SCHOOL OF ENGINEERING AND BUILDING ENVIRONMENT

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COURSEWORK 2

PART1

EVALUATION & APPRAISAL OF CONTEMPORARY TIMBER CONSTRUCTION FOR A KINDERGARTEN

PART2

THE TIMBER INDUSTRY AND THE GOVERNMENT

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Abstract

This report split into two part;
Part 1 starts with evaluation & appraisal of contemporary timber construction for a kindergarten. Firstly, investigates an educational philosophy which advises a participatory progress on all stages of project. A summarized explanation about the Modern Methods of Construction (MMC) follows an examinations of possible construction types be built aligned to educational philosophy. Then elaborates the environmental impacts of building within the CLT systems which is chosen for the proposed kindergarten.
Part 2 investigates the relation between the industry and the government classified as two subject as 'Timber Industry and Housing' which argues how timber can be a solution within the dwelling shortage in UK and 'The Safety of Timber Dwellings' which draws a rationale conclusion which allays fears of government

EVALUATION & APPRAISAL OF CONTEMPORARY TIMBER CONSTRUCTION FOR A KINDERGARTEN

1 Evaluation & Appraisal of Contemporary Timber Construction for a Kindergarten

1.1 Introduction

Kindergarten being a place of early education for children, plays an important role in their development due to inspire their creativity and stimulate their learning capacity. Furthermore, in order to create a kindergarten, practical and innovative approach need to be adopted to build a place that provides the best possible settings for children to grow up in.

For the new kindergarten will be built at Napier University Craiglockhart Campus, this report examines the building type and the educational pedagogy of the kindergarten regarding to the appropriateness of the constructional system and materials to be used in relation to the buildings function.

1.2 Educational Philosophy

Friedrich Froebel, the most influential German educational theorist during the second half of the 19th century defines the term of “kindergarten” as that: The institution is to provide an environment where children felt secure enough to match their inner life with the demands of the outside world, where opportunities existed for children to experiment through their play in areas not yet known, but vaguely surmised. Such protection and predictable environment was more like a nursery where the gardener tended his plants, provided water and air and moved plants into the sunshine so that they could grow and flourish. As an American author, Robert Fulghum’s book called as “All i need to know I learned in Kindergarten” has given a clue, kindergartens where the children are greatly influenced.

Today’s Britain kindergarten approach derived from Froebelian educational ideas brought by many German liberals emigrated to Britain after the failure of the revolution in Germany of 1848. He claims that there are forces within children that move them towards those activities that stimulate development. Therefore, the physical and restless activity of children should be sustained and directed by the teacher towards these developmental goals. Thus, the traditional role of the active teacher and the passive class would be reversed. Children would be given a wide range of materials and encouraged to carry out various sorts of creative and expressive handwork; self-activity became the means of education. This was to be the basis of a new education of particular relevance to the youngest children. Presently, kindergartens approach differed in one respect from Froebel’s German system as they expanded in the 19th century. More emphasis was placed on play organised by teachers and less on children’s free play (Dudek, M. 2000).

While the thoughts of Forbelian still indicates teacher as leader who puts the aims to infants to encourage their improvement, Italian educator Loris Malaguzzi developed the Reggio Emilia Approach which draws the relation between two as team players, in the 1940s. A style of preschool and primary school education in which young students are encouraged to initiate self-guided explorations of both their physical environment and their immediate social community. The Reggio Emilia Approach prescribes that the teacher is not a dictator, rather she is a co-learner and collaborator with the students. Malaguzzi states, “There are three teachers of children: adults, other children, and their physical environment.” the latter of which is subsequently referred to as the `Third Teacher`. Behind educators and families, physical spaces hold the potential to influence what and how children learn. Children constructing knowledge based on their experiences and interactions with others and with a multitude of materials and resources in the environment. They are also communicators, developing intellectually through the use of symbolic representations, including words, movement, drawing, painting, building, sculpture, shadow play, collage, dramatic play, and music – all of which lead children to surprising levels of communication, symbolic skills, and creativity. In the Reggio Emilia approach the school is seen as a place of research, a place of participation, and shared construction of value and meaning with an emphasis on understanding relationships and involving high levels of thinking. The role of the teacher as an observer is extended to 'documenter and researcher' (Baker, 2015).

The new kindergarten for Napier University is to be situated on a green-field site at Craiglockhart Campus. In accordance with Reggio Emilia approach which considers children as contributors in educational environment, it is aimed pupils to be involved and be part of the process from the design stage till the final product erected for the purposed kindergarten. In the end everyone would know what is coming and feel some degree of possession which roles significantly as it promotes the daily personal responsibility of the pupils as well as their critical awareness in curriculum work. The focus on personal responsibility, initiated by participation in the school's design and development. Furthermore, the idea of 'third teacher' Malaguzzi branched out from Emilia's approach which refers the school building after pupils and staff will lead the building became future proofing building performance. This approach recommends that all architectural decisions (materials, construction system, energy consumption etc.) be taken on the basis of ecological compatibility. There is a distinctive example about this issue which is that: Kemal Ozcul who received the European Environmental Prize in 2034 for his services in saving the forest of Lower Bavaria, the son of poor Turkish immigrants, he attended the school of Gelsenkirchen in Germany which is one of Peter Hubner's self-build project (Jones, 2014) as a small child starting in 1994, and it had completely changed his life. The story charts of the designing and building the school, enacting its ecological policies, being inspired by school master nicknamed 'Eco', his family taking part in the development of self-building housing adjacent and so on. As an adult Kemal tells how he went on to do ecological work for he had won the European Prize, so he owed everything to the school (Jones, et al., 2005)

Consultation strategies may include: Visits, role-play; workshops and events; meetings, discussions; models and drawings; exhibitions and presentations.
While there are other methods that could be added to this list, it is likely that the design team working on the job will have been involved in previous consultation exercises and may therefore be able to offer some advice on the best means of progressing the project within the available timescales (Scottish Government, 2007).

Figure 1 Illustration of participatory design as students collaborated with the architects to create a space of their own

1.3 Kindergartens as Building Type

All the pioneers of the discipline seem to agree that the form should be appropriate to children and visibly different from other institutions, there is no established consensus about what form it should take. Rodolphe Luscher in Lausanne, for example, tried to make the layers of construction and servicing clear so that children can learn about different materials and their assembly. The geometry is regular and orthogonal to show this discipline and help develop their constructive sense, but can young children really appreciate it? Gunter Behnisch adopted a different approach with a kindergarten in Stuttgart, conceived as a stranded ship, complete with portholes, leaning decks and canted walls. This approach might be in danger of being too literal, of leaving too little to the children's imagination. Peter Hubner's approach in Stuttgart lies between the two. He sees some value in the structure -in this case timber- being legible, and he also accepts the need for a building which stimulates children and provokes exploration, but thinks the image should not be too firmly fixed. For this recent building, Hubner sought to create a network of spaces within a recognisable order, yet he also allows for variety and encourages exploration (Jones, P. 1996).


Figure 2 External views of the kindergartens, Behnisch' (left) and Hubner'(right)

The seeking of form will come up along the cooperation with users aligned the educational philosophy in our building. The provocation of children exploration is placed to the core of the building from the first stage. It is aimed them to understand scale through the clay works and paints. During the design process, wooden frameworks assembles with the help of the architect for the prototypes of the building. Therefore, they will see how the spaces work.

