems and issues, and technology is being imported from other countries and other sectors of the industry. Examples of such new products include SIPs (Structural Insulated Panels), timber I beams and a greater use of brick slip systems.

Structural Insulated Panels (SIPs)

SIPs are a type of load-bearing panel which comprise a rigid insulation core bonded between two sheets of material such as plywood or plaster board etc. They differ from ordinary construction panels in that SIPs do not rely on studs within the panel to bear vertical loads.

4. Pro's and Con's of offsite production

As with any technology there are advantages and disadvantages. From a technical standpoint there are a number of potential benefits from off-site manufacture. The extensive use of jigs and templates should provide greater accuracy and tolerances, which in turn can lead to lower wastage of material because more components can be ordered cut to size. Wastage will also be reduced because the construction process is sheltered from the weather and better facilities for storage of materials leads to less damage and theft.

The controlled conditions within a factory mean better quality of finish and fewer defects can be achieved. Services can be tested within the factory prior to the units being despatched, leading to lower latent defects.

All of the above could be achieved on a conventional building site with the right workforce and site management, but there is one potential advantage that some manufactured systems would have that would not be available with conventional masonry construction. Because of the way some framed systems are put together it is quite feasible for them to withstand some tensile forces which masonry would not. Situations where this would be an advantage are in cantilevered structures and in situations where subsidence might be a problem.

There are also social benefits to prefabrication. Because much of the construction is undertaken in the factory there is less activity on the construction site leading to a number of benefits for the local environment adjacent to the site where the development is taking place. These include:

- Shorter build times
- Less noise and dust
- Fewer tradesmen visiting the site thus reducing local disruption from parking and pollution.

In addition the establishment of factories creates employment which has a beneficial impact on the local economy. Because the factories can be located anywhere with access to the road network, they can be established where unemployment is greatest. Lower wastage of materials leads to lower volumes of material going to landfill.

Many would argue that factory assembly leads to jobs being lost in the vicinity of the site, and much higher overall levels of pollution because of the need to transport the finished units by road. However, both these views are simplifications of complex issues.

It may be that less local labour is used on a site, but this is far from certain. In many cases, because of skills shortages, local labour is not available in the right quantity and at the right time, and the work is therefore carried out by operatives who travel some distance to the site. It is also questionable whether the jobs created by using only local labour would be permanent.

Transport is also a contentious issue. Because many workers travel quite long distances to a conventional site the fuel used during many journeys undertaken in smaller cars and vans can easily equate to the relatively few journeys undertaken by large lorries delivering the units. Workers in a factory would in general live nearby, so the impact from fuel use would be less.

Working conditions in factories tend to be better than on a construction site leading to both health and safety benefits and greater incentive for employers to invest in staff training because the workforce will be local and therefore be more easily retained.

There are also drawbacks to off-site assembly, the most commonly quoted of which is cost. At the moment capital cost of manufactured housing tends to be higher than conventional masonry construction, and usually requires a minimum number of units through the factory in one batch (40 is often quoted as a typical viable threshold). This, though, does not take into account the future maintenance costs. For private sector developers maintenance is not their problem (although it may be a selling point if they were confident of the benefits), whereas for a housing association whole life costs may be a legitimate way of approaching the issue of cost.

There are also developments in computing that offer the possibility of linking the production and assembly line to CAD software. In the future this could enable one-off dwellings to be produced for the same unit cost as a production run.

Another disadvantage often quoted is the fact that with factory production the design needs to be finalised in much more detail well in advance, so that material and components can be ordered and stocked at the factory ready for use. The latter point means that factories are very dependent on the supply chain.

Future maintenance is also a potential problem for manufactured housing. Inevitably some specialised components and materials will be used during the manufacturing process. These materials may not be available decades after the dwelling is manufactured, and may not be available at all to owner occupiers, which could prove problematic from a maintenance viewpoint. This raises the issue of standardisation of key components and/or dimensions – something the industry ought to be addressing now. It is also the case that, because specialised materials are used the maintenance requirements for manufactured housing will differ from that required by conventional masonry housing. This too is something that manufacturers should be addressing, perhaps in the form of a user manual.

Marketability

Much effort has been put into making many non-traditional housing systems look traditional. Historically the reason for this may be due, in part at least, to planning restrictions. Planning consent is still an issue, but many developers/ manufacturers are making houses 'traditional' in appearance to make the point that there is no need to think of them as being different. For some systems this may negate the potential benefits in the use of prefabrication or result in dwellings that would have performed better had they been traditionally built.

However, many of the houses that are distinctively non- traditional either have appearance problems from the outset as a result of the materials used, or because the materials do not age and weather sympathetically.

Appearance can also be affected by the shapes involved, by their repetition and by the sizes of component involved.

A component basis with a small module gives greater flexibility. Historically larger units have tended to reduce variety (for example Calder houses illustrated in figure 14) and this is one of the reasons why volumetric became relatively unpopular.

