

Faster, Smarter, More Efficient: Building Skills for Offsite Construction

April 2017





Study prepared by Pye Tait Consulting from a commission by CITB.

The views expressed by research participants are their own and do not necessarily represent those of their employers.

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Executive summary

Overview of the research

Offsite construction is the manufacture and pre-assembly of construction elements or components in a factory environment prior to installation onsite at their intended, final location. Offsite construction currently accounts for less than 10% of total construction output, but is on an upward trajectory. Strong drivers for growth are underpinned by the need for significantly more housing, the availability of new technologies and an impetus for extending the benefits of offsite construction as outlined in the Farmer review¹.

It is vital therefore, that CITB is able to have a clear understanding of the extent of current and future demand for offsite construction skills and training, and of the actions that need to be taken to respond appropriately and in a timely fashion, to industry needs. The main aim of this work is therefore to provide a robust evidence base of the likely nature of industry demand for skills, training and qualifications in offsite construction and onsite assembly over the next five years. The findings of this research need to be considered in the context of a changing external landscape for funding², the review of CITB³, and the increasing importance of offsite construction for the industry generally.

Key findings

Offsite construction can increase productivity, reduce timescales and lower build costs compared with traditional construction. The greatest potential for growth in offsite is in the housing and commercial sectors. However, there are also opportunities to upscale adoption in large-scale infrastructure projects, notably HS2 and Hinkley Point.

In order to capitalise on these opportunities, the UK needs to have sufficient capability and capacity within its construction sector workforce. This research has identified six key functions⁴ for offsite construction:

- Digital design;
- Estimating/commercial;
- Offsite manufacturing;
- Logistics;
- Site management and integration; and
- Onsite placement and assembly.

¹ Farmer, M. (2016) *The Farmer review of the UK construction labour model: modernise or die*

² Discussed in more detail in section 9

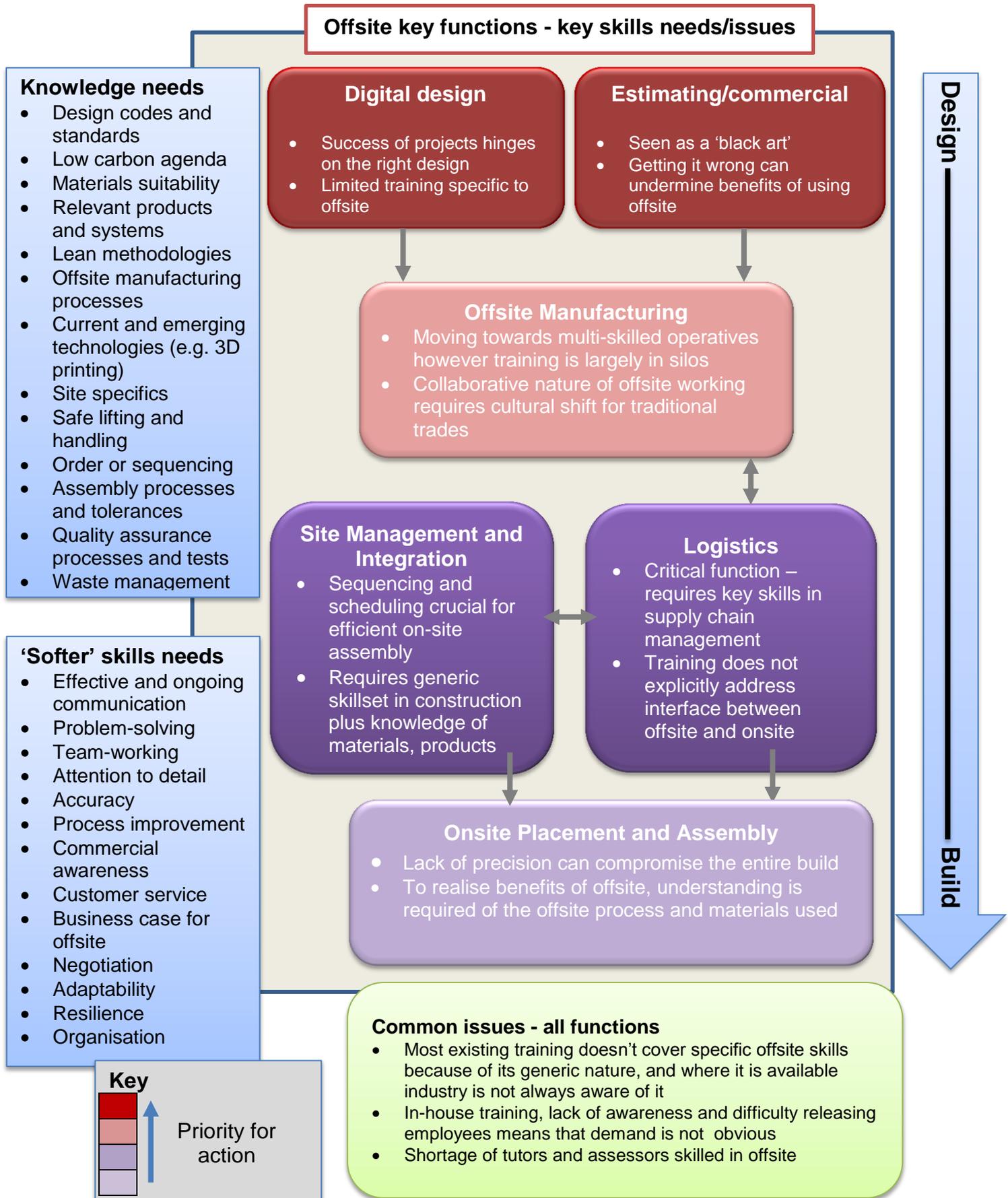
³ The Government announced in October 2016 that Paul Morrell has been appointed to undertake a review of CITB as part of a wider assessment of the future for the UK's industry training boards

⁴ Functions, rather than job roles, were selected so that identified skills needs are relevant to the various roles that carry out the function/activity.



Figure 1 below summarises the key skills needs for each function, with knowledge and ‘softer’ skills needs common to all functions, as well as issues that need to be addressed to enable upskilling of the offsite sector workforce.

Figure 1: Offsite functions: common skills & knowledge needs and issues





This research finds a number of issues with training and qualifications, acting as barriers to delivering the skills needed, notably:

- Limited training and qualifications that are specific to *offsite* construction, rather than traditional construction;
- Training that is available does not typically include coverage of relevant ‘softer skills’, including behaviours and attitudes for offsite, even though these are very important for the holistic nature of offsite work;
- There is a shortage of skilled tutors and assessors with relevant and sufficient knowledge of offsite to be able to deliver high-quality training;
- Where relevant training and qualifications are available, most employers are not aware of them, or are unable to access them because few providers offer the courses or because they are not able to release employees to attend training; and
- The tutor/assessor shortage is one reason for the limited training provision on offer. However, this is also because of a tendency among employers to assume relevant training does not exist and to train in-house instead. As a result this suggests to training providers there is limited demand.

There is a clear case demonstrating why CITB needs to have an interest in supporting offsite construction despite its overlap with manufacturing (i.e. not part of CITB’s sector footprint). Traditional construction trades are being used in the manufacturing environment, and are also being affected onsite, with a need for more multi-skilled operatives for installation and assembly.

Recommendations

The suggested actions for CITB are summarised below⁵:

- Conduct a review of National Occupational Standards (NOS), where required, to determine whether there is a need to develop new NOS or amend existing ones, for the purpose of developing new qualification units;
- Develop new qualification units (i.e. formal, accredited) and standalone knowledge training (i.e. non-accredited) spanning skills as well as knowledge needs, which embed the appropriate ‘softer skills’, including behaviours and attitudes for offsite;
- Enable either standalone courses or training materials to be accessed by providers. Delivery of training could offer blended learning to make training more accessible on the job;

⁵ Recommendations are discussed in more detail in section 10.2



- Consider the use of CITB funding to help establish⁶ regional specialist training hubs (not necessarily physical facilities) for offsite construction, to improve accessibility to relevant training, share best practice and offer a flexible, blended learning model taking account of different learning styles (including training for trainers). This 'hub and spoke' model should consider how existing manufacturing facilities can be harnessed for this purpose;
- Consider the use of grant funding for:
 - in-company training schemes⁷; possibly those which are aligned to the industry-approved offsite qualifications and units so as to support standardised training;
 - linking new qualifications/units/training to CITB grant to incentivise training provision and uptake;
 - supporting those still employed in industry to deliver face-to-face train the trainer courses. This could generate a 'pool' of appropriately skilled tutors and assessors; and
 - the development of a central hub of resources (e.g. videos, webinars, case studies) that tutors and assessors could access remotely to improve their knowledge and ability to teach offsite principles and techniques.
- Promote the existence of relevant offsite training among the sector, to raise awareness and understanding of the types of training and qualifications on offer, notably the NVQ in modular construction and the multi-skilled assembly technician apprenticeship;
- Consider whether there is a need to develop a competency framework for offsite construction, spanning skills, knowledge, 'softer skills', including behaviours and attitudes;
- Consider whether there is a need for an offsite CSCS card;
- Extend coverage of offsite construction sector careers within CITB marketing materials, events, information and guidance etc.;
- Within the current DfE review, consider whether CITB may be in a position to absorb some or all of Proskills⁸ remit to support the manufacturing sector.

⁶ Potentially working with other partners in the sector such as the Construction Leadership Council specifically in relation to their commitment to support and create Centres of Excellence for skills and knowledge

⁷ CITB are already offering funding for in-company training schemes through a training plan – but the scope may need to be expanded for example to provide more funds; it is also likely that awareness of this option will need to be raised among relevant organisations

⁸ The Sector Skills Body for manufacturing which closed in July 2016



1. Introduction

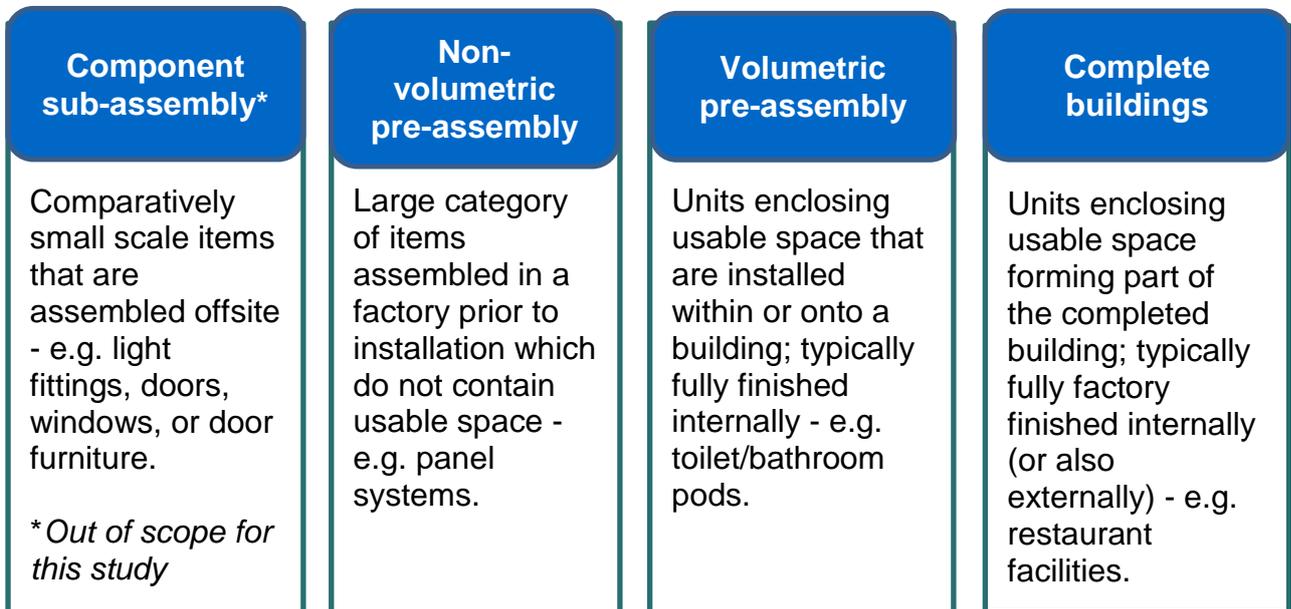
1.1 Offsite construction and the need for this research

Offsite construction is the manufacture and pre-assembly of construction elements or components in a factory environment prior to installation onsite at their intended, final location. Buildings constructed offsite and assembled onsite are designed and erected to comply with all applicable building regulations and are generally indistinguishable from traditional site-built construction.

This report uses the term ‘offsite construction’. It should be noted that offsite construction can also be referred to as: prefabricated (pre-fab) construction, modular construction and offsite manufacture. The Farmer Review, published in October 2016, uses the term ‘*pre-manufacture*’ to describe all processes which reduce the level of on-site labour intensity and delivery risk⁹.

While there is no one single, universal definition of offsite construction, it is generally accepted that there are four core categories as described in Figure 2¹⁰. Component sub-assembly was out of scope for the research as this is an augmentation of traditional techniques rather than a wholly new construction process.

Figure 2: Core categories of offsite construction



⁹ Farmer, M. (2016) *The Farmer review of the UK construction labour model: modernise or die*

¹⁰ Gibb et al (2016) *Build Offsite Glossary of Terms (2nd Edition)*



Offsite construction currently accounts for less than 10% of total construction output, although estimates may change depending on the definition that is used. Previous research suggested the value of the offsite construction sector ranges between £1.4bn to £4bn¹¹, with research conducted by UKCES suggesting the lower end of the scale¹². Some umbrella organisations suggest a higher overall value: for example, an Explore Offsite seminar stated the offsite sector to be worth £3billion¹³.

For the purpose of this study, offsite construction is broadly defined as incorporating any construction-related delivery, which may be a job role – i.e. *site manager* or overarching function such as *site management*. For example manufacture of components, units of complete buildings to be constructed onsite are in scope, because many of the factories undertaking this work use construction tradespeople, such as joiners. Offsite construction therefore overlaps directly with the manufacturing footprint¹⁴, but functions deemed to be purely manufacturing with no crossover into construction, are outside of research scope. That notwithstanding, it should be noted that there may be a need for sector footprint boundaries to be reviewed¹⁵ in light of the growing importance of offsite construction and the evolving landscape for skills bodies¹⁶.