The focused user in the purpose will be the children. In Scotland, the school year begins in mid-August. Children in Scotland usually start school between the ages of 4.5 and 5.5 years old (Bradshaw, et al., 2012). It will serve as full-day kindergarten will be build up one storey. The following interior rooms consist in main programme: 1 room for each group linked with one separate additional room which belongs to group room; 1 assembly hall to accommodate all the children exposed daylight, spacious and bright, ideally 1 room per group for resting and sleeping; 1 hall for physical education shared by all groups, 1 washroom and separate toilets for each group, rooms for special activities music, language training and development; an administrative office,1 staffroom and 1 flexible space for the use of parents and public or in use of that where children present their artwork. Storage and maintenance area is placed at outside. Those are the facilities which are embodied main organization, through the workshops the main body is considered as open to extensions. The landscape design will be considered along the chosen pedagogical line as a third teacher defined equivalents with student. This is brought up reality while the ground encourage children to gain first hand experiences , the student is expected to be contribute its growth in such ways as taking care of the plants or the existences of cultivation areas ideally. In all stages of the decisions taken, pedagogics will be companied. The process will be operated interdisciplinary and owed to timetables committed.

Compliance with the Building Regulations can have a significant effect on design solutions. This task will be controlled by architects as to be aware of the relevant standards. Furthermore other influences will be taken into considerations which are The Disability Discrimination Act (DDA) 1995 and the Education (Additional Support For Learning) (Scotland) Act 2004.

1.4 Modern Methods of Construction (MMC)

Off-site construction is the manufacture and pre-assembly of components, elements or modules before installation into their final location. Urbanisation and colonial expansion prompted the need for efficiency and quality of product, resulting in the first major exploitation of off-site techniques. With the evolution of construction components and techniques, varying forms of off-site construction have also progressed to become Modern Methods of Construction (MMC) (Hairstans, R. 2010).

Modern methods of construction (MMC) is a philosophy of construction which aims to produce better quality efficient projects in less time to the entire satisfaction of the customer. MMC basically aims to to reduce waste and improve certainty through adoption of disciplined processes, encourages continuous improvement, and emphasizes on delivering improved projects to meet growing customer demand for better quality and improved performance in terms of environmental impact and costs.

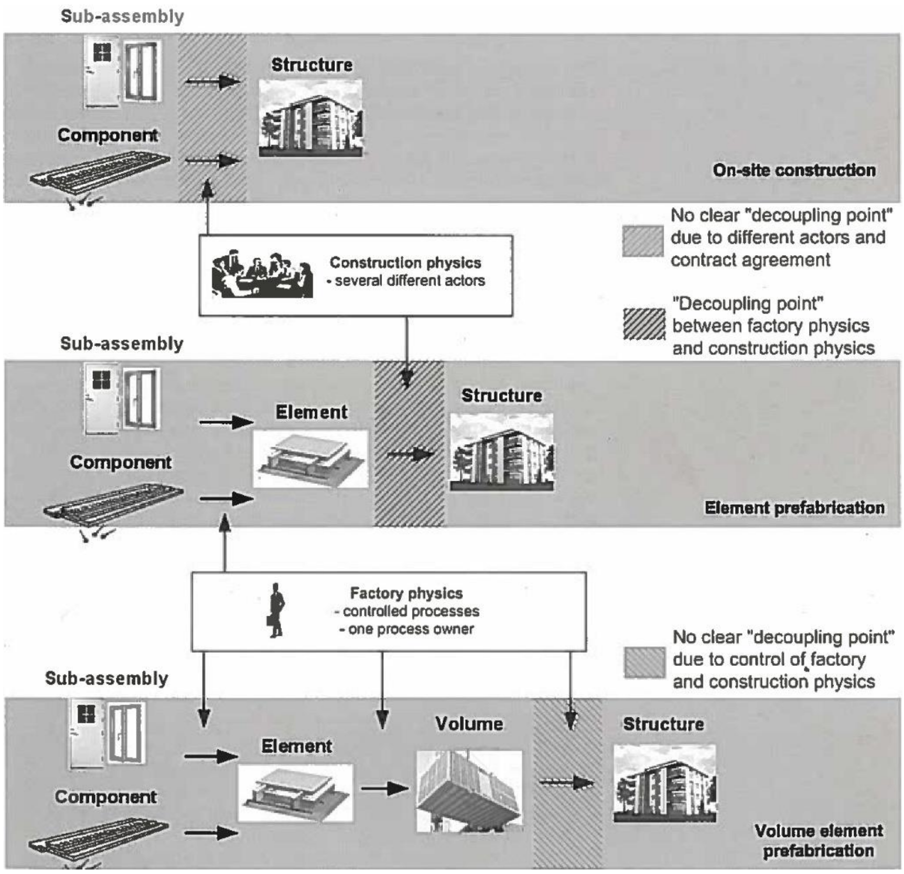

Figure 3 Level of off-site construction (Sandberg et al, 2008)

The procurement process in off-site MMC is important. Private and social contracts have different demands. Each sector makes different demands on the supply chain and logistics, the relative level of standardisation and mass customisation that can achieved varied levels (Hairstans, R. 2010).

To achieve the above-mentioned benefits government is encouraging the use MMC. Timber being a material offers enormous opportunities to be used in MMC, as most of the timber construction systems such as timber frame, Glulam and CLT & SIPS are based on the concept off site construction, which is the main attribute of MMC (TRADA, 2013).

The structural system of building will be bodied by timber constructional which is natural and sustainable, capable to bring cultural values to project and appropriate for creating various structural forms. In the following section timber constructional systems explained and appraised in terms of their appropriateness for the purposed kindergarten.

1.5 Timber Construction Systems

1.5.1 Timber Frame System

The method of timber frame construction generally used in the UK is known as platform frame.

'Open panels' (studs, rails, lintels, sheating and breather membrane) that have been manufactured in a factory environment are delivered to site and craned onto 'platform', which is formed by the building foundations sole plate. The panels are fixed into position with nails into position with nails and then floors are installed to create another platform. The floor is either cassettes or loose joists (now frequently engineered joists), with a wood based panel structural deck. The final part of erection process is to position, fix and brace the roof, normally trussed rafters. 'Open Panel' structures, such as this, are dry-lined after the insulation and a vapour control layer on site.

Higher levels of prefabrication can be achieved with 'closed panels' where the insulation, services, vapour control layer, internal linings and possibly also the joinery and cladding are all applied in the factory.