Figure 14 *Calder houses. One of the better known forms of Volumetric housing*

More modern examples of volumetric construction have demonstrated that variety can be achieved, as with the Guinness Trust development at Chelmsford.

Feedback from the occupants of recent manufactured developments has been quite positive, so barriers to the uptake of this sort of housing does not appear to be the result of public perceptions. There are few, if any, technical barriers to the greater use of manufactured housing. Building science and the way materials decay, weather and interact are much better understood now than when non-traditional housing was first introduced, so there is no reason why past mistakes should be repeated.

Market surveys undertaken recently as part of a DTI-funded project on off-site manufacture indicates that the real barriers to the further uptake of manufactured housing result from risks (real or otherwise) perceived by a number of different players associated with the delivery of housing. Some of these players, and the risk or issue they perceive, are listed below.

Financial institutions:

- The dwelling may not hold its value in the medium to long term, and thus may not represent adequate security for a loan.

Warranty providers:

Warranty providers have a number of concerns with manufactured housing. A number of specific issues are listed below.

- Concerns that a systematic defect should manifest itself during the warranty period, leading to a disproportionate number of claims
- A lack of historic claims data means that there is uncertainty over the cost of repair of some innovative systems.
- Life expectancy and the link between expected life and maintenance (which may not be carried out).
- Difficulties associated with inspection of the structure during fabrication.

In addition to these specific points there are more general issues that concern warranty providers. The warranty normally covers a fixed period (e.g. ten years) and, given that most structures would last ten years even if they were prone to rapid decay, there ought not to be much of an issue.

The problem with that approach is that implicit in the issuing of a ten year warranty is an expectation that the structure would last much longer than that. The whole process of issuing a warranty, with the associated quality inspections and use of standard details, gives lenders much more confidence in the structure than the warranty guarantees. If the structure were to fail before its design life (which would be long after the warranty had expired) then confidence in warranty organisations would be undermined, thus devaluing the warranty.

Registered Social landlords:

- Tenants may not be happy to live in manufactured housing
- Cost is an issue for some RSLs, although the more forward-looking ones are considering life cycle costs when making procurement decisions

House Builders:

- Materials being used may not be durable enough to give required life expectancy.
- Potential purchasers' may not want to buy them.
- If there are failures in the short to medium term company 'brand' will suffer.

Surveyors:

- There may be problems (latent defects) associated with novel forms of construction that they are not able to diagnose on inspection because
  - a) they may not be able to get access to certain areas of the structure because of the way it has been assembled
  - b) the technology used to construct the dwelling may be novel and not familiar to them
  - c) a lack of information on the life expectancy of key components.

Insurance companies:

Novel construction techniques may make it difficult for insurers to asses the costs of repairing dwellings if they are damaged by flood, fire subsidence etc.

Building control:

- The nature of building control will be vastly different for manufactured housing for the following reasons.
- Much of the construction occurs in a factory which may be a considerable distance from the site where they are to be erected. It may be necessary therefore for separate arrangements to be made for factory and site.
- Construction details such as position and nature of damp-proof courses will be totally new, and little guidance is available for Building Control Officers to refer to.

Manufacturers of dwellings:

- Some manufacturers have a great deal of experience in manufacturing buildings such as fast food outlets and hotel accommodation, however houses will tend to have a longer design life. Thus some of the materials and construction techniques they use may not be suitable for the new market, forcing them to make changes to their traditional practices.

What does the future hold?

There is an intention to radically alter the way that the construction industry operates largely based around the Rethinking Construction Agenda. The agencies that are promoting this agenda wish to see construction become far more akin to a manufacturing process with greater use of pre-fabrication and less work carried out on site.

However, this has implications for both new housing as well as the existing stock. Britain has a large stock of buildings that have been produced over a long period. A large proportion of this stock was constructed using 'traditional' methods and much of it will need to be maintained using traditional skills. Traditional craft skills are on the decline and if off site fabrication takes hold a new breed of multi-skilled workers will need to emerge – those skills will need to serve two very different markets.

Much work is being done to increase market confidence in off-site manufacture. The work of the housing forum has been the Government's voice in promoting off site fabrication, but has not generally addressed the issues of confidence.

BRE has recently started a project to develop a 'benefit realisation toolkit' for innovative housing. The project, which is involving players from across the industry (including the CML), aims to address the range of issues listed in the previous section above. The output from the project will be a number of tools, each one aimed at a specific player, which will enable them to identify and manage their own perceived risk.

Manufacturers are increasingly getting their systems certified by organisations such as BRE Certification and the BBA, in an effort to allay the concerns of their potential clients and warranty providers. One warranty body already has a scheme for issuing a manufacturers warranty, but to date there has been little take up of the scheme.