Construction 2025 sets out a vision of the industry's future underpinned by smart construction and digital design, sustainable construction and improved trade performance, and supports opportunities to maximise offsite construction to help boost economic growth as well as improve productivity and more predictable delivery¹⁷. The Construction Leadership Council (CLC) uses the term 'Smart Construction'¹⁸ to summarise all aspects that aim to achieve enhanced productivity in the sector – which include offsite approaches.

The process of manufacturing components offsite can reduce waste, improve efficiency and productivity, and contribute to costs savings overall. Reducing the amount of time spent on-site also minimises contractor risks and means the construction process is less dependent on uncontrollable factors such as the weather. A further driver for offsite construction, and one that may be highly significant is that of government policy. The recent Housing White Paper makes strong references to construction skills and training linked to the need for a more productive industry that embraces innovative construction and delivery models. There is a clear need for social housing to plug the UK's housing deficit and the Homes and Communities Agency (HCA) has set an objective to increase offsite

¹¹ RLF Building Futures (2016) *The Benefits of Offsite Construction*, blog: <http://www.rlf.co.uk/the-benefits-of-offsite-construction/>

¹² HM Government (2014) *Offsite construction companies take a new approach to tackling skills shortages*: <https://www.gov.uk/government/news/offsite-construction-companies-take-a-new-approach-to-tackling-skills-shortages>

¹³ ARV Solutions (2015) *Explore Offsite*: <http://www.arvsolutions.co.uk/news.php?id=39>

¹⁴ Described in more detail in section 2.5

¹⁵ Discussed in more detail in section 2.1

¹⁶ Notably the closure of Proskills, the sector skills body for the process and manufacturing sector, in June 2016

¹⁷ HM Government (2013) *Industrial strategy: government and industry in partnership Construction 2025*

¹⁸ Defined by CLC's Innovation Workstream as: "Building design, construction and operation, that through collaborative partnerships makes full use of digital technologies and industrialised manufacturing techniques to improve productivity, minimise whole life cost, improve sustainability and maximise user benefits"



construction as part of its 2015-2018 affordable homes programme¹⁹. It has more recently also launched its £1.7 billion ‘Accelerated Construction Programme’ to specifically incentivise offsite delivery across England (outside of London). In London itself, the Greater London Authority (GLA) ‘Homes for Londoners’ prospectus details plans for its £3.15 billion affordable housing funding deal from central government, which has also clearly identified the role of new construction skills development, offsite construction and general delivery model innovation in helping to address London’s severe housing under supply.

Technological drivers of change notably the digitalisation of the construction sector, the mandate for Building Information Modelling (BIM)²⁰ and desire to transition towards greater use of robotics and 3D printing, all strongly underpin growth of offsite construction, and are enablers of effective Design for Manufacture and Assembly (DfMA) that underpins effective offsite projects.

Clearly there are no guarantees that these drivers will result in a surge of demand for offsite construction; there has been resistance to offsite in the industry as it can be perceived as ‘risky’²¹. This stems partly from long-held perceptions about poor quality of pre-fabricated construction compared with traditional construction, and partly from a lack of understanding of the benefits among clients and organisations with a role in financing projects. In turn this has created barriers to investment into upscaling of offsite construction.

However there is a strong impetus for change. The Farmer review refers to a “*window of opportunity*” for offsite construction in the UK to “*domestically grow a new sector and retain the gross value add within the UK economy*”. Significant upscaling of offsite construction, underpinned by the likes of meaningful investment into R&D and strategic leadership, is suggested as a logical solution for the residential sector initially, but with scope to move into other sub-sectors²². The Farmer review also proposes a broader remit for CITB funding, to enable investment, through the grant scheme, into innovation and technology. This would help to support a transition towards manufacturing-led construction on a much larger scale.

Thinking more specifically about part of CITB’s core remit to support industry skills and training, offsite construction relies heavily on a collaborative approach to working, bringing together for instance, designers, engineers, architects, manufacturers and on-site managers and operatives. This approach can be in conflict with the traditional construction sector, which operates predominantly in silos²³. Thus skills and training needs, and qualifications, are equally traditionally structured in silos; in practice this means construction sector stakeholders have in the past few years identified a variety of gaps in training and qualification provision,

¹⁹ HM Government (2014) Affordable Homes Programme 2015 to 2018: guidance and allocations: <https://www.gov.uk/government/collections/affordable-homes-programme-2015-to-2018-guidance-and-allocations>

²⁰ BIM is a process that creates and manages all of the information on a project before, during and after construction. This develops a Building Information Model, essentially a digital description of all aspects of the built asset

²¹ Build Offsite (2012) *Buildoffsite Review 2012: the business case for offsite*

²² Farmer, M. (2016) *The Farmer review of the UK construction labour model: modernise or die*

²³ UKCES (2013) *Technology and skills in the construction industry*



some of which falls short of delivering the holistic skills and knowledge needed for offsite construction.

As a result there is a skills shortage among some of the most important offsite occupations, including designers, engineers and project managers. This is partly because of the need for offsite skills and training to have a basis in manufacturing, not just construction and, in many cases, to provide a synthesis of skills and knowledge spanning both sectors.

It is vital therefore that CITB is able to have a clear understanding of the extent of current and future demand for offsite construction skills and training, and of the actions that need to be taken to respond appropriately and in a timely fashion, to industry needs. The findings of this research need to be considered in the context of a changing external landscape for funding²⁴, the review of CITB²⁵, and the increasing importance of offsite construction for the industry generally.

1.2 Aim and objectives of this research

The main aim of this work is to provide a robust evidence base of the likely nature of industry demand for skills, training and qualifications in offsite construction and onsite assembly over the next five years.

This translates into the following core objectives:

- Identify and map precise skills, knowledge, training and qualification requirements for a number of key functions in the offsite construction sector;
- Determine the extent of use of offsite construction across different industry sub-sectors, and how this might expand in the next five years;
- Conduct a detailed gap analysis of current and future training provision for offsite construction; and
- Assess the extent to which current and future supply of offsite training provision matches current and future skills and training needs.

1.3 Research methodology and report structure

The methodology comprised five main elements as shown in Figure 3 below:

Figure 3: Summary of research methodology

²⁴ Discussed in more detail in section 9

²⁵ The Government announced in October 2016 that Paul Morrell has been appointed to undertake a review of CITB as part of a wider assessment of the future for the UK's industry training boards



Desk-based research was used to identify key offsite functions on which to focus the research²⁶ as well as to map relevant training provision and qualifications. Depth interviews were conducted with a sample of employers, manufacturers, training providers, industry stakeholders and clients. A survey of clients was also undertaken, to assess likely future demand for offsite construction.

CITB also provided raw data from its employer attitudes and motivations panel survey²⁷, which included 9 questions about offsite construction specifically to support this study.

Research data were triangulated and fully analysed to develop ‘personas’ in respect of each of the key functions, to summarise the main skills, training and qualification needs, alongside core job roles and career pathways. Personas also highlight any sector-specific requirements, where relevant.

This report first discusses the market for offsite construction and CITB’s role in this, in chapter 2. Chapters 3-8 then consider each of the key functions - these personas are included at the start of each of these chapters. Chapter 9 assesses the supply of and demand for training and qualifications, and conclusions and recommendations for CITB are presented in chapter 10.

²⁶ Please see Appendix 1 for a more detailed explanation of the research methodology

²⁷ CITB (October 2016) *Employer Attitudes and Motivations regarding Learning and Training, Wave 16 Unpublished research prepared for CITB by IFF Research*

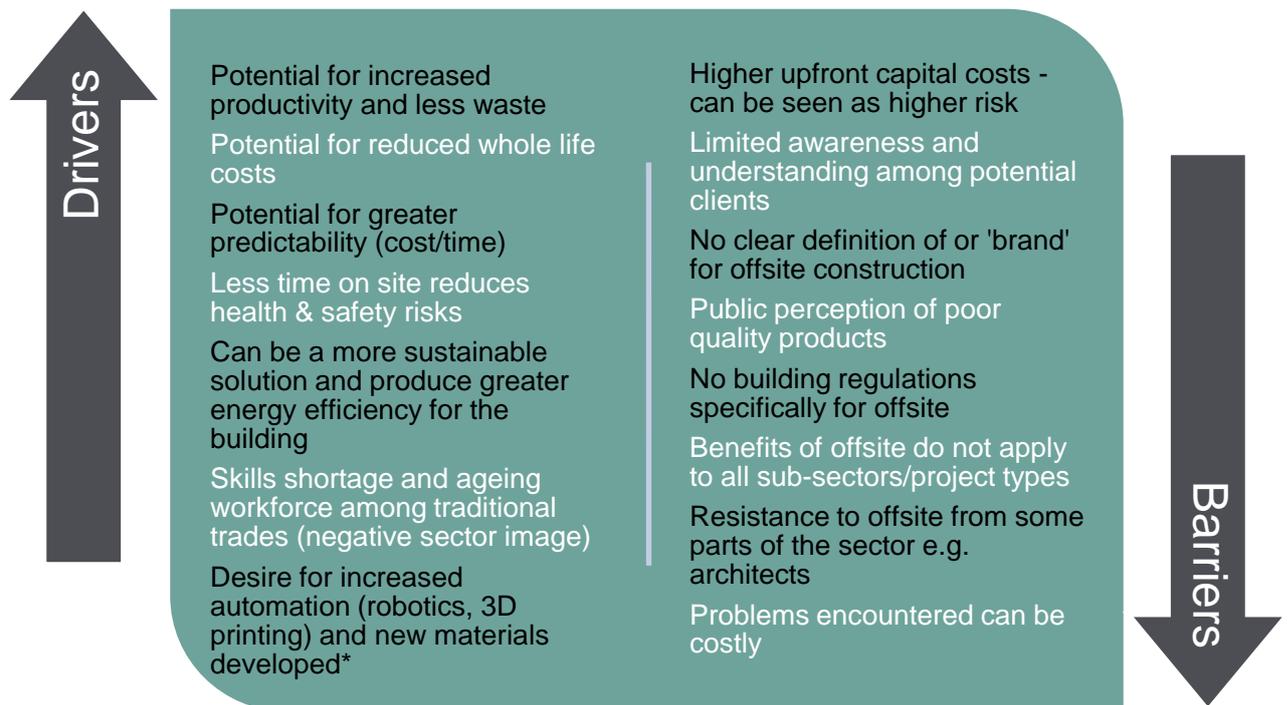


2. The market for offsite construction

2.1 Drivers and barriers of growth

There are a number of generic drivers and barriers for growth in the offsite construction market, summarised in Figure 4:

Figure 4: General drivers and barriers for growth in offsite construction



*transition expected over the longer-term e.g. 10-15 years

Some of the main drivers of growth stem from offsite construction's potential to overcome critical issues currently experienced in the industry. Notably: low productivity, uncertainty of the build programme (costs and time taken), and the generation of waste. It is important to note the use of the term *potential*, as it is only possible to fully capitalise on the benefits that offsite offers if processes, skills and project management are all fit for purpose. When projects do not go to plan, or planning is not fit for purpose, problems can be very costly to fix, and can help to embed negative perceptions about offsite.

The sector has faced a skills shortage, underpinned by an ageing workforce and poor image of the industry, for some time. This makes it challenging to recruit new entrants into the sector, and has prompted many construction businesses to employ a mix of skilled and semi-skilled workers from overseas. Following Brexit, there is some uncertainty as to whether the sector can continue to rely on an injection of labour from other countries. Offsite construction offers the opportunity to use multi-



skilled operatives in factories and onsite, which can be a more efficient and productive way of working. This is likely to require more flexible skillsets. Furthermore, offsite construction has elements which could be more attractive to potential new entrants to the sector by comparison with traditional construction; manufacturing products in a more comfortable factory environment rather than dealing with the unpredictability of being on site in all weathers, with higher health and safety risks. The digitalisation of the construction sector and its direct links to offsite in the form of design for manufacture and assembly (DfMA), use of BIM and emergence of 3D printing, is also considered to be a ‘pull’ for new entrants, particularly young people.

What predominantly restricts the growth of offsite construction is a lack of awareness and understanding. Whilst there are higher upfront capital costs as a general rule for offsite, compared with traditional construction, some clients and some parts of the supply chain do not understand or value the longer-term benefits of reduced whole life costs. This is a particular issue within commercial roles such as estimating²⁸ and among banks and other investors, who can view offsite as higher risk by comparison with traditional construction as a result. Long-held perceptions that “pre-fab” is a lower quality product, also undermines the concept of offsite construction among potential clients.

Limited knowledge (that is accurate) about offsite construction is linked to its lack of ‘brand’; multiple terms are used to describe it, and there is no clear definition as to what actually constitutes an ‘offsite construction project’. This makes it harder for offsite companies to educate, and sell to, their target market and to the rest of the supply chain. Architects and designers in particular can be wary of offsite as some believe it obstructs creativity of design.

It is fair to say that offsite construction does not lend itself well to all sub-sectors, for example its potential is more likely to be fully harnessed in the housing market – timber frame homes are already well established – and for large-scale projects where there are economies of scale (discussed in more detail in section 2.2). Equally, traditional construction regulations and planning processes do not always align with offsite projects – for example obtaining planning consent can be a major obstruction by adding time and cost that cannot always be controlled. This can undermine the business case made to ‘sell’ the offsite solution, given that speed with which the overall project can be delivered is a particularly desirable factor for clients. The sustainability agenda, however, and particularly the Gold Standard of Sustainability in Scotland²⁹, may be a force for change in the future.

“As part of the regulatory process to achieve gold standard [of sustainability] you have to be able to say how much of the housing can be disassembled and how much can be recycled. Working towards these regulations I feel will be a driver for change”

²⁸ Discussed in more detail in section 4

²⁹ Scottish Government (no date) Building Standards information on ‘Sustainability’

<http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/techbooks/Sustainability>



Offsite company (house-builder), Scotland

Moving further into the future, although this could be c.10-15 years away, there may be more widespread adoption of greater automation to implement robotics into offsite manufacture and the machinery used. New materials that could drive growth of offsite, such as glass reinforced concrete, bespoke mouldings, 3D print glass moulds, and 'smart walls' (internal modular walls, developed and painted offsite with sockets, electrics etc. all fitted), may also become more widely adopted.

2.2 Drivers of growth – offsite construction sub-sectors

Figure 5 shows specific drivers by sub-sectors: housing, commercial, infrastructure and industrial.