Figure 4 Timber Frame Systems; Open Panel System(left) and Closed Panel System(right)

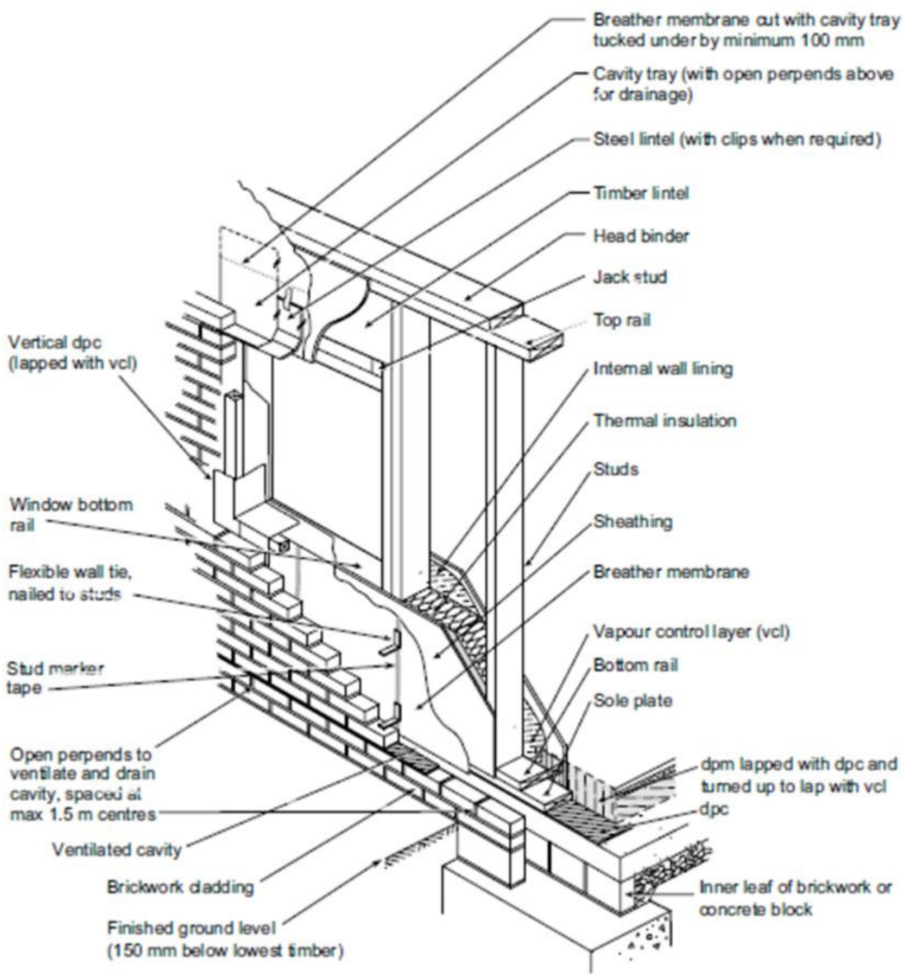

Figure 5 Externally sheated timber frame wall with brick cladding(TRADA,2016)

The stud work is vertical loadbearing skeleton of the external wall. The framework consists of vertical studs and horizontal rails. Studs are most commonly 38mmx140mm.A significant effect of the 2010 revisions to the building regulations(which demand %25 reduction in heat loss over the 2006 reuirements) is that 140mm is no longer be sufficient to accommodate the insulation needed. Larger sizes may be used to provide increased thickness of insulation (TRADA, 2016).

In our design we expect the structural system meets with lower energy demand and enable to flexible solutions which might require special manufacture when the design process ended. Even it is possible to achieve to gain energy efficiency with widening wall thickness and as the system procurable with in Scotland which means reduction of CO_2 emissions due to transportation, this construction system is more suitable for where the design does not demand different heights and various volumes in final product which is not convenient in our case.

1.5.2 Cross Laminated and Glue Laminated Timber

Cross-laminated timber is factory made construction based on manufacturing technique developed in the late 20th Century. Essentially, slices of softwood timber are assembled to form sheets, with the grain of each set perpendicular to its neighbour. The sheets or layers are then glued together under pressure(laminated) to create a stable, structural product.

Panels are commonly available up to 16.5m x 2.95m in size and can, if required, be produced by some manufacturers to 20m x 4.8m, with the practicalities of transportation generally being the limiting factor.

Glued Laminated timber, is a high specification engineered timber beam, fabricated by bonding together stress-graded planed timber laminations. This forms a structural unit of excellent strength and dimensional stability.

The principal difference between CLT and glulam is that in the latter the timber is glued in layers that are parallel with each other, rather than perpendicular. This gives glulam directional strength, which is glulam elements are chiefly used for structural elements such as beams as columns (TRADA, 2016).

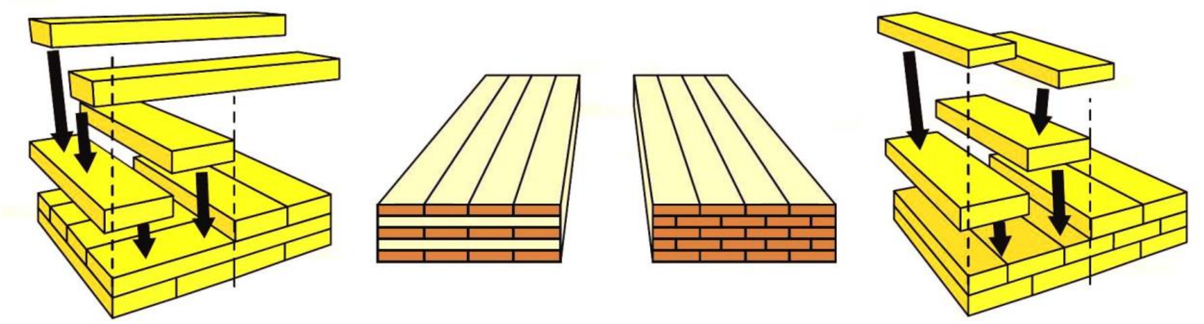

Figure 6 Cross Laminated Timber technique(left), Glue Laminated Timber technique(right)

Door, window and other openings can be simply positioned and executed, free of any super-ordinate grid. CLT allows a high degree of prefabrication. Wall assemblies are characterized by a clear separation in layers for construction, insulation, installation and cladding. This enables different degrees of prefabrication at the factory, a step-by-step finishing on-site, and an easier execution of repair and alteration work at the facade, insulation and installation. With regard to building physics and in comparison, to light-weight timber constructions, CLT exhibits less air permeability and a distinctive specific storage capacity for humidity and thermal energy (Brandner, F. 2016)

The main producers of CLT and glulam both are currently located in central Europe and Scandinavia. Transport by articulated lorry brings the completed pre-fabricated panels from these locations to the UK for fast site assembly.

Figure 7 (Left) five-layer CLT element; (middle to right) impressions from project Wittenbauerstraße/Graz/Austria: two three-storey residential buildings