The fears and concerns listed above are very understandable, and addressing them will not be easy. It is, though, inevitable that the way houses are constructed will change in the coming few years. All of the organisations listed above will need to adapt to the new market. In some cases this may be a good thing. There has been a decline in building standards over recent years. To reverse that trend would require a change in culture for which there appears to be little appetite.

A move to a different way of doing things will require the workforce to be trained in new skills and will cause many within the industry to pay a lot more attention to what is happening in an effort to protect their interests. That is probably no bad thing for the future of the construction industry.

Appendix 1:
List of BRE Reports on Non-Traditional Housing

BRE report number	Title
AP137	Set of 15 leaflets describing various houses type:- Falkiner-Nutall steel-framed houses Forrester-Marsh houses Cast rendered no-fines houses Incast houses Universal houses Fidler houses No-fine houses BRS type 4 houses Nissen-Petren steel-framed houses Birmingham Corporation steel-framed houses Arrowhead steel-framed houses British Housing Steel-framed houses Keyhouses Unibuilt steel-framed houses Steane steel-framed houses Cowieson steel-clad houses
BR34	The structural condition of Boot pier and panel cavity houses
BR35	The structural condition of Cornish Unit houses
BR37	The structural condition of Smith system houses
BR40	The structural condition of Woolaway houses
BR41	Timber framed housing – a technical appraisal
BR50	The structural condition of Ayrshire County Council (Lindsay) and Whitson-Fairhurst houses
BR51	The structural condition of Dorran, Myton, Newland and Tarran houses
BR52	The structural condition of Parkinson Framed houses
BR54	The structural condition of Stent houses
BR 63	The structure of Ronan Point and other Taylor Woodrow – Anglian buildings
BR71	Smith system houses in Sandwell, West Midlands
BR74	Large panel system dwellings: preliminary information on ownership and condition
BR77	BISF British Iron Steel Fed House
BR78	The Howard steel-framed houses
BR90	Moisture conditions in walls of timber-framed houses – the effects of holes in vapour barriers
BR93	Overcladding external walls of large panel system dwellings
BR105	Boswell houses: investigation of structural condition
BR107	The structural adequacy and durability of large panel system dwellings
BR110	Dorlonco steel-framed houses
BR111	Thorncliffe cast-iron panel houses
BR112	Bibliography on cold-formed, thin-walled steel structures, 1978-86
BR113	Steel-framed and steel-clad houses: inspection and assessment
BR116	Reema large panel system dwellings: constructional details
BR118	Bison large panel system dwellings: construction details
BR119	Roften steel-framed houses:
BR120	Dennis-Wild steel-framed houses

BRE report number	Title
BR130	The structural condition of Easiform cavity-walled dwellings
BR131	Cyclone-resistant houses for developing countries
BR132	Cussins steel-framed houses
BR133	Livett-Cartwright steel-framed houses
BR139	Cruden Rural steel-framed houses
BR144	Falkiner-Nuttall steel-framed houses
BR145	Crane steel-framed bungalows
BR146	Trusteel MkII steel-framed houses
BR147	Trusteel 3M steel-framed houses
BR148	Atholl steel-framed, steel-clad houses
BR149	Dorlonco steel-framed houses. Supplement to the 1987 BRE Report
BR152	Hawthorn Leslie steel-framed houses
BR153	The Structural condition of Wimpey no-fines low-rise dwellings
BR154	Improving the habitability of large panel system dwellings
BR163	Nissen-Petren SFH
BR188	Lowton-Cubitt Steel-framed houses
BR189	Telford steel-clad houses
BR190	Mowlem in-situ concrete low-rise dwellings
BR191	The renovation of no-fines housing
BR193	Cranwell steel-framed houses
BR196	Birmingham corporation SFH
BR197	Hills Presweld steel-framed houses
BR198	Arcal steel-framed houses
BR199	Homeville Industrialised steel-framed houses
BR200	5M steel-framed houses
BR201	Arrowhead SFH
BR202	British housing SFH
BR203	Keyhouse unibuilt SFH
BR204	Open System Building steel-framed houses
BR205	Steane SFH
BR217	Cowieson Steel-clad Houses
BR218	Weir steel-clad (1920s) houses
BR219	Stuart steel-framed houses
BR221	Riley steel-framed houses
BR222	Coventry Corporation steel-framed houses
BR228	Moisture conditions in the walls of timber-framed houses
BR233	Briefing guide for timber-framed housing
BR275	The structural condition of cast-in-situ concrete low-rise dwellings (Only available on CD2/96)
BR282	Timber frame housing systems 1920 to 1975: inspection and assessment
BR283	Timber frame housing systems built in the UK between 1920 and 1965
BR284	Timber frame housing systems built in the UK between 1966 and 1975
BR318	The structural condition of cast-in-situ concrete high-rise dwellings (Only available on CD ROM 3/96)
BR325	Sulfide-related degradation of concrete in Southwest England ('the mundic problem')

BRE, Garston, Watford, WD25 9XX