Figure 5: Drivers of growth in offsite construction, by sub-sector

 Housing	 Commercial	 Infrastructure	 Industrial
<ul style="list-style-type: none"> • Need for affordable housing/ Government house-building targets • Government investment for house-building (Autumn Statement 2016) • Rise in demand for high rise apartment blocks • Some major house-builders committing to a % of offsite per annum • Multiple public and private sector customers • Large-scale new entrant to the market (e.g. L&G Homes) 	<ul style="list-style-type: none"> • Growth market for steel frame student accommodation blocks and budget hotels • Economies of scale in hospitality, retail, leisure, healthcare & education sectors (e.g. multiple builds, same or similar product such as primary schools – easy to scale up) • Interest from schools, hospitals and care homes because of reduced time on site and less disruption compared to traditional build 	<ul style="list-style-type: none"> • Demand for huge investment to upgrade rail and water infrastructure • Increasing interest in use of precast concrete for highways and motorways 	<ul style="list-style-type: none"> • Major opportunities stemming from HS2 and Hinkley Point • Evidence of existing use (notably Scotland's Queensferry Crossing) that could be used as a case study to 'sell' offsite



Figure 5 illustrates that the key growth areas expected for offsite construction are in the housing and commercial markets.

There is clear evidence of appetite for offsite construction among some of the major house-builders. The market already makes use of timber frame³⁰ to construct houses, notably in Scotland, where this is extremely well established. Offsite can be a realistic alternative solution for house-builders experiencing delivery problems with traditional construction methods. Major players such as Bovis, Crest Nicholson and Barratt Homes are moving towards committing to a certain percentage of their output to be constructed offsite. In cities in the Midlands and the North, and Central London, there is a strong driver to produce high rise apartment blocks (30 storey plus) to compensate for a lack of space. Manufacturers also anticipate demand for single occupancy accommodation blocks, and 'starter' and retirement homes.

The arrival of Legal & General into the offsite housing market (L&G Homes) is underpinned by a multi-million pound investment with an aim to become the largest house building factory in Europe. Their site near Leeds spans nearly 600,000 square feet and holds the largest cross-laminated timber (CLT) press in the world. The aim is to produce ready-to-assemble sections of CLT homes. The factory has the capacity to create 100,000 cubic metres of CLT per annum. The long-term ambition is to produce 3,000 homes a year.

Other housing specialists are setting out ambitious plans for growth and innovative approaches to delivery:

"We are making pods the size of articulated lorries which are fully fitted out – these just need to be fitted together on site. Our aim is to produce a house in 20 hours, and an apartment block in 2 weeks. We can build low, high rise, terraced, detached. Our ambition is to produce 10,000 homes a year"

Offsite house-builder (UK)

There is also a market for offsite retrofit³¹, which extends the housing sector's range of potential customers from private developers, to local authorities, housing associations and registered social landlords. One example of how housing specialists are using offsite approaches to retrofit delivery is *Energiesprong UK* – adopting an approach first introduced in the Netherlands. A range of social housing providers, trade bodies, construction companies and other sector organisations have formed this group with the objective of delivering whole house refurbishments to rows of houses that will guarantee substantial improvements in energy efficiency³² whilst utilising economies of scale.

³⁰ Please see Appendix 3 for an overview of materials and products used in offsite construction

³¹ Although usually this needs to span an entire street as a minimum to achieve economy of scale to make it worthwhile

³² National Energy Foundation (2015) *Energiesprong UK* press release



There is also a growing market for light steel frame for residential offsite construction – this can span apartment blocks, student accommodation, care homes and budget hotels, for example. This is largely because light steel is ideally suited to stacking, and for high volumes of small rooms. Steel is also widely used in the education sector – often a combination of hot rolled and panelised steel. Again, this material works well as these builds need large volumes of small rooms.

There is growing interest in offsite from schools and colleges, as it is a faster build sequence compared with traditional construction, with less disruption for staff and students.

Demand is expected to remain high for offsite student accommodation, across the whole of the UK.

“Student accommodation is a buoyant market. The student accommodation market is unregulated in terms of cost, so universities see it as lucrative. Reliability on site is important to clients – less time on site is less cost, even if the product is slightly more expensive”

Offsite manufacturer, England

For commercial clients, the potential for cost savings is a critical driver. It can take time, however, to gain buy-in at senior level within large client organisations. The larger the project, typically the more economical it is to construct offsite. Many respondents believe there is unmet need in the commercial market, for the likes of shopping centres and airports to be constructed offsite.

Many offsite construction companies believe there are opportunities for growth in the infrastructure and industrial sectors, although compared with housing (which is receiving a strong Government focus) and commercial projects these are less well developed. However the likes of HS2 and Hinkley Point present major opportunities for long-term, lucrative offsite approaches.

2.3 Clients’ current and future demand for offsite construction

To understand the likely level of demand for offsite among clients, a survey of 100 construction sector clients was undertaken. It should be noted that only clients with existing experience of commissioning offsite construction were surveyed (i.e. those able to provide detailed responses to the questions). As such, these findings should be considered in the context of likely future demand from ‘informed’ clients rather than across all clients.

The majority of clients first commissioned offsite projects because they felt the work would be quicker and cheaper. In most cases the main contractors bidding for the work first introduced them to the offsite concept. When asked about their main reasons³³ for continuing to use offsite construction, 36% of client responses suggest it is faster than traditional methods, and 32% of client responses, because it is

³³ Respondents could select multiple options



cheaper. It appears from the survey responses that once introduced to offsite, clients strongly prefer this approach to traditional construction and tend to commit to future offsite work.

“This is the first time this department has used offsite construction and we are impressed with the approach. The project was easy to manage and you would never know this is a modular building. The new air terminal was completed only four months after work started on site. Externally, it is clad in smooth red-faced brickwork, with vertical timber cladding at higher levels. By moving much of the work into a factory environment, we saved around two months on the programme compared to traditional site-based methods, with no compromise whatsoever on the quality of the finished building”

“We urgently required additional classroom space for the coming academic year. The permanent onsite option was far too slow. The contractor came up with the best modular construction solution for the school’s urgent needs”

“Constructing in a factory-controlled environment enhances quality control and reduces risk from adverse weather conditions, which can affect critical path activities. The high quality modular kiosks are the perfect retail building solutions”

“My colleagues and I were very impressed at the speed and build quality achieved on our complex projects within the confines of a working hospital. Modular building ticks all the right boxes as far as we are concerned”

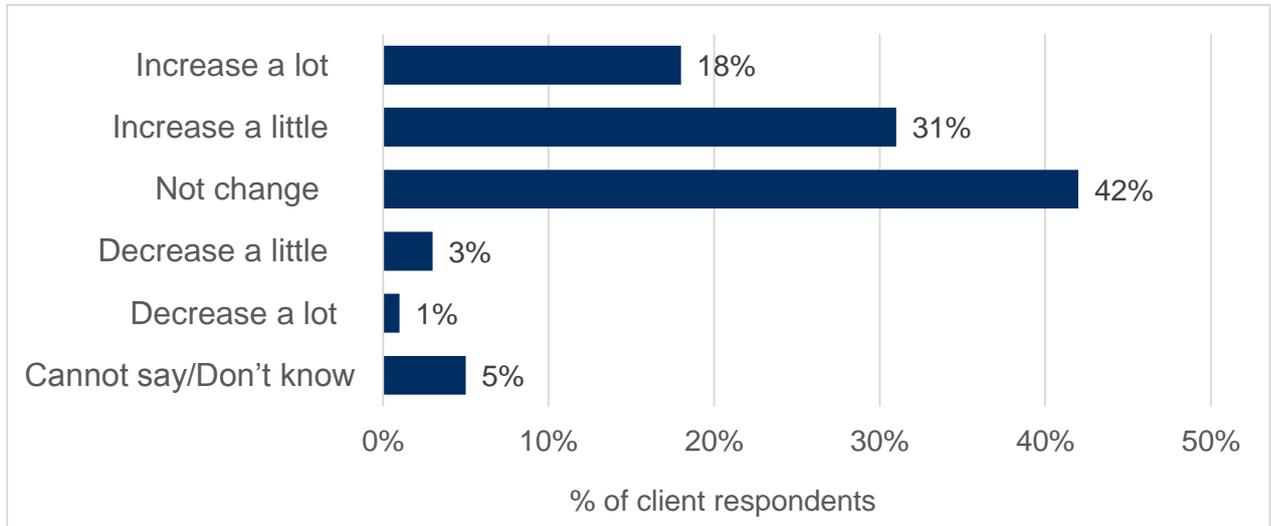
“Every company we contacted suggested offsite as the way to achieving Passivhaus Standards. I’m a private Landlord so speed of construction was important: the sooner the properties are built the sooner the income stream starts”

Feedback from clients surveyed

On average, clients surveyed say 26% of their current work is constructed offsite. Nearly half of those clients expect this proportion to increase over the next five years, with only 4% of respondents that anticipate a decrease in the use of offsite construction (Figure 6). Of the small number that expect their use of offsite to decrease, this is because they think it is more expensive compared with traditional builds.



Figure 6: Over the next 5 years, do you expect the percentage of all your construction work that comprises offsite construction to:



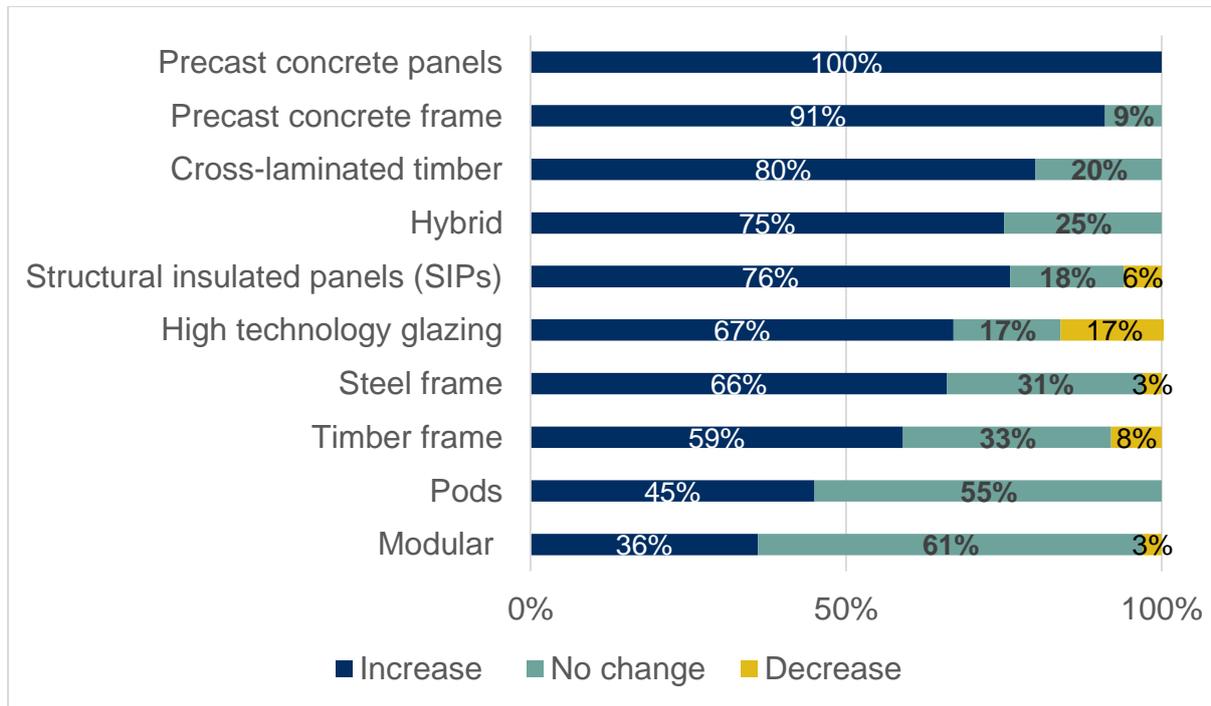
Base 100

In relation to materials and products, there is a desire for a more developed product in housing, using the likes of enclosed panels and pods. Manufacturers expect to produce more closed panels systems and hybrid (integration of panels and pods) as a result. The level of demand for different products varies by region and nation. For example, offsite housing is currently more prevalent in Scotland, and in the South of England. There is also a stronger market for panels in drier climates, and for pods in wetter climates. This is mainly because pods, or ready-made rooms, can be very quickly fitted together onsite or slotted into existing structures without being significantly affected by wet weather. Panels need to be assembled on site and many come with wiring and plumbing already fitted, to speed up the construction process. In a drier climate these panels can be exposed to the elements onsite without slowing down the assembly process due to wet weather.

Clients predict a significant increase in the use of concrete and cross-laminated timber over the next five years. This may be because timber and steel frame are already reasonably well established but concrete, particularly used in precast panels and frames, is predicted to increase strongly (Figure 7).



Figure 7: Of the types of offsite construction materials and products used on your work, do you expect the level of use over the next 5 years to:



Base 100

2.4 Industry expectations for the offsite construction market

“Everyone is busy. There are full order books - there is a lot of scope in the [offsite] market”

Offsite manufacturer, UK

A survey of 1,248 employers conducted for CITB in early 2016 showed that around 16% are currently using offsite approaches. Those employers undertaking offsite construction report current and expected future use of a range of offsite methods and materials. For each method generally 2 to 3 percentage points more expected to use it in 3-5 years’ time³⁴.

This survey also found the use of offsite construction to be more common amongst larger firms with 100+ employees (32% of respondents), and those operating in specialist construction (23%) and general construction (21%). Usage of offsite is expected to increase slightly among those surveyed, from 16% currently to 18% expecting to in 3-5 years’ time. Larger companies expect a higher rate of use of offsite compared with the average – 42% of respondents with greater than 100 employees across the UK expect their business to use off-site construction methods in three to five years’ time, compared to only 17% of those employing 2 to 9 people.

³⁴ Source: raw survey data, *Employer Attitudes and Motivations regarding Learning and Training, Wave 16* Unpublished research prepared for CITB by IFF Research (October 2016)



This may have an impact on the supply chain (i.e. small and medium-sized companies would require skills and knowledge relating to offsite) given the high use of sub-contracting in the sector. This relatively modest predicted increase should be considered in the context of the barriers to growth and strong drivers of growth in the housing market in particular (Figures 4 and 5), as well as the clear commitment to upscaling of offsite as set out in the Farmer review and growing client demand³⁵.