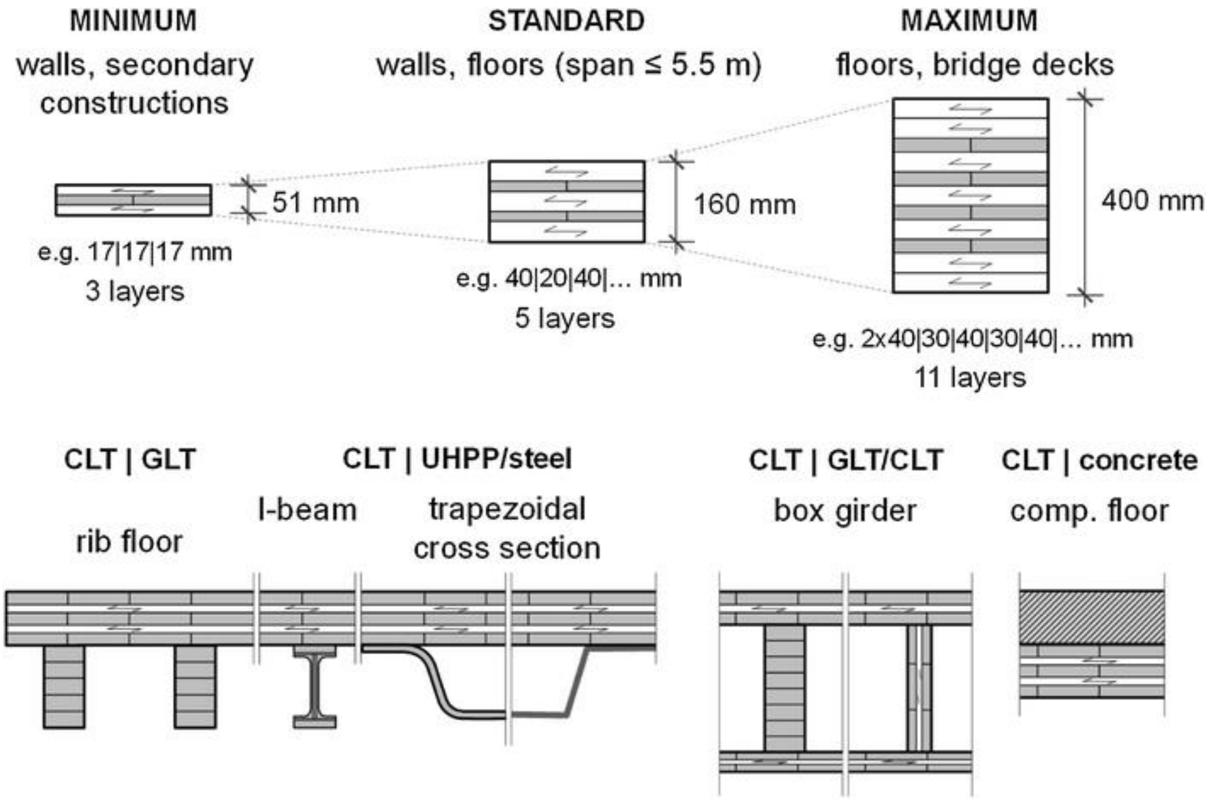

Figure 8 (Top) layup examples for given purposes; (bottom) examples of composite structures of CLT and glued laminated timber (GLT), ultra high performance plywood (UHPP), steel or concrete; adapted from Schickhofer (2015)

Providing high reduction of energy demand and being free from size limitations together meet the proposed building needs. CLT is the system recommended cooperates with the overall project strategy regarding its future proofing building performance and being capable to meet with demands of different sizes.

1.5.3 Structural Insulated Panels (SIPS)

Structural insulated panels (SIPs) are composite engineered products in a sandwich formation, where the ‘bread’ is typically sheets of orientated strand board (OSB), and the filling is a low-density, cellular foam insulating core. Bonded tightly together in controlled factory conditions forming a stressed-skin panel construction, the composite structure of these panels produces high-performance yet lightweight components with good loadbearing capabilities, suitable for use as walls and roofs for residential and commercial buildings.

SIPs generally achieve BRE Green Gude ratings of A and A+ for wall and roof elemnts, and use SIPs contributes to UK Government’s strategy for sustainable construction because of their relatively low embodied energy and good thermal performance. A number of UK-based manufacturers of OSB use home-grown timber in the manufacture of their products, reducing transport related carbon emissions (Taylor, 2015).

SIPs wall panels can be of any thickness, although most manufacturers will make panels between 100mm and 250mm thick. Most new build developments will have external wall U-value targets of between 0.1 W/m^{2}K and 0.2 W/m^{2}K which SIPs can easily achieve. Building with SIPs will cost about

15% more than, say, a conventional timber frame according to self-build.co.uk.

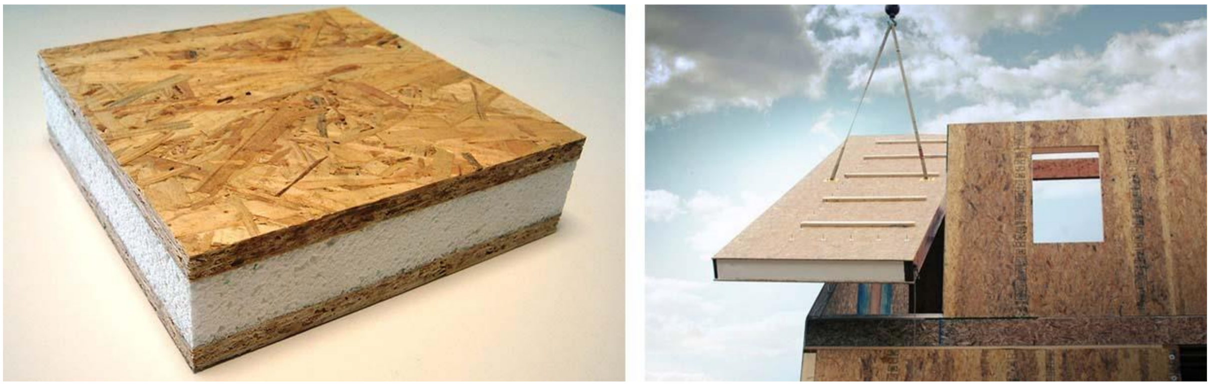

Figure 9 SIPs, showing OSB with foam infill(left), a view of its built from construction site(right)

Regarding to features mentioned above, SIPs could be taken as the best solution for the proposal. The unique but effective issue what makes the system eliminated is the cost of building likely beyond the budget allocated for kindergarten in Craiglockhart Campus by the Estate Committee of Edinburgh Napier University.

1.6 Enviromental Impact of Building

Wood consumes only about 50% of specific energy(Kw/M^3) needed to produce concrete and about 1% of the energy needed to produce steel. This low embodied energy, coupled with the fact that trees can , with good management, improve land quality and soil fertility and are also a prime sink for carbon (carbon fixed from the atmosphere CO_2 by photosynthesis), means timber has potential to be a completely sustainable resource(Hairstans, R., 2010). According to the research conducted by Wood for Good, there are two ways to decrease CO_2 in the atmosphere, either by reducing emissions, or by removing CO_2 and storing it. Wood has the unique ability to do both.

Carbon sequestration describes long-term storage of carbon dioxide or other forms of carbon to either mitigate or defer global warming and avoid dangerous climate change. This is an extremely complex process that has taken mankind centuries to mimic. The latest technological advances have made it possible to take carbon dioxide out of the air via mechanical processes and store it deep underground, but this is only a recent innovation.

Solid wood products such as cross laminated timber (CLT) are natural, renewable and are far less energy-intensive to produce and apply than alternative materials. When compared to other building materials such as concrete or steel, the environmental credentials of CLT are far superior. Not only is it a renewable material, it involves very little waste during production and is extremely carbon efficient to transport. When we consider the whole manufacturing processes for the production of each m3 of CLT, -676kg of CO_2 will still be stored after the production process.

Due to the woods sequestration of CO_2, the overall carbon footprint for a CLT building is lowered by up to 75%. To put into context the extent of the benefits of CLT, a typical timber house has the ability to lock up 19 tonnes of CO2, meaning that if the government were to hit their target of building 200,000 homes per year, but only using timber frame methods, this would mean an extra -3.81million tonnes of CO_2 sequestered and stored every year. It is believed that a single five-storey, cross laminated timber building is able to cut emissions by levels equivalent to removing as many as 600 cars from the road for a year.