2.5 CITB and offsite construction

The Industrial Training Act 1964 enabled most private sector industries at that time, to operate a levy-grant system via Industry Training Boards (ITBs). CITB is the ITB for the construction sector, and is a statutory Non-Departmental Public Body (NDPB)³⁶ accountable to Parliament. CITB does not receive grant-in-aid direct funding from the Government, but raises most of its funds via the levy and commercial activities. Secondary legislation (scope orders) defines the boundaries of CITB's coverage, distinguishing this from that covered by other ITBs such as ECITB, the engineering and construction industry training board³⁷. For example one company cannot be under the scope of multiple ITBs although different subsidiaries of the same parent company can, as appropriate. CITB also holds the licence to operate as the Sector Skills Council (SSC) for construction³⁸, and as such has a remit to work with industry to encourage training, set standards and ensure the sector has an appropriately skilled and qualified workforce.

Offsite construction relies heavily on a collaborative approach to working, bringing together for instance, designers, engineers, architects, manufacturers and on-site managers and operatives. This approach can be in conflict with the traditional construction sector, which operates predominantly in silos defined by traditional trade demarcations and professional boundaries which are replicated in the supporting infrastructure of trade associations, professional bodies and qualification grouping³⁹.

By extension, the education system for the sector is also traditionally siloed in nature⁴⁰. The Farmer review acknowledges that training initiatives spearheaded by industry leaders are typically separate, representing trade-specific interests rather than a joined-up strategy⁴¹.

As a consequence, construction sector stakeholders have in recent years identified a variety of gaps in training and qualifications, as existing provision falls short of delivering holistic skills and knowledge needed for offsite construction. For instance,

³⁵ Although it should be noted that evidence of increasing client demand is based in this report upon a sample of clients already using offsite construction i.e. 'informed' clients

³⁶ An NDPB is a body which has a role in the process of national government but is not a government department, or part of one and therefore operates to a greater or lesser extent at arm's length from ministers

³⁷ Department for Business, Innovation & Skills (BIS) (2015) *Combined triennial review of the industry training boards (construction, engineering construction and film)*

³⁸ A remit originally undertaken in conjunction with the Construction Industry Council (CIC) and CITB Northern Ireland

³⁹ UKCES (2013) *Technology and skills in the construction industry*

⁴⁰ Morell, P. (2015) *Collaboration for change*

⁴¹ Farmer, M. (2016) *The Farmer review of the UK construction labour model: modernise or die*



offsite skills and training need to have a basis in manufacturing, not just construction, and in many cases, require a synthesis of skills and knowledge spanning both sectors.

The result is a skills gap among some of the most important offsite occupations, including designers, engineers and project managers. Historically, CITB's core footprint (as defined in scope orders) comprises onsite construction only, and does not directly cover building services engineering, facilities management or manufacturing. However, offsite construction clearly overlaps with manufacturing, and to some extent, with engineering. For example, in a manufacturing environment (typically a factory), production is of items that will be used to construct buildings or structures – for example panels manufactured from raw materials such as timber, or entire bathroom or kitchen pods. However, many factories involve 'traditional' construction job roles in this manufacturing process, including steel fixers and joiners.

Furthermore, once the components/modules etc. are transported to site for installation, there is typically a need to interface with 'traditional' construction roles such as site supervisors, logistics managers and site operatives. Skills, training and qualification needs must be considered in light of the impact on 'traditional' roles, as well as new roles that are emerging, underpinned in some cases by technological developments. For example, as the adoption of pre-manufactured frames reduces the use of brick structures; a bricklayer may need to develop new competencies in onsite cladding.

A new emerging role in some large offsite companies is that of a project co-ordinator – with a remit to manage the crucial interface between offsite manufacture and onsite assembly, reporting into the overall project manager.

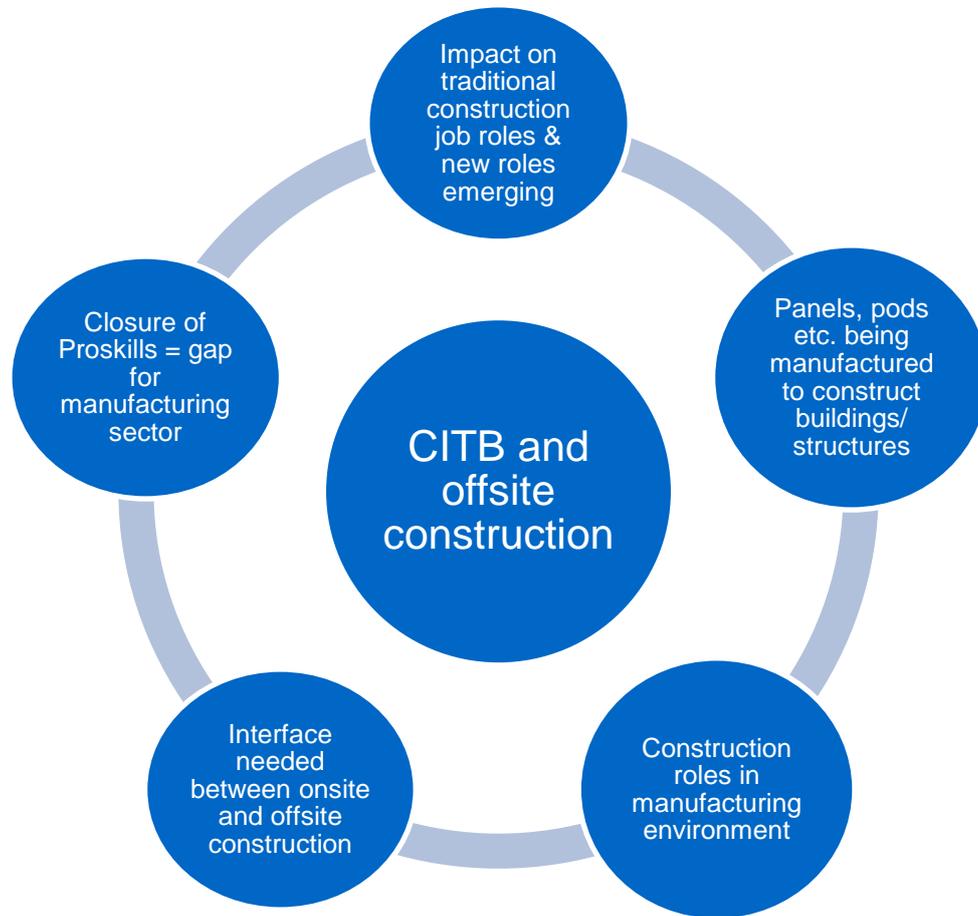
CITB needs to understand the specific skills, training and qualification needs for offsite, not just now, but also for the future as these needs evolve - in order to support the industry and ensure the most appropriate use of levy funds for this purpose.

There are also a small number of examples of large, well-established construction companies that are creating purely manufacturing roles specifically for offsite construction – for example factory operatives to produce the likes of panels and pods. A crucial consideration should be the closure of Proskills, the sector skills body for the process and manufacturing industries, in mid-2016. This leaves a gap for the manufacturing sector in terms of supporting up-skilling, training and qualifications.

It is important to recognise these aspects in demonstrating that offsite construction should form part of CITB's remit (as illustrated in Figure 8 below). Without a coordinated response to the training requirements that span the manufacturing and constructing environments the potential scale and benefits of offsite approaches will never be fully realised. In the longer term, increasing automation may give rise to broader convergence of technology and skills across manufacturing industries which will also need to be considered.



Figure 8: CITB and offsite construction



2.6 Key functions within offsite construction

2.6.1 Job roles or functions?

The original brief for this research was to assess the skills, training, qualification needs and career pathways for a limited number of job roles in offsite construction – the intention being to identify the ‘key’ roles. In practice, it became quickly apparent that this approach would be too restrictive - largely because offsite, unlike much of traditional construction, is not siloed - but adopts a more holistic, collaborative approach to working.

Furthermore the definition of job roles and the functions they contain can vary significantly across the industry, depending on the size and remit of organisations. For example a senior manager in an SME may have responsibility for estimating, tendering, aspects of project management etc., whereas larger companies are more



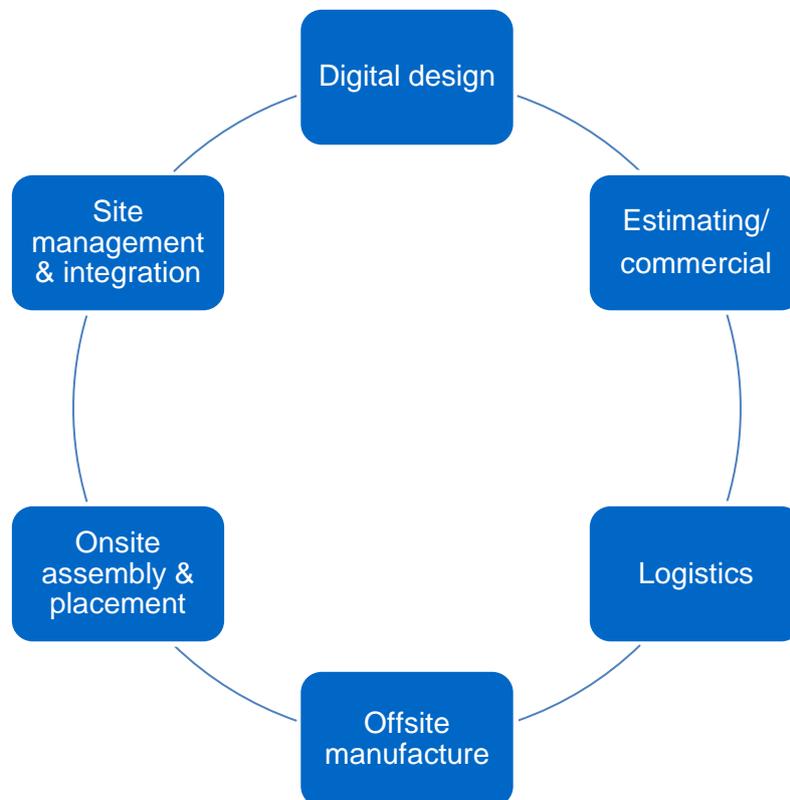
likely to have dedicated estimators, project managers etc. undertaking only those functions.

On this basis it was decided to focus on the overarching functions rather than job roles, as this would result in a more meaningful and more useful output.

2.6.2 The key offsite functions

Desk-based research identified six key functions deemed to be in scope for this research. These functions were reviewed and tested with a sample of industry stakeholders, and subsequently refined, as described in Figure 9.

Figure 9: Key offsite functions for the purpose of this research



Although each of these functions is discussed separately in the following chapters 3-8, this should not be interpreted to mean that they operate as separate functions. They are represented above in circular fashion deliberately, to illustrate the holistic and collaborative nature of offsite – these functions need to be underpinned by regular communication and collaboration to bring them all together rather than working in isolation.



2.6.3 The key offsite functions and the use of personas to represent them

Chapters 3-8 begin with a summary persona, showing the technical skills, knowledge and softer skills/behaviours required of the function. Each persona lists all the skills and knowledge needs identified which are applicable to that particular persona. They also show training and qualifications available and the gaps in relation to these, as well as preferred methods of training delivery identified via the research.

When using the personas please note:

- job roles deemed to be core for the offsite function are shown in ***bold italics*** with traditional job roles that may be impacted, in normal font. Levels of job role are indicated by four overarching headers: skilled worker, supervisor, manager and senior manager-professional. In this context 'supervisor' is also an indication of level rather than needing to be in a supervisory role as such;
- available training and qualifications are given a rating, and these have been based on the evidence gathered for this study⁴². Ratings are indicated using colours: red denotes there appears to be very little or no content directly aimed at offsite construction, amber denotes that there appears to be some content directly aimed at for offsite construction, and green denotes that there is a good amount of content directly aimed at offsite construction;
- preferred methods of training delivery are also given a rating, depending on the strength of the preference. Red denotes that very few or no employers expressed a preference, amber denotes that some employers expressed a preference, and green denotes that most or all employers expressed a preference.

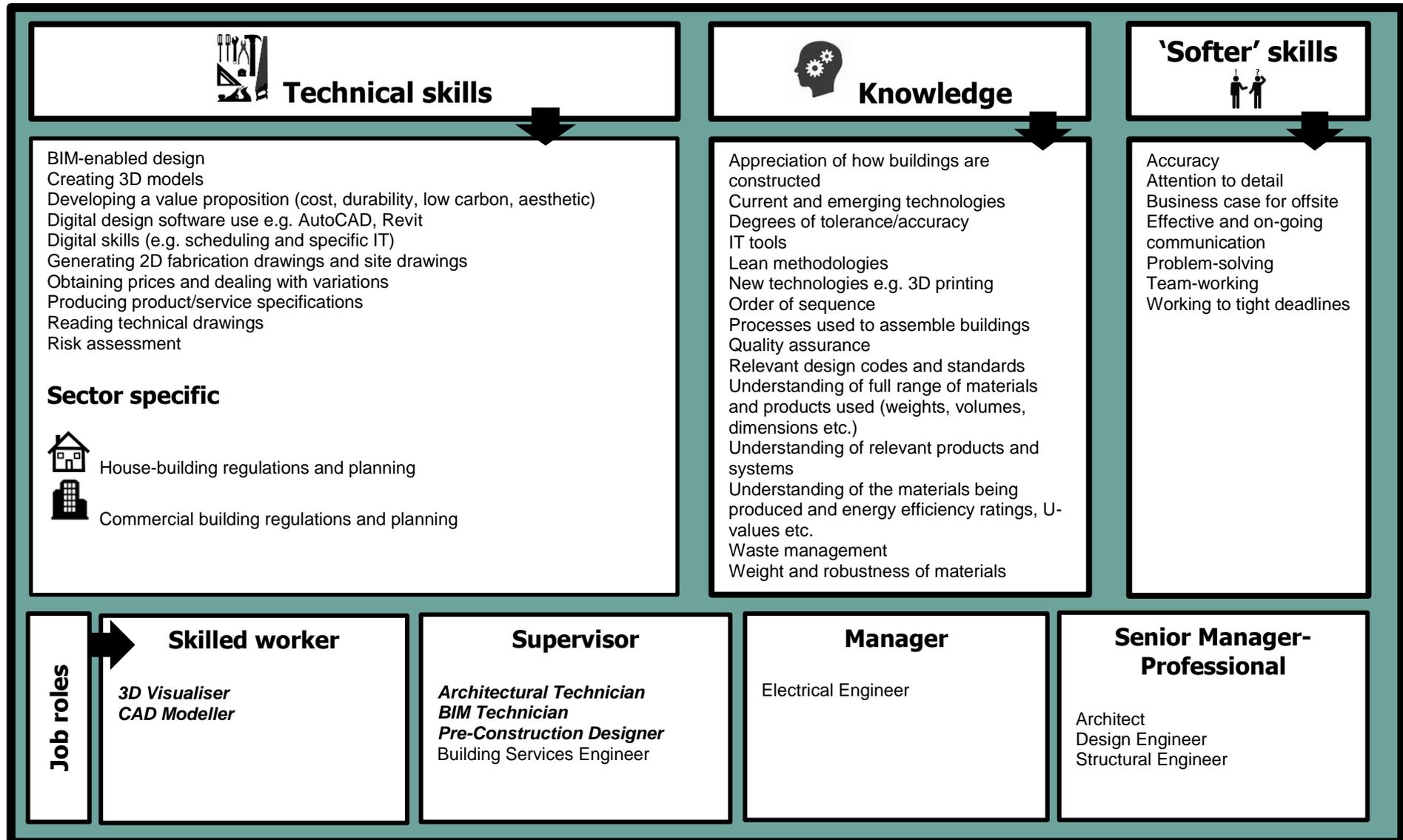
⁴² Drawn from the desk-based research and primary evidence gathered directly from a sample of employers and training providers. It should be taken into consideration that training providers may change their offer and as such the suite of available training and qualifications is also liable to change. It should also be noted that assessment of training and qualifications was largely based on a review of content published on training provider websites/in course manuals etc., and that if offsite content was not obvious from this clearly it will not have been taken into account.