End of Life Scenarios

The effect of six different end of life scenarios for the CLT frame has been considered: re-use in its existing form; re-engineer the panels into smaller sections and re-use; incineration without energy recovery; incineration with energy recovery; landfill, assuming 20% of the timber decays (Weight, 2011) and no energy recovery from landfill gas. The results are shown in Table 2.

	tCO$_2$e				
	re-use	re-engineer	incinerate	incinerate with energy recovery	landfill
to end of construction	-1100	-1100	-1100	-1100	-1100
Demolition	22	22	22	22	22
Transport	12	12	12	12	12
Manufacture		10			
Transport		12			
Construction	45	45			
Combustion			1192	1192	
Energy from combustion				-628	
Emissions from landfill					1013
Total	-1021	-999	126	-502	-53

Table 1 Embodied Carbon of CLT frame with different end of life scenarios

They indicate that re-use of the CLT panels is the best option and could potentially reduce the total building embodied carbon to 136tCO$_2$e and increase the differential to 1525 tCO$_2$e. The worst option in 7 terms of emissions is incinerated without energy recovery, increasing the total building Ec to 1283tCO2e with the differential reduced to 378tCO$_2$e (Darby, H., J. et. al. 2012)

1.7 Conclusions

It is convinced that timber construction is shortening build time, providing low energy-demand, achieving superior thermal insulation and superior quality through factory-based quality control whilst also contributes social advantages. Throughout the educational philosophy for proposal of kindergarten defines environment as third teacher, the building with the high level of energy efficiency will be the concept will be the first learned by the youngest team players of the triangular along the their partnership from the first stage. CLT is the selected specific system for construction, credited for flexibility and speed of build with high energy performance.

THE TIMBER INDUSTRY AND THE GOVERNMENT

2 The Timber Industry and the Government

2.1 Timber Industry and Housing

2.1.1 Introduction

The idea that Britain needs to build 250,000 houses a year comes from Barker Review in 2004. It reckoned that such a level of private building was consistent with "real" (ie, inflation-adjusted) house-price increases of 1% a year.

But almost ten years on from Barker our house building performance remains dire and has been made considerably worse by the impact of recession and the fallout from the credit crunch. Indeed, since 2004 we have failed to build over a million of the 3m new homes identified as necessary by the Barker Report. England is now delivering fewer homes than in any peacetime year since the First World War, even before accounting for a much larger population and smaller households. As a result, the country faces a large and accumulating shortfall between the homes we need and the houses we are building of approximately 100,000 to 150,000 homes a year. If we remain building at current levels, we build a million fewer homes than we need every seven years.

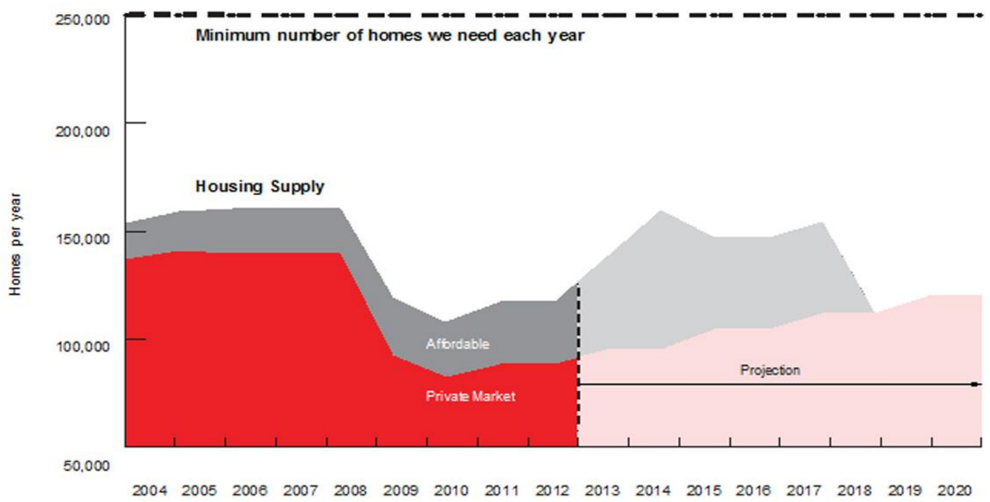

Table 2 Comparison between housing supply and minimum numbers needed each year

Progress of planning permission, public sector building fall, lack of available land, skills and materials shortage are the most featured reasons are needed to take an action. This paper sets out the suggestions for closing this housing shortage briefly and focuses on the how timber industry can help to tackle skills shortage and provide new building regulations demand more energy efficient dwellings in future.

2.1.2 Overcoming Arising Issues

Turnover in the second-hand housing market, though, is slow. In the late 1980s more than 2m properties were bought and sold each year, twice as many as change hands today according to The Economist, the English newspaper. As the population has aged, the average homeowner has become less likely to want to move, says Bob Pannell of the Council of Mortgage Lenders, an industry body.

Moreover, with prices rising fast, people are not rushing to sell up. The number of UK households renting property rose from 2.3 million in 2001 to 5.4 million in 2014, according to RICS (Royal Institution of Chartered Surveyors). It said that any further investment in property by landlords had been hit by changes to stamp duty in April 2016. Anyone buying a home that is not their main residence must now pay a 3% stamp duty surcharge. Stamp duty, a tax on house buyers, has risen steeply over the long term, providing another disincentive to moving: someone buying an average-priced home in London faces an upfront bill of £15,000. In Scotland, the equivalent tax is the Land and Buildings Transaction Tax (LBTT) was also up-rated. Abolishing stamp duty would boost transactions by 8-20%, according to different estimates. Moreover, the government could boost transactions further by supporting bridging loans, in which a bank offers short-term finance to someone to buy a home before they have sold their current one.

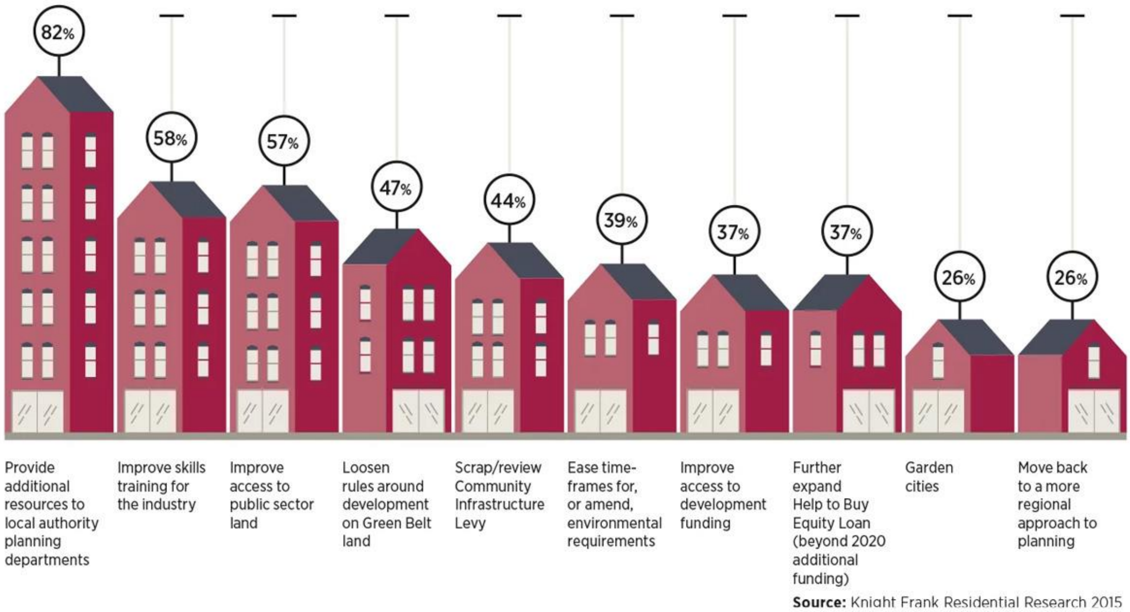

Figure 10 The measures policymakers take to help boost housing supply

2.1.3 Skill Shortage and New Regulations

Over 1,800 people leave the construction industry each year. Many are retiring and this rate looks set to grow as 22% of the construction workforce are over 50, 15% of which are in their 60s according to Kristen Helson director of at KLH Sustainability. The industry is also losing out to competing sectors where work is more stable and pay is more competitive. With an aging workforce and a poor pipeline of young people, the construction industry looks sure to face a skills crisis in the next decade. Construction sector are persistent and hard to fill because employers cannot recruit staff with the right skills, qualifications or experience, and the demand is forecast to rise even further.

For the new dwellings built up, UK have targeted carbon neutral homes with the zero carbon policy was first announced in 2006 which requires all new homes from 2016 to mitigate, through various measures, all the carbon emissions produced on-site as a result of the regulated energy use. The fabric energy efficiency performance, CO2 emissions limits which must be less than or equal to the Carbon Compliance limit established for zero carbon homes are the core requirements which must all be met for a home to qualify as zero carbon.

Figure 11 UK's Zero Carbon core requirements

2.1.4 How Timber Industry Helps

In the housing sector there have been a number of different descriptions given to delivery methods which set out to improve product and process. The term Modern Methods of Construction has in the past been adopted for new products and technologies. Offsite is a construction term to describe a delivery method that adds substantial value to a product and process through factory manufacture and assembly intervention. The whole objective is to deliver to the construction site elements that are to an advanced state of completion thus removing site activity from the construction process. In some cases this may be in a three dimensional volumetric form or more commonly for housing in open or closed panel form.

Off-site construction technologies offer a wide range of advantages over conventional forms. These include:

• Shorter build times, typically less than half the time it takes to build a conventional, masonry house.

• Superior quality, through factory-based quality control, precision engineering and design standardisation.

• More energy-efficient, achieving superior thermal insulation, with in-use energy savings of at least 20% over conventional methods.

• Less waste, through efficient use of materials, up to 90% less waste than conventional construction sites.

• Lower ownership costs, through lower bills and reduced maintenance.

• Upskilling and strengthening UK manufacturing, through high-technology manufacturing and openning up of new supply chain opportunities as well as export potential.

• Reduced impact on transport systems, pollution and infrastructure, where off-site construction will reduce the amount of raw materials needed to be transported to the site.

Timber frame's inherent strength, durability, sustainability, availability and relatively low cost give it a competitive advantage over other methods of construction. Structural timber, manufactured offsite, is monitored at every stage of its production and is not reliant on a multitude of other trades and determinants. Frames are constructed in a controlled and precise manner using the latest industry innovations and technology such as breathable membranes with thermal, acoustic, and fire protection inbuilt into the timber's design.

Furthermore, a factory-based environment ensures safer working conditions for employees. Offsite timber construction doesn't carry the same height risks as construction carried out onsite and is not weather reliant. This is a huge benefit given our changeable climate. Using offsite construction methods, strong winds, heavy rain and below freezing conditions has no effect on workers which leads to safer, better quality, more efficient and quicker production.

Moreover, an increase in offsite construction, as offered by timber frame, will improve the construction industry's image among young people, helping to alleviate the chronic skills shortage within the sector. The government report, Construction 2025, outlined how the construction industry's poor image was having a "detrimental effect on companies' abilities to recruit and retain the best talent". A more professional setting, away form the elements, will help convince prospective apprentices and graduates that their skills are best served within the construction industry.

Additionally, there are various cost benefits associated with building timber frame housing. Timber is a readily available material that can easily meet industry demands. Supplies of brick and block have recently suffered shortages and when a material is in short supply, a premium is placed on its price. There is also an alarming shortfall in the numbers of skilled bricklayers within the UK construction sector, with a recent Royal Institute of Chartered Surveyors (RICS) survey revealing 60% of respondents have difficulty in finding bricklayers for projects. These skill and supply shortages not only increase the financial burden on housing projects but at this moment when speed of construction is of the essence, they create unwelcome and unnecessary delays.

Timber not only enables specifiers to choose a material that is precision engineered and cost effective but also sustainable. Structural timber's low heat conductivity, low embodied carbon, high structural strength, airtight construction and traceable supply chain make it an ideal choice for housebuilders with sustainability in mind.

With consideration to all these benefits associated with timber frame homes, an increase in the use of timber frame within the house-building sector would provide a solution to the perennial housing shortage crisis.

2.2 The Safety of Timber Dwellings

2.2.1 Introduction

Timber is amongst the oldest building materials used by humankind. We have been building with timber for millennia, and in its various forms timber has consistently remained a key structural and building material in most cultures (along with masonry and, more recently, concrete and steel). However, various conflagrations in largely timber-built towns and cities around the world throughout the history of civilization, typically called the "Great Fires" (e.g. of Rome, Constantinople, Hangzhou, Utrecht, Amsterdam, London, Baltimore, Tokyo, etc.) led to the use of timber structural and cladding materials being reduced or explicitly restricted within dense conurbations, with a preference for non-combustible structural framing, cladding, and roofing materials, particularly for multi-storey and high-rise construction (Bisby, L. A. & Frangi, A. 2015).

In UK, the fire in a house in Manchester in June 2014 that spread to two adjacent dwellings and caused the loss of all three dwellings has brought the matter of safety of timber dwellings attention to House of Commons which is spoken by Sir Andrew Stunell the member of RIBA, the member of Parliament for Hazel Grove who served till 2015. Doubts about the fire protection of timber dwellings are risen by the casualties and turning into a crucial point roles in the future of timber industry which presently stands for a major part of the overall economy due to their environmental credentials, and societal goals striving for sustainable development with lower energy demands and less pollution.

This paper reveals the fire safety of timber buildings with examining fires in dwellings while under construction and after occupied. Therefore, draws a rationale conclusion which allays fears of government as to the safety of timber frame dwellings.

2.2.2 Statistics

For buildings under construction in England, it is unlikely that there would be an issue with identifying whether a building is timber-framed or not. From April 2009 to March 2012, there were 118 fires in timber frame buildings under construction compared to 1,103 fires in buildings under construction whose structure was of no special construction. Among buildings under construction, the ratio of fires in timber frame buildings to fires in buildings of no special construction is much higher at 1:9 (118 compared to 1,103) compared to the same ratio for buildings not under construction (1:57, 2,485 compared to 141,075 fires). The distribution of the area of damage for buildings under construction of timber frame, and no special construction, are shown in table 3 for dwellings.