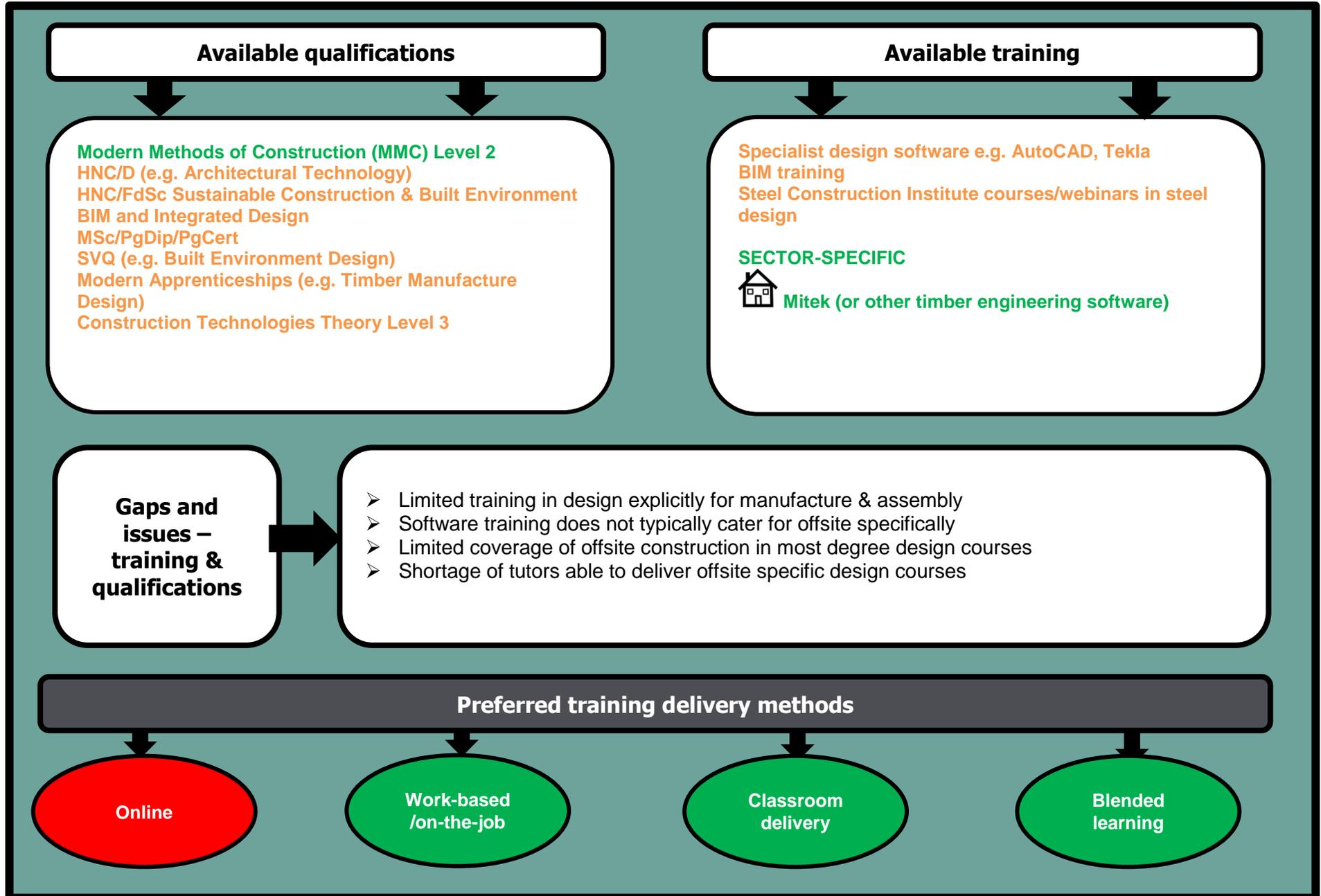


3. Digital design

3.1 Digital design persona

The critical difference between design for traditional construction and design for offsite, is that the latter needs to design specifically for manufacture and subsequent assembly, using appropriate technology and digital skills.







3.2 Overview of the digital design function

The design function in offsite construction has been described by respondents as “*an art in its own right*”. Frequently described as ‘design for manufacture and assembly’ (DfMA), design for offsite requires understanding of new materials and specification, designing for mass-customised production, consideration of assembly requirements and varying production costs.

Digital design is a crucial part of design for offsite. The use of BIM to enable 3D/4D modelling and ‘testing’ makes it easier to predict a range of aspects in relation to the way the structure will perform and function at design stage. This can be particularly important to avoid the risk of needing modifications once the manufacturing process begins – as this would severely undermine the offsite concept by adding in time and cost. Getting the design right at the outset is vital.

3.3 Skills and knowledge needs – digital design

Those employed in the design function need an understanding of onsite construction, manufacturing and assembly processes, and a practical understanding of how a range of products will be installed is also required.

“the best investment is at the design phase – this is where the value is”

Offsite company (commercial sector), Wales

To some extent, the critical success factor for digital design for offsite is the process that is followed from the outset – to be fully fit for purpose, the design function must be integrated into early stage planning with the contractor and client. This is a major ‘break from the norm’ culturally speaking, and it can be challenging to change behaviours and mindsets to adopt this more collaborative approach to the design phase.

“it’s about changing deep-rooted mindsets. For example our architects [for offsite projects] will work through the digital designs 18 months before starting any work. It’s about re-engineering thoughts and attitudes”

House-builder, UK (undertakes offsite and traditional construction)

At an early stage, costs, quality and logistics must all be considered. The design function needs to consider the types of materials to be used to ensure structural robustness in line with building regulations. It must also consider how readily materials can be transported to site having been pre-constructed offsite. As an example, design processes can vary greatly depending on the type of materials used - light gauge thin steel does not shrink during the construction process (unlike timber, which can create problems for installing lifts), but conducts heat, so insulation needs to be taken into account. Hot-rolled steel sections may need to be included as part of



the depth of light steel floors and walls, to allow for heavy point loads. It is, therefore, critical for the digital design function to understand the range of materials that can be used in offsite construction and their different applications depending on the project(s).

Data acquisition and use of data to create drawings and convert to 3D models needs to be underpinned by expert knowledge of one or more specialist design packages (see section 3.4). As an example, when using packages such as AutoCAD, the designer is able to work out how many timbers, struts etc. are required and use these data (with other supporting evidence as required) to calculate manufacturing time and costs. Again, there is a need for collaboration with other offsite functions – estimating and logistics should typically receive this kind of detail to incorporate into their own processes and planning.

Designers need to be competent in their chosen design package and have good attention to detail in order to optimise their value in terms of accuracy and planning.

“If we can draw it right it can be built right”

Architect, offsite construction, Scotland

To continue to support the rest of the project and other functions, the design function provides product and service specifications to support procurement and site installations. Quality control checks of the design process and outputs also must be factored in. Process improvement (for example by adopting lean manufacturing⁴³ and construction principles), communication, accuracy and attention to detail are important ‘softer’ skills for the design function. Process improvement links closely to customer service and commercial awareness, to enable cost-effective, value-engineered solutions that continue to meet client expectations.

Meeting client expectations should involve co-ordination between the designer, client and contractor as drawings are produced and revised. Respondents consider that this flow of information can be limited in traditional construction, which compromises the speed and efficiency of the project. For offsite construction, coordination and integration between on and offsite is needed to ensure the manufacturer is able to follow the client-approved drawings precisely (or risk running into problems at installation stage). The use of BIM is considered to allow for greater collaboration at the design stage, translating into better outcomes, cost efficiencies, greater building durability and improved profitability⁴⁴.

3.4 Training and qualification needs – digital design

In terms of qualification needs, designers are usually expected to have a degree; some businesses employ designers with an HND.

⁴³ An approach that aims to maximise efficiencies by eliminating waste and delivering quality outcomes on time with the least cost

⁴⁴ NBS (2014) *NBS National BIM Report 2014*



The core technical training requirements relate to the use of BIM (to at least level 2) and other software packages. BIM training needs to consider both data management and how it affects project delivery, as well as information management of the life cycle of the asset (i.e. how the design will be maintained in the future).

Designers must be computer literate, and must understand how to maximise value from modelling data, such as choice of materials, production scheduling, planning and collaboration. Some examples of software packages relevant for this function include:

- AutoCAD
- ArchiCAD
- Consultec
- GangNail
- hsbCAD
- Mitek (timber engineering)
- NAVIS
- PAW
- Revit
- Tekla (3D modelling)
- Vector Works

Although designers may have knowledge of the appropriate software, training does not always explain how to apply this to an offsite construction project. Notably training may not make clear how to maximise the value and fully utilise data for collaborative benefits within the offsite project team – such as for informing scheduling and plan visualisation.

The preference among respondents is for relevant skills and knowledge to be embedded within HE programmes of study, and particularly for BIM to be included within this. Specific training for example on specialist software (as opposed to that in more general use such as AutoCAD) would be expected to be standalone courses or CPD.

Degree programmes do not typically include sufficient coverage of design specifically for manufacture and assembly, with a handful of exceptions (which typically offer integrated training in design and BIM). Designers need to understand how to maximise the value from the software, thinking about aspects such as plan visualisation, creating production schedules and enabling team collaboration. Respondents perceive that one reason for the lack of relevant design coverage may be a shortage of tutors with relevant training and experience; they find not all college or private training providers have access to trainers with the necessary experience of industry. Offsite companies interviewed for this research typically train their designers in-house; they say the training they need does not exist.

3.5 Job roles and career pathways – digital design

Job roles within this function can include engineers as well as architects and technicians. Offsite companies can find it difficult to recruit and retain skilled engineers and designers that have the right skillset to meet their needs.



Career pathways can be varied enabling those in the design function to transition, should they so wish, into roles including sales, estimating and manufacturing. Some designers have the option to move into site-based roles although few seem to go down this route. In short, as with other offsite functions, career pathways can be wide-ranging and varied – the understanding of the design function provides an extremely strong skills and knowledge base with which to move into senior project management roles for example.

3.6 Key issues for consideration – digital design

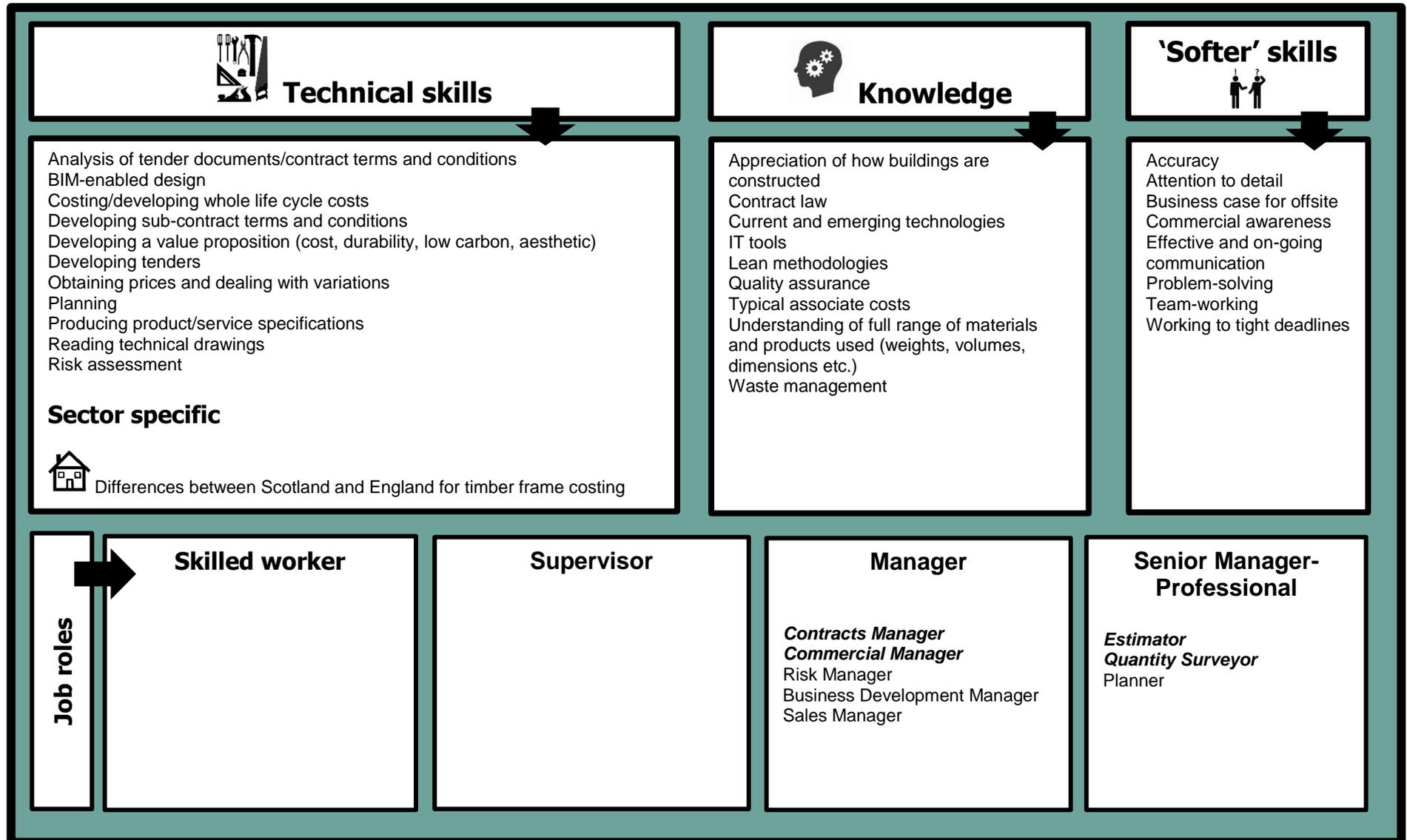
- There is insufficient coverage of design specifically for offsite manufacture and assembly within existing training and qualifications. Where this does exist, it is typically integrated training in design and BIM rather than for offsite per se;
- There is more relevant coverage within Scottish degree courses compared with the rest of the UK, but this can focus strongly on timber frame rather than other materials, given the dominance of timber frame in Scotland;
- Software training typically focuses on how to use the software, not on how to use it specifically for offsite construction; and
- It is difficult to find tutors or trainers with the relevant knowledge of design for offsite manufacture and assembly, to deliver training and qualifications.