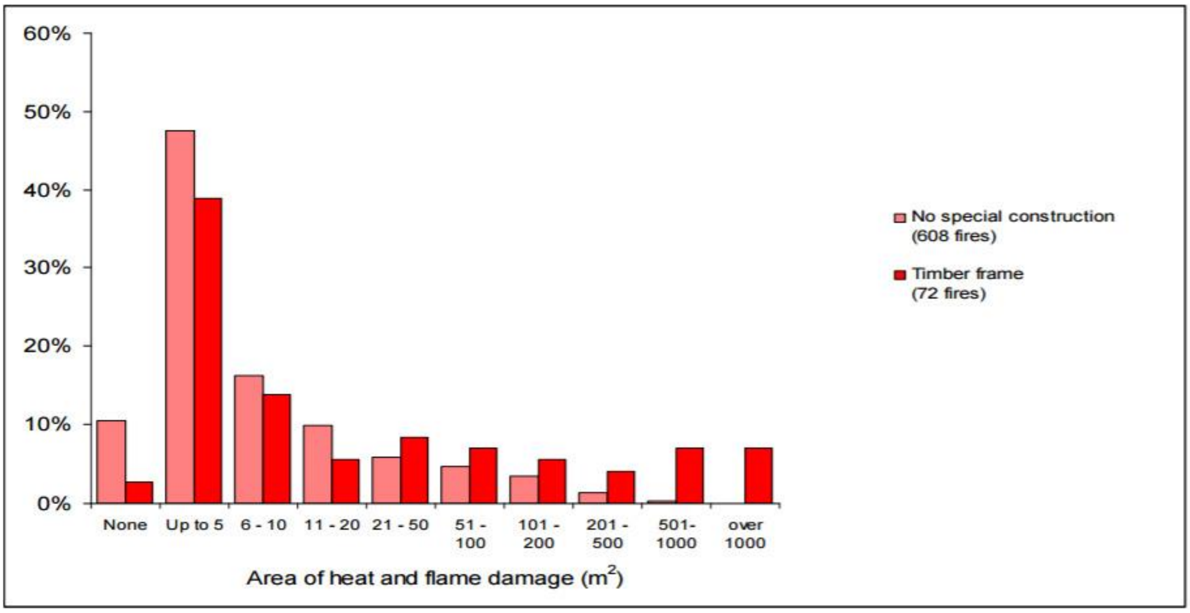

Table 3 Distribution of area of heat and flame damage fire in dwellings under construction, England, April 2009-March 2012

Turning to casualties in buildings under construction:

• there were no fatalities over the period (April 2009 to March 2012)
• among buildings under construction, there were eleven non-fatal casualties from fires in timber-framed properties, and thirty-four in fires in buildings of no special construction. These numbers are too small to allow robust conclusions to be drawn over rates of casualty in buildings under construction.

Fires in timber frame dwellings after construction were proportionally fewer in the lowest category included in the analysis (21-50m^2) than for dwellings of no special construction. The opposite is true for all categories of greater area of damage (table 4) (Department for Communities and Local Government , 2012).

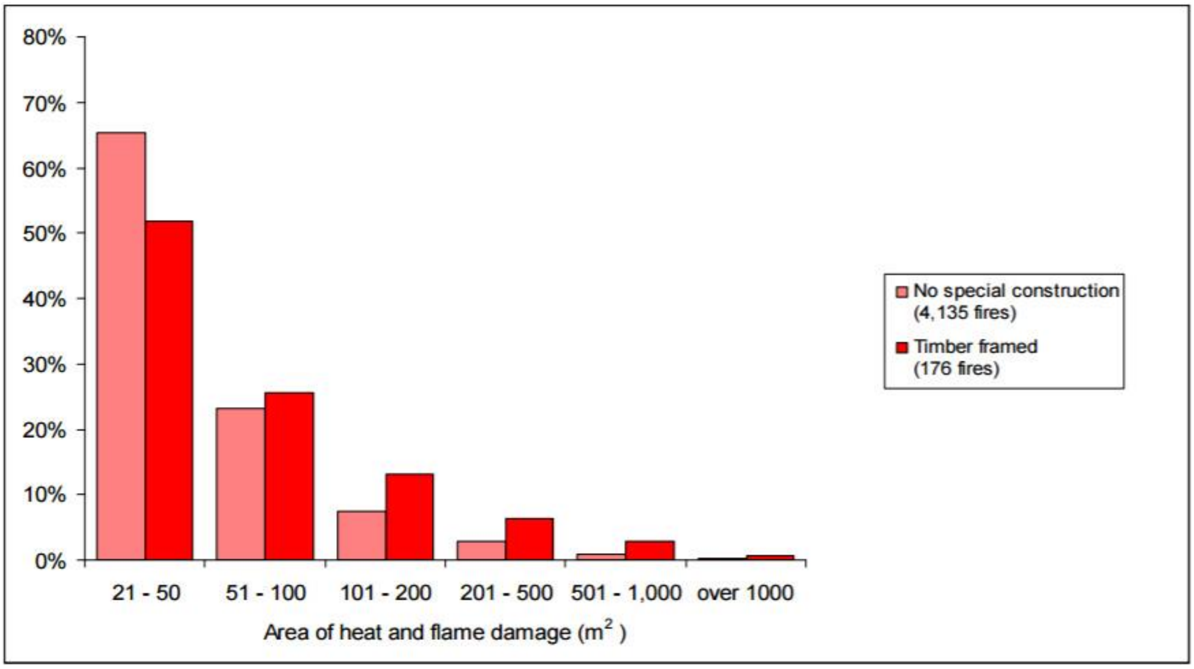

Table 4 Distribution of heat and flame damage over 20m^2 in fires in dwellings, England, April 2009-March 2012

The overall trend for England has been extremely encouraging with fatalities and non-fatal casualties steadily falling for three consecutive decades, up to 2010. Fatalities have fallen every year for the last five years and are 55% lower in 2010 than in 1984/5 according to report presented in March 2010 by Communities and Local Government, the department responsible for building regulations and planning, entitled "Fire Statistics Monitor". Non-fatal casualties, too, are falling. In 2009/10, this was 8% lower than 2008/09 and is the lowest figures since records in this format began in 1994. Completed timber frame dwellings are no more likely to cause fatal or non-fatal injuries as the figure 13 shows below.

	Dwellings				Non Dwellings			
	Timber Frame		'No special construction'		Timber Frame		'No special construction'	
	Quantity	Rate/fire	Quantity	Rate/fire	Quantity	Rate/fire	Quantity	Rate/fire
Fatalities	3	0.008	265	0.008	0	-	6	-
Non-fatal casualties	67	0.19	6200	0.18	16	0.04	488	0.05

Table 5 Fatalities and non-fatal injures: finished timber frame versus other forms of construction (CMLG report)

The rates of fatal and non-fatal casualties per fire are very similar for timber frame and other forms of construction (categorised as 'no special construction'). One would expect the casualty and non-casualty rates to be approximately 3% given the proportion of dwellings made using timber frame. In fact it is closer to 1% according to the report statistics. The report comments that it is likely that some timber frame dwellings are wrongly assumed to be other forms of construction because they use brick outer rain screen cladding. We acknowledge this would narrow the margin by which timber frame scores better than other forms of construction, but the margin is very great from the figures taken from the report (Scott, 2010).

	Calculation	Percentage
Timber frame dwellings as a percentage of English dwelling stock	500,000 / 17m*	Approx 3%
Timber frame dwelling English casualties as a percentage of all forms of construction casualties	3/268	1.1%
Timber frame dwelling English non-fatal casualties as a percentage of all forms of construction English casualties	67/6,167	1.1%
Timber frame English fires as a percentage of all English fires (dwellings and non-dwellings)	802/61,000	1.3%
*These are rough estimates but sufficiently accurate to arrive at a figure of approximately 3%.		

Table 6 Casualty and non-casualty rates of dwellings made using timber-frame (DCLG Report)

As long as buildings comply with building regulations, which many forms of timber frame have adequately proven, their construction type will have little impact on the level of injuries or casualties in habited premises. So private homeowners and social housing tenants and landlords need have no concerns whatsoever on this front.

2.2.3 Steps Taken by Industry

To constructively overcome the above mentioned scenario United Kingdom Timber Frame Association (UKTFA) and Wood for Good consulted Health and Safety Executive, the London Fire Brigade, fire engineers and others industry excerpts to understand the real causes of those fires to come up effective solutions and restore the confidence of stakeholders. In July 2008, they launched 16 Steps to Fire Safety, a booklet providing practical advice on how to protect timber frame site sand reduce the risk of fire. It provides the backbone for key decision-making processes for setting up and running a timber frame site of any size because of its comprehensiveness and has been regularly used by HSE as part of their site inspections (UKTFA, 2008).

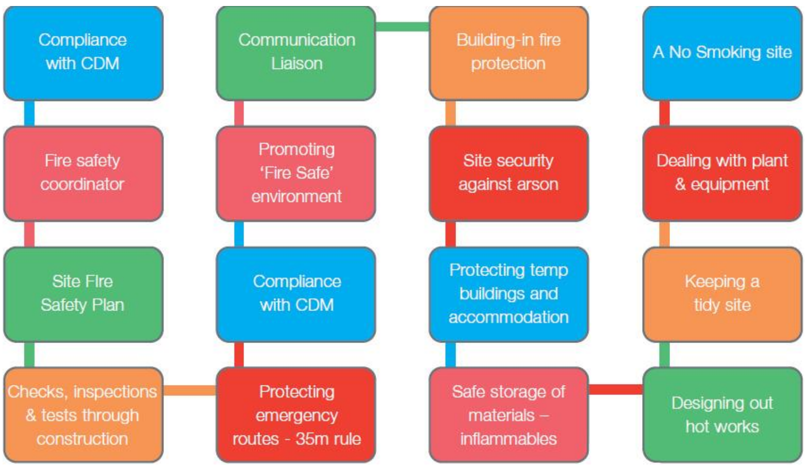

Figure 12 16 Steps to Improve Fire Safety during Construction Source: (UKTFA, 2008)

2.2.4 Conclusions

Timber frame construction brings with itself significant benefits so just ignoring it because of a relatively minor fire risk is an unwise attitude. Provided that it has been designed and built by people who understand the technology, the risks from fire in a typical timber frame house do not seem to be any different from those that are faced by the occupants of a brick and block equivalent. The statistics mentioned in the report strong support the case for timber frame as they reveal based on facts and figures timber frame is significantly less prone to experiencing fires than other forms of construction and comparatively more safe and cause less damage in case of fire mainly due to its inherited material properties of charring and predictable rate of burning (TRADA, 2013).

The fire safety community must work together to collectively ensure that the relevant fire safety challenges for timber buildings are knowingly and appropriately addressed during design, application, and use; so as to avoid the problems of the past and ensure that timber can be safely used to support the global push for sustainable urbanism and increased urban density (Bisby, L. A. & Frangi, A. 2015).

3 References

Archi Ninja (2013), *The Third Teacher: Learning Through The Environment*
[Online] Available at: http://www.archi-ninja.com/the-third-teacher/ [Accessed 20 april 2017]

Baker, Fiona S. (2015). *Reflections on the Reggio Emilia Approach as Inspiration for Early Childhood*

Barker K (2004) *Review of Housing Supply: Delivering Stability: Securing our Future Housing Needs*, Norwich: HMSO

BBC, (2016). *UK faces critical shortage of homes to rent, says Rics*. 4 October.

BBC, (2015). *Why can't the UK build 240.000 houses a year?.* 13 January.

Bisby, L., & Frangi, A. (2015). *Special Issue on Timber in Fire. Fire Technology*,51(6), 1275-1277.

Bradshaw, P. et al., (2012). *Growing Up in Scotland Early Experiences of Primary School,TECHNICAL APPENDIX,* s.l.: Scottish Government.

Brandner, Flatscher, Ringhofer, Schickhofer, & Thiel. (2016). *Cross laminated timber (CLT): Overview and development. European Journal of Wood and Wood Products*, 74(3), 331-351.

Buchanan A, Östman B, Frangi A (2014) *Fire resistance of timber structures: a report for the National Institute of Standards and Technology*.

Darby, H., J., Elmualim A., A. & Kelly, F. (2012), *A case study to investigate the life cycle carbon emissions and carbon storage capacity of a cross laminated timber, multi-storey residential building.*

Department for Communities and Local Government , (2012). *Analysis of fires in buildings of timber framed construction, England, 2009-10 to 2011-12,* London

Sandberg, M., Johnson, H., and Larrson, T. (2008) *Knowledge based engineering in construction: the prefabrication timber housing case*. IT Com

Scott, R., (2010). Timber frame and fire. *In Touch with Timber Magazine,* Issue 3.

Dudek, M. & Dorothea, B., (2007). *A Design Manual, Schools and Kindergartens.* Basel: Birkhäuser.

Dudek, M. (2000). *Kindergarten architecture: Space for the imagination (2nd ed.)*. London: Spon Press.

Hairstans, R. (2010). *Off-site and modern methods of timber construction : A sustainable approach*. High Wycombe: TRADA Technology.

Henson, Kristen (2014). *Mind The Gap: Tackling The Construction Skill Shortage*. [Online] Available at: https://www.linkedin.com/pulse/20140725081608-7330932-mind-the-gap-tackling-the-construction-skills-shortage [Accessed 20 april 2017]

Institution of Mechanical Engineers, (2015). *UK House Building Manufacturing Affordable Quality Homes* [Online] Available at:

http://www.imeche.org/docs/default-source/position-statements/uk-house-building-manufacturing-affordable-quality-homes-policy-statemen.pdf?sfvrsn=0 [Accessed 20 april 2017]

Jones, P. (1996). *Kindergarten chats*. Architectural Review, 200(1195), 48.

Jones, P. B., 2014. Learning Process: Justus-von-Liebig School, Moers, Germany, by Peter Hubner. *Architectural Review,* Volume 236(1412), pp. 70-83.

Jones, P. B., Petrescu, D. & Till, J., 2005. *Architecture and Participation.* Londra: Spon Press.

Matt Griffith and Pete Jefferys (2013), *Solutions for the housing shortage How to build the 250,000 homes we need each year*

Scott, R., 2010. Timber frame and fire. *In Touch with Timber Magazine,* Issue 3.

Scottish Government, 2007. *Guidance for local authorities on internal environmental conditions in schools,* Edinburgh: Scottish Executive.

Scottish Government, 2007. *School Design: Optimising the Internal Environment - Building our Future: Scotland's School Estate,Section 3 Concept Design*

Teacher Education in Abu Dhabi, UAE. *Early Child Development and Care*, 185(6), 982-995. [Online] Available at: https://www.scribd.com/doc/37120894/087-Kindergarten-Archictecture-Space-for-the-Imagination-by-Mark-Dudek [Accessed 20 april 2017]

The Economist, 2016. *The housing market.Can we fix it?* 16 June.

Taylor, L., 2015. *Seven Resons to Consider SIPs,* Exova BM TRADA.

TRADA, 2016. *A Short Introduction to Cross Laminated Timber*

TRADA, 2016. *Introduction to Timber Frame Construction*

TRADA, 2013. *Timber Research and Development Association.* [Online] Available at: www.trada.co.uk/academic [Accessed 20 April 2017].

Weight, D. H. (2011), *Embodied through-life carbon dioxide equivalent assessment for timber products*, Proc. ICE Energy 164, Issue EN4, pp. 167–182