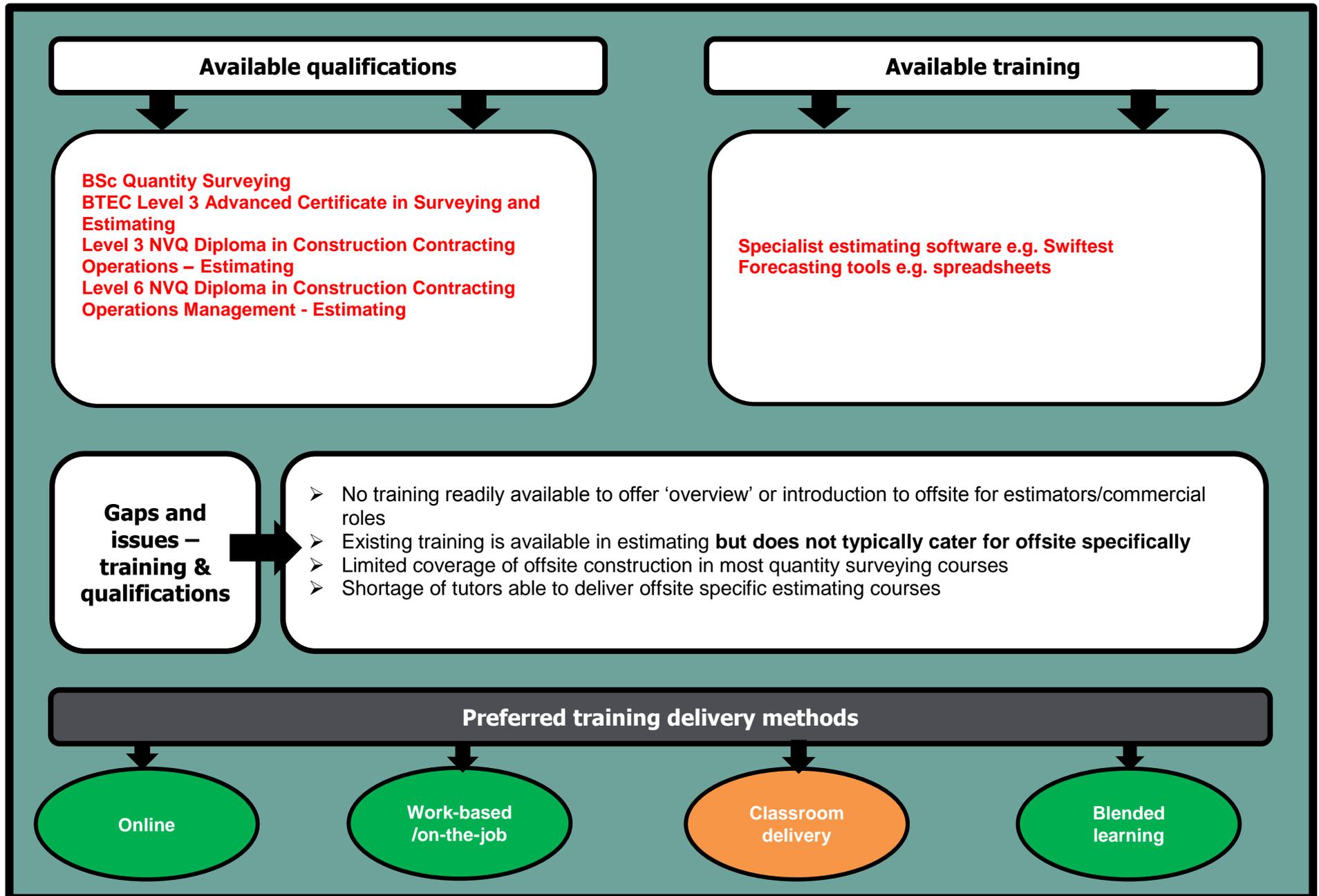


4. Estimating/commercial

4.1 Estimating/commercial persona

Estimating is a crucial element of delivering the fundamental cost savings of offsite (compared with traditional) construction, but is subject to substantial skills shortages.







4.2 Overview of the estimating/commercial function

“Estimating is almost a black art”

Offsite manufacturer, Scotland

Industry stakeholders strongly emphasised the importance of including the estimating/commercial function for offsite, as it is a crucial element of delivering the fundamental cost savings of offsite (compared with traditional) construction, but is subject to substantial skills shortages.

This function relies upon a clear understanding of lean methodologies such as ‘Just in Time’ in order to accurately price, taking into consideration materials to be used, transportation costs and risk assessment. This is not unique to offsite, but is an essential requirement for the function of estimating/commercial in offsite construction projects.

4.3 Skills and knowledge needs – estimating/commercial

Accuracy in pricing and forecasting of costs is a critical skills need. However before a project has been won, it is frequently subject to time constraints and tender deadlines. Although supporting preparation of tenders is a fundamental part of the function, companies do not win every tender, so cannot spend a disproportionately long time on estimating for the purpose of winning work. Therefore they must be skilled in producing accurate estimates within very tight deadlines to support business development.

Accuracy in pricing can only be underpinned by extensive knowledge of the wide range of materials and products used in offsite construction, which in turn can vary greatly according to the needs of the project. As an example, one respondent described their use of precast concrete for offsite projects. As the factory outputs (panels, frames etc.) need to come in all shapes and sizes, this means that on a daily basis, the concrete mould is set up, sufficient concrete for that day is transferred to the mould and used, the moulds are disassembled. The following morning moulds are reassembled and the concrete ordered. Concrete must therefore be ordered on a daily basis, and estimating the amounts and cost of this can be very challenging without a detailed appreciation of this process, and of the way materials are used/manufactured. Getting it wrong can prove to be very expensive. Even minor differences in estimating the amount of material to be used can radically affect costs. This also requires on-going communication with suppliers, and with the logistics and manufacturing teams.

“Ordering concrete is a skill, estimating the amount of concrete needed is a skill”

Offsite company (house-builder), Wales



The impact on costs of employing different techniques is highlighted by the variation between England and Scotland in the use of timber frame. Scottish companies have far greater experience of using timber frame, and typically adopt a more multi-skilled approach to installation than in England. Using fewer operatives onsite for assembly (i.e. a smaller number of multi-skilled people) in Scotland, can mean labour costs are lower than they would be for the same project in England (which would use a higher number of onsite operatives rather than a multi-skilling approach to assembly). Estimators therefore need awareness of the potential benefits and feasibility (for example whether trained workers would be available) of using multi-skilled operatives and the impact for project costs.

This function also has a role in selling the value proposition of offsite. Lack of knowledge of the offsite concept can be a major barrier, and an understanding of whole life cycle costing is key to 'selling' the concept to clients. Again, communication is vital: the estimator needs to talk to everyone involved in delivery to obtain a good understanding of the product. Developing the customer value proposition hinges on being able to assess risks accurately, especially as more upfront costs can be deemed as increasing risk. This also means being transparent about what may not be suitable for the customer.

For many offsite projects, the costing model differs from traditional construction, as a much higher proportion of costs are incurred at the outset (prior to being onsite). This can be off-putting for customers. Being able to 'make the case' for the value proposition therefore requires a good knowledge not just of costs, but of durability, aesthetic and energy efficiency (low carbon specifically).

Training in BIM for this function is a distinct advantage for providing the relevant skills in estimating and making the business case for offsite. BIM models can also incorporate timelines and building schedules (4D BIM, time being the fourth dimension) so that the design and construction processes can be fully integrated. However it can also be used to automatically calculate quantities and cost estimates, adding a further dimension, cost, thus creating 5D BIM. In some forms 5D BIM can enable the performance of the building to be modelled through its entire lifecycle, enabling accurate whole-life costs to be calculated for different design options.

Those in commercial and estimating functions also need to be cognisant of emerging technologies used in offsite construction, particularly where they may have an impact for waste management and speed of build which will affect the costs.

4.4 Training and qualification needs – estimating/commercial

“No-one is training estimators”

“There are no [relevant] training courses that we've found”

Offsite companies, UK



There is a significant shortage of estimators with the right skills for offsite construction, with limited if any options in either training (such as CPD) or formal qualifications. Companies struggle to find estimators that have been trained in different forms of construction with an understanding of the range of materials used.

There is a desire for specific training and qualifications for estimators in offsite. Getting it wrong can mean the project is undervalued (and thus under-priced) and/or the risk factors are not sufficiently well assessed. Respondents believe some form of specific training in offsite construction is required – via CPD, but say this does not exist, and have concerns about the supply of tutors available to deliver bespoke training.

There are bespoke tools available to support this function, notably the Build Offsite cost estimator tool, however respondents say that there is no guarantee such tools will be available in the long-term, and therefore there is a risk in becoming reliant upon them.

4.5 Job roles and career pathways – estimating/commercial

The key job roles requiring specific training include estimators, commercial managers and quantity surveyors. Respondents agree those in such roles would be able to move into other functions (with relevant training) including sales, business development, logistics and planning.

4.6 Key issues for consideration – estimating/commercial

- There is a substantial shortage of relevant training for the offsite estimating/commercial function;
- Training needs to incorporate knowledge units that will enable estimators to have a clear understanding of the range of materials and products that could be used, and the cost implications of using them on different projects;
- CPD type training offered by the Offsite Management School, which includes estimating, does not appear to be well known among respondents;
- Few respondents were aware of the BuildOffsite Estimator Tool⁴⁵; and
- Offsite companies struggle to recruit adequately skilled and experienced estimators due to skill shortages.

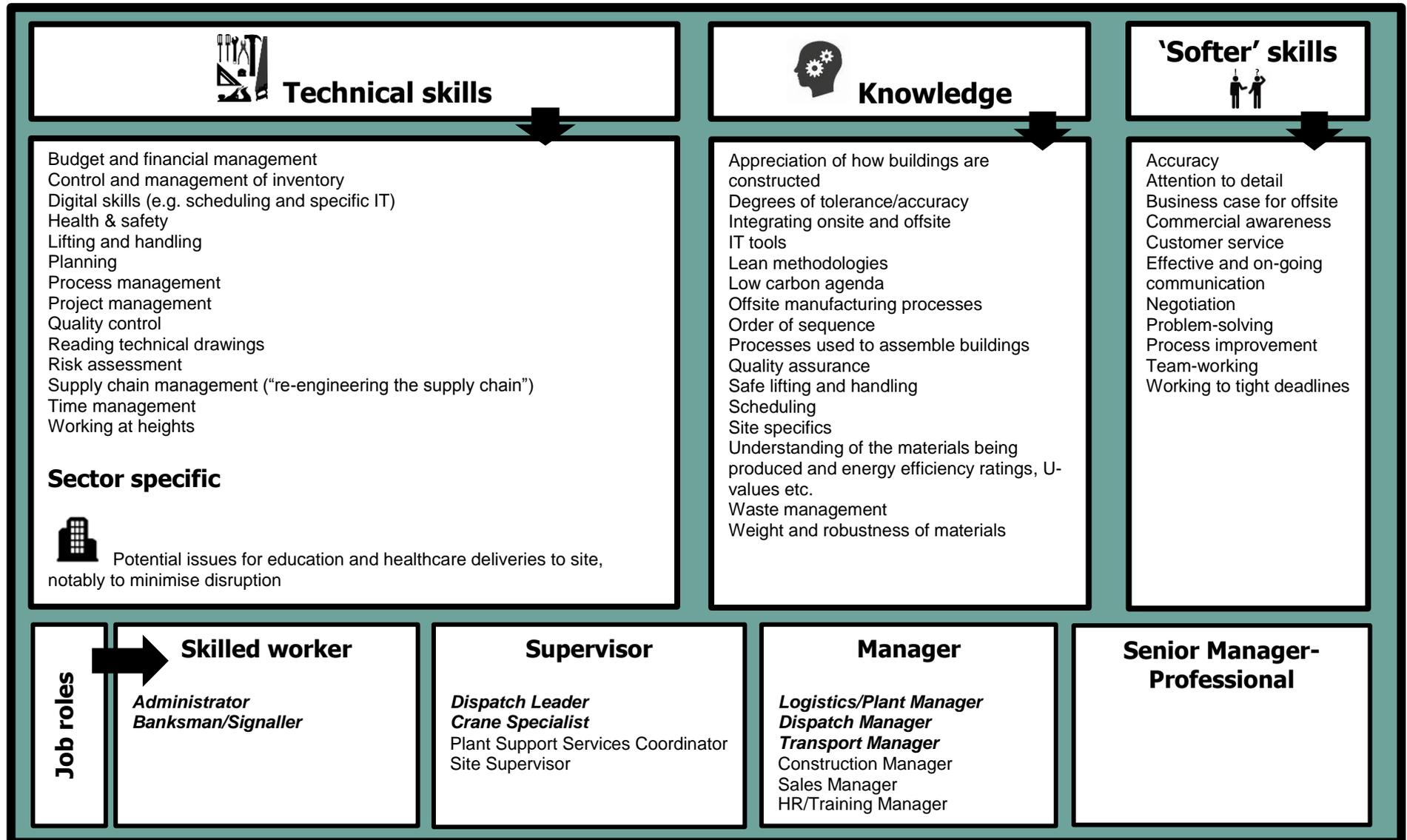
⁴⁵ At the time of writing this tool could not be located on the Build Offsite website www.buildoffsite.com

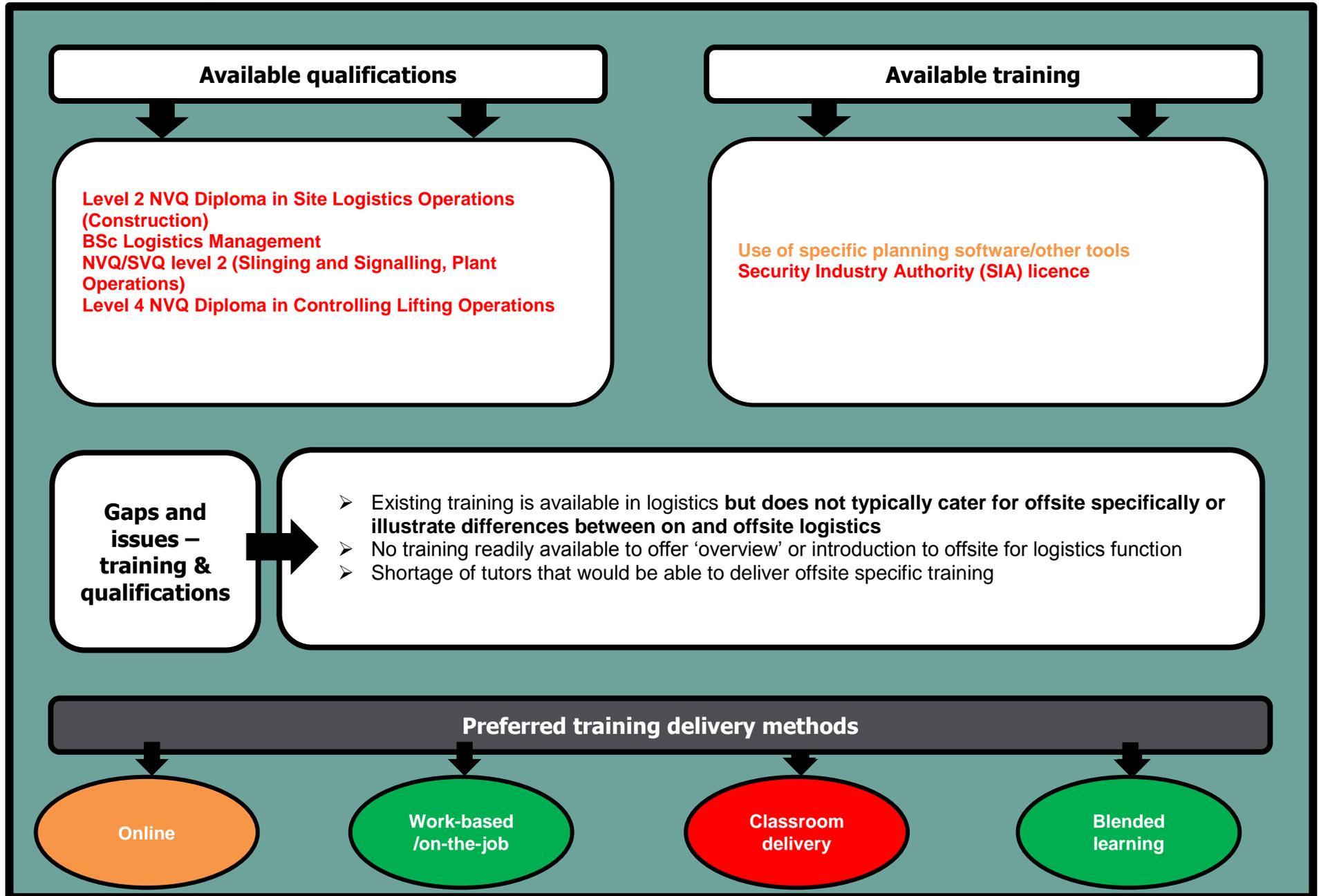


5. Logistics

5.1 Logistics persona

Logistics in this context spans the product: planning, transportation, scheduling, goods in/goods out etc., and also supply chain management. This function spans offsite and onsite.







5.2 Overview of the logistics function

“Offsite logistics and construction requires a lot of patience and control, while traditional is more chaotic. There is a difference in quality and focus”

Offsite company (house-builder), Wales

Logistics in this context spans the product: planning, transportation, scheduling, goods in/goods out etc., and also supply chain management. It should be noted that most respondents view this role as a crossover between on and offsite, i.e. coordination for the factory, supplier deliveries etc. but also oversight of logistics to bring offsite and onsite together i.e. arrival of components on to site. That being said, there are clear distinctions between factory and onsite logistics – where relevant these are flagged up in the subsequent sections.

5.3 Skills and knowledge needs – logistics

As this role can bring onsite and offsite together, fundamental skills are process and time management. Effective planning has to underpin effective process and project management. Within offsite those specifically in logistics roles need to communicate early in the process, reflecting the collaborative nature of offsite. As so much of the function is about coordination and integration, it is important for individuals working in relevant roles to be able to listen and extract the right/necessary information.

Digital skills are becoming more important, particularly for planning and time management, as many companies require their logistics teams to use tablets or mobile devices to plan, monitor and log everything they are doing. This can include for example all the steps from design to delivery/installation and all of the job roles involved, so that it is clear what is involved at each stage of the process and how it all comes together.

Thinking specifically about factory logistics, suppliers need to deliver as promised otherwise delays can result. A lot of materials are imported from overseas; it is essential to get the timing and communication with suppliers right so these arrive into the factory on time. Managing supplier relationships is therefore another critical skill; within offsite this can be about “re-engineering the supply chain”. A more integrated supply chain underpinned by regular process improvement is needed to make supplier relationship management “more refined and defined”. In turn this makes team working and negotiation skills vital.

Thinking specifically about onsite logistics, and transporting from the factory to site, there is a need for detailed understanding and knowledge of the layout and operation of the site and implications for logistics such as the journey route, any height restrictions, obstructions along the way. Storage capacity onsite may also need to be considered, as well as accompanying safety and security issues. This may have a bearing on the type(s) of materials to be used, the type(s) of lorry/crane, and timings



of deliveries. Again this requires regular communication and negotiation with suppliers, specifically thinking about the number and type of deliveries required. For some housing projects procurement requires delivery costs not to exceed a certain percentage. Knowledge and understanding of different approaches to optimise delivery times and manage costs for movement from factory to site. Understanding different methods and approaches (one example being the flying factory model⁴⁶) is vital to know a) when they may be necessary and b) how to implement them.

For the logistics function consideration of ‘cross-training’ (i.e. training for both onsite and offsite logistics), for those that work on and offsite is necessary, but often on a project-by-project and/or site-by-site basis, because it may be cost prohibitive to train on both unless prompted by specific project needs. For instance managers who control inventory (which can include offsite consolidation centres for storage), forklift drivers and lorry drivers can all operate offsite and onsite. The logistics function must ensure the right people, the right equipment and the right skills are available to carry out the work, and this means identifying the people to be trained, and how to fit in the training around project delivery.

“When this beautiful thing has been designed and built, they haven’t thought about how it will be moved to site”

“No-one thinks about how to move it and if the transportation doesn’t meet regulations the whole project can be rejected”

Offsite company (education sector), England

Offsite construction relies on collaboration and communication between all parties, at the outset. The logistics function may be required to support the main contractor in understanding and planning how to move the product. This can mean communication with the relevant parties from the stage of planning application. Even at this very early stage logistics must consider traffic, building size, likely disruption around the site for the public, carbon emissions and the like. Skills in planning for delivery of multiple products in the same load are necessary to reduce disruption and increase efficiency. As an example (considering the use of offsite is increasing in the healthcare sector), it would be important to understand issues affecting the healthcare sector and patients’ needs, for instance the level of noise if installing next to a ward. Offsite projects can be assembled close to existing facilities, so the logistics function may need to take the health and safety of the public into account.

Knowledge of different vehicles and how they can be used depending on the situation is also important – for example whether transport can be vertically loaded with cassettes, lifted using hydraulic systems, can take cassettes to site where they can be lifted off. In effect this is about creating a safe load to travel to site and to unload.

⁴⁶ The ‘flying factory’ is a term coined to describe a process of near-site manufacture typically a rented facility used to assemble prefabricated components before delivery to site.



It should be noted that the skills and knowledge described above are not unique to offsite per se, but there are crucial differences which need to be taken into consideration. For example, when transporting from the factory to site, often the logistics function is dealing with far bigger loads, and larger structures, compared with traditional construction. Route planning needs to take into account that greater access is likely to be needed – not just to get to site, but to get *on* to site. Sites in offsite projects are not necessarily easily accessible as they have not been prepared specifically for the purpose of a build, unlike most traditional construction sites. The logistics function may need to consider, for example, how to deliver large loads to a working hospital, or to a holiday chalet park, both of which have residents which necessitate additional consideration of health and safety for the public.

Correct sequencing is crucial – if for example a pod is placed in the wrong place on site, it may be extremely difficult (and/or time-consuming) to gain access to move it. In some cases respondents will send people to assess the sites in advance of delivery, which does not always happen in traditional construction (as it does not need to), adding another layer to the process. This can be a particular consideration for retrofit – for example thinking how to turn pods on their end and hoist them in the confines of very small spaces. For this reason, in some cases logistics informs the design process, which would not be typical in traditional construction.

Looking further ahead to the future, some respondents aspire to a “*pull logistics model*”. This would mean suppliers would be told when to deliver by the site team, rather than the other way around. Currently, suppliers may deliver all their products to site (“push logistics model”) even if not required on site at that point in time. Development of and use of new software tools or web portals is expected to help with coordination – again this shows the need for strong digital skills.

5.4 Training and qualifications needs – logistics

In respect to qualifications, there is a need for N/SVQs for logistics operatives and managers to fulfil the more traditional functions of logistics, for example in signalling⁴⁷, in respect to onsite functions (i.e. placement/delivery once delivered from the factory/supplier). CSCS cards are needed for certain roles on site, so this includes the Health, Safety and Environment (HSE) test in addition to the relevant N/SVQ to gain the card. In some cases those delivering to site require a CSCS visitor card, which does not require an N/SVQ but does need the HSE test.

Frequently there is a need for a certain level of security training – typically the Security Industry Authority (SIA) licence is required.

Training in digital skills is needed which would likely be delivered via CPD. This would include use of handheld devices such as tablets to log data and maintain accurate records.

⁴⁷ Slinger/signallers are primarily responsible for attaching and detaching loads to and from cranes; initiating and directing safe movement of the crane and the load; and the use of correct lifting apparatus and accessories



Other training needs relate more to the ‘problem-solving’ elements of offsite logistics – for example route planning and managing access restrictions. Respondents consider this type of training needs to be bespoke, and delivered via some form of CPD by experienced trainers (ideally currently working in the industry).

Combining logistics functions for onsite and offsite can be challenging when it comes to training. Respondents say that training may not necessarily consider the differences in the physical environment between offsite and onsite, which can impact on the type of vehicle used, for example. What is missing, from their perspective, are training and qualifications that consider onsite and offsite together, allowing people to develop skills and knowledge that are transferrable between the two.

“When you bring someone to an offsite facility from onsite they struggle with structure as there’s more rigour and control. It’s a tricky area and this is perhaps where there is a lack of fundamental training – joining the two together”

Offsite manufacturer, England

Another issue is the lack of training offered to the crucial role of the logistics administrator who would support key functions such as planning, scheduling and liaison with the supply chain, yet typically does not have detailed knowledge of offsite construction, and would benefit from some form of ‘overview’.

5.5 Job roles and career pathways – logistics

Typically those in the logistics function may begin their career as forklift or delivery drivers. Progression can be through to supervisory or management roles in the warehouse. Graduates may begin as entry level managers. Logistics operatives onsite can also progress into site management roles, with longer-term progression into operations management.

In some cases companies move people in the logistics function from onsite to offsite and vice versa, but this is reliant on having sufficient numbers of people with the appropriate training, qualifications and experience.

5.6 Key issues for consideration – logistics

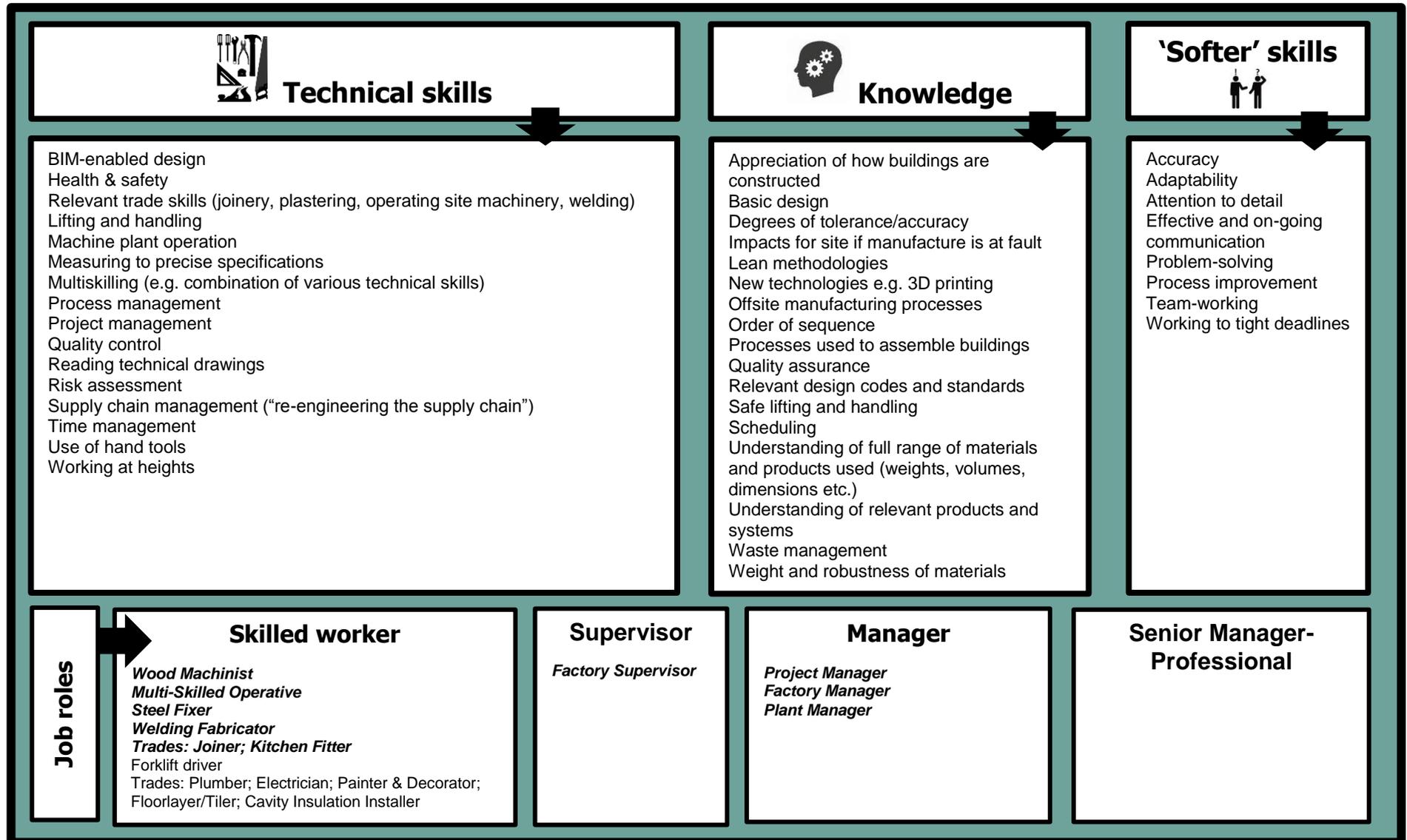
- Offsite logistics processes do not mirror those of traditional construction; transferrable skills between the two functions are important but training does not typically take into account the differences;
- The logistics function can operate on and offsite so cross-training is required, but there is a gap in training in terms of joining the two together;
- Administrators play a key role but do not always have sufficient knowledge and understanding of construction (traditional as well as offsite).

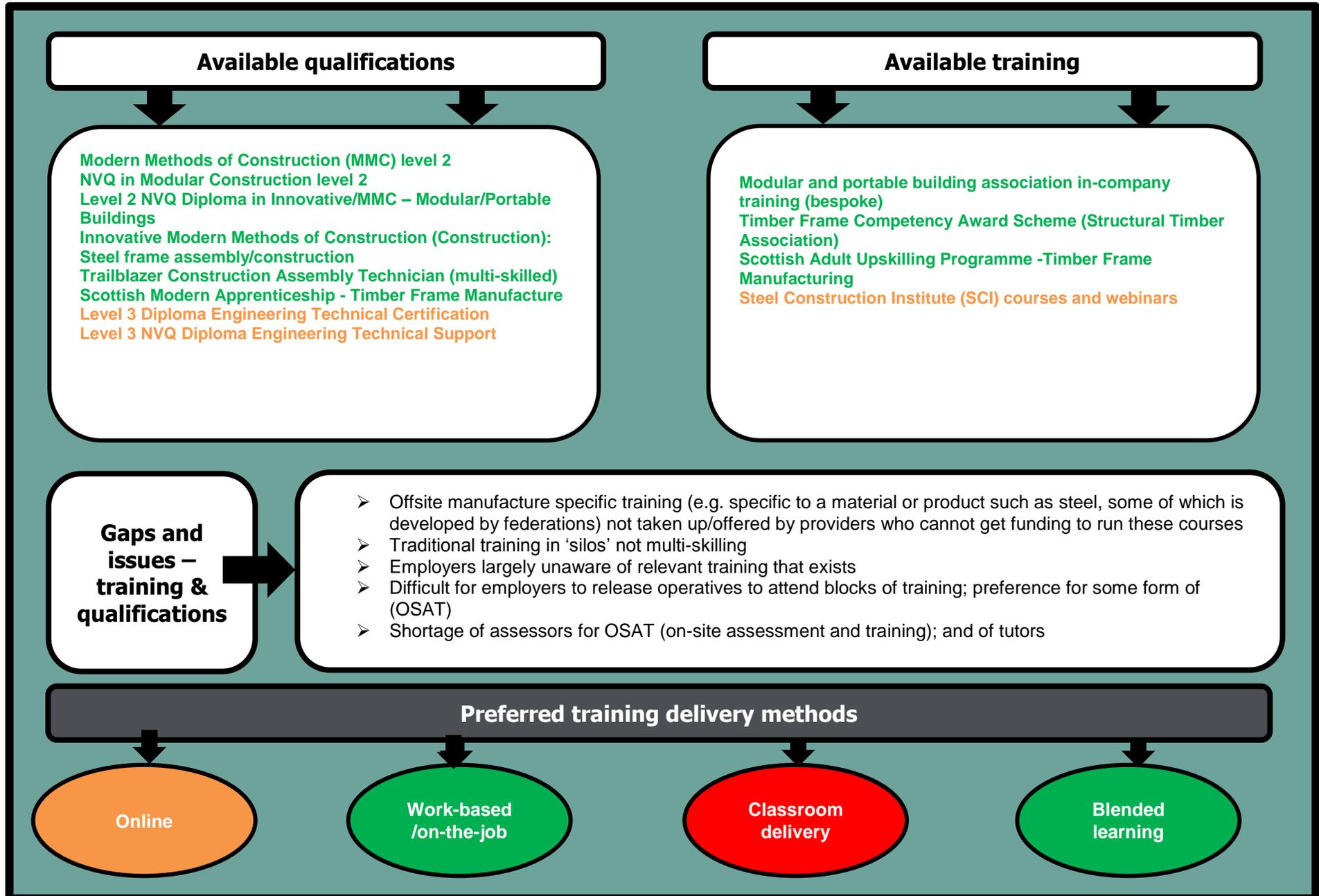


6. Offsite manufacture

Offsite manufacture refers to the creation of components, modules or entire buildings that are subsequently taken to, and assembled/installed onsite.

6.1 Offsite manufacture persona







6.2 Overview of the offsite manufacture function

Typically undertaken in factory environments, offsite manufacture refers to the creation of components, modules or entire buildings that are subsequently taken to, and assembled/installed onsite.

6.3 Skills and knowledge needs – offsite manufacture

The offsite manufacturing function requires a wide range of technical skills including welding, joinery, steel fixing, quality testing, use of hand tools and operation of machinery. It also relies upon good knowledge of manufacturing for construction across a range of products and techniques. The need for product knowledge varies depending on the needs of the organisation and typical projects undertaken, but an ideal knowledge base for most respondents would span light steel, timber frame, and structural insulated panels (SIPs). The type of product being manufactured also dictates the skillset required – for example the key technical skill for some steel manufacture is roll-forming⁴⁸ (it is rolled, punched and stacked).

Although many factories use traditional trades in offsite manufacture - notably joiners and steel fixers - increasingly respondents are moving towards having multi-skilled operatives able to carry out a wider variety of tasks. This could span for instance: use of hand tools to cut panels, screwing/nailing/bonding of components; operation of machinery (keeping it running, checking for tolerances), welding and basic skills in plastering (e.g. plastering the outside of concrete panels to make them smooth). Some manufacturers also make ancillary components – this is essentially fabrication work using traditional trades and skills. Machinists and operatives would therefore benefit from basic design knowledge to understand not only what the finished output should look like, but how it will function and how it will be assembled onsite, to help with the quality assurance and checking aspects of the manufacturing process.

“At the moment we tend to need all roles [trades] in every project. I’ve worked in other places where they have multi-skilled people, this is likely to be how the industry moves forward in the future”

Offsite manufacturer and assembler (commercial sector), England

Steel fixers and joiners work from plans and need to know how to read technical drawings. All work is typically undertaken in a sequence – the factory or project supervisor must schedule the work so the operatives know what and how much to produce, and in what order. Operating safely but to agreed timelines is essential. The production team must work to this agreed schedule and quickly adapt to and overcome any problems, to avoid delays in production. This scheduling must allow sufficient time for quality control such as testing of completed products (this can be to check tolerances, energy efficiency, correct measurements etc.)

⁴⁸ This process involves the continuous bending of a long strip of sheet metal into a desired cross-section



The sequencing is also critical for logistics and onsite assembly. To this end, panels etc. are usually numbered when they are produced in the factory, so that onsite assemblers can follow the correct sequence to install them once onsite.

The knowledge base also includes understanding of tolerances, energy efficiency ratings and an appreciation of how the building is constructed. Unlike a more traditional factory environment, the finished product leaves the factory to be fully assembled elsewhere, so problems may only be encountered for the first time onsite. As previously stated, an understanding, even at a relatively basic level, of how the products are to be assembled/installed, helps the offsite manufacture function identify and respond to potential problems.

“It’s basically having building knowledge. This is why we use traditional tradespeople [in the factory] where we can”

Offsite manufacturer, Scotland

In the future some respondents anticipate using more traditional trade functions (albeit possibly using multi-skilled workers instead of tradespeople), as factories produce increasingly more sophisticated components, underpinned by technological developments. This may mean the likes of plumbers and electricians are needed in the factory – this is already happening although may take place on a more widespread basis in the next 3-5 years.

6.4 Training and qualifications needs – offsite manufacture

In terms of qualifications, traditional trades working in the factory require an N/SVQ e.g. in joinery or plastering. When it comes to training, not all multi-skilled operatives have accredited qualifications, but are trained ‘on-the-job’. Nearly all respondents state that relevant training for offsite manufacture is not readily available on a nationwide basis, therefore most companies train their own teams in-house which may be a case of ‘bolting on’ offsite knowledge to an existing technical skillset.

This offsite knowledge needs to encompass product/material-specific knowledge and an appreciation of manufacturing for construction – i.e. the need to precisely follow the drawing otherwise it will result in problems onsite.

The right behaviours and attitudes are crucial; respondents say that the collaborative nature of offsite manufacture can be a huge cultural shift for traditional trades accustomed to working in silos; these ‘softer’ skills need to be embedded into training and qualifications. Most respondents would prefer standalone knowledge and behavioural training to be available in some form of CPD or as a unit to be added into existing qualifications. CPD would ideally be delivered on-the-job in some way to avoid interruption to the working day by taking people out of the factory.



6.5 Job roles and career pathways – offsite manufacture

The immediate progression for factory operatives is into supervisory roles. There is also the opportunity to move into site-based roles (e.g. for joiners, plasterers, kitchen fitters etc.)

6.6 Key issues for consideration – offsite manufacture

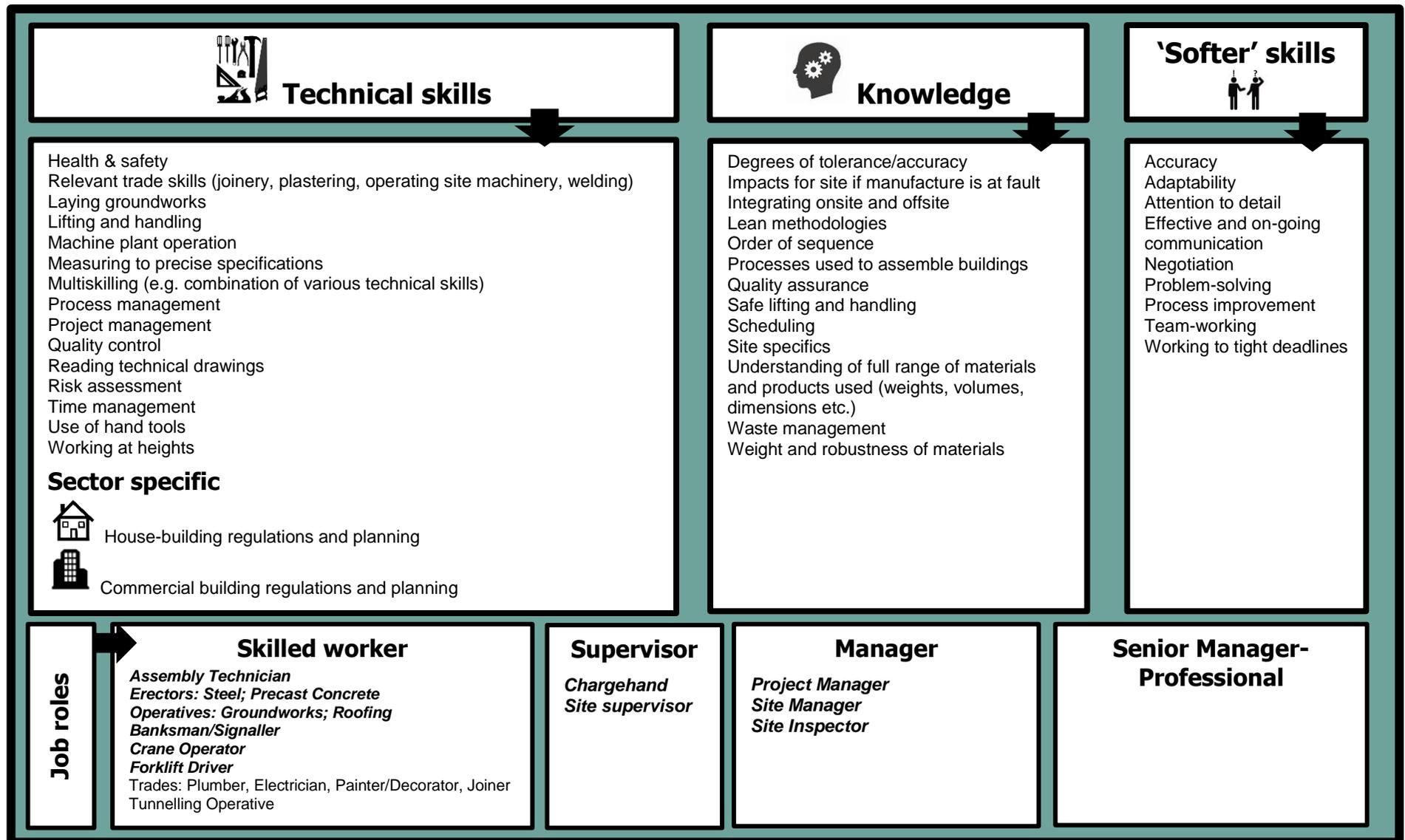
- A number of trade federations and other bodies (e.g. Structural Timber Association) have developed their own bespoke training for the sector, however as a rule it is very difficult to persuade colleges and other providers to offer the training on a national basis. This is largely because of the way in which provision is funded, and future uncertainty about how the funding will be made available.
- There is a need for a general ‘overview’ of offsite within traditional training courses but it is rarely covered to the extent needed.
- Offsite increasingly requires more multi-skilled workers and also uses traditional trades in the factory such as joiners and steel fixers. Training for these trades tends to be in silos; focusing on one role rather than offering a basis for multi-skilling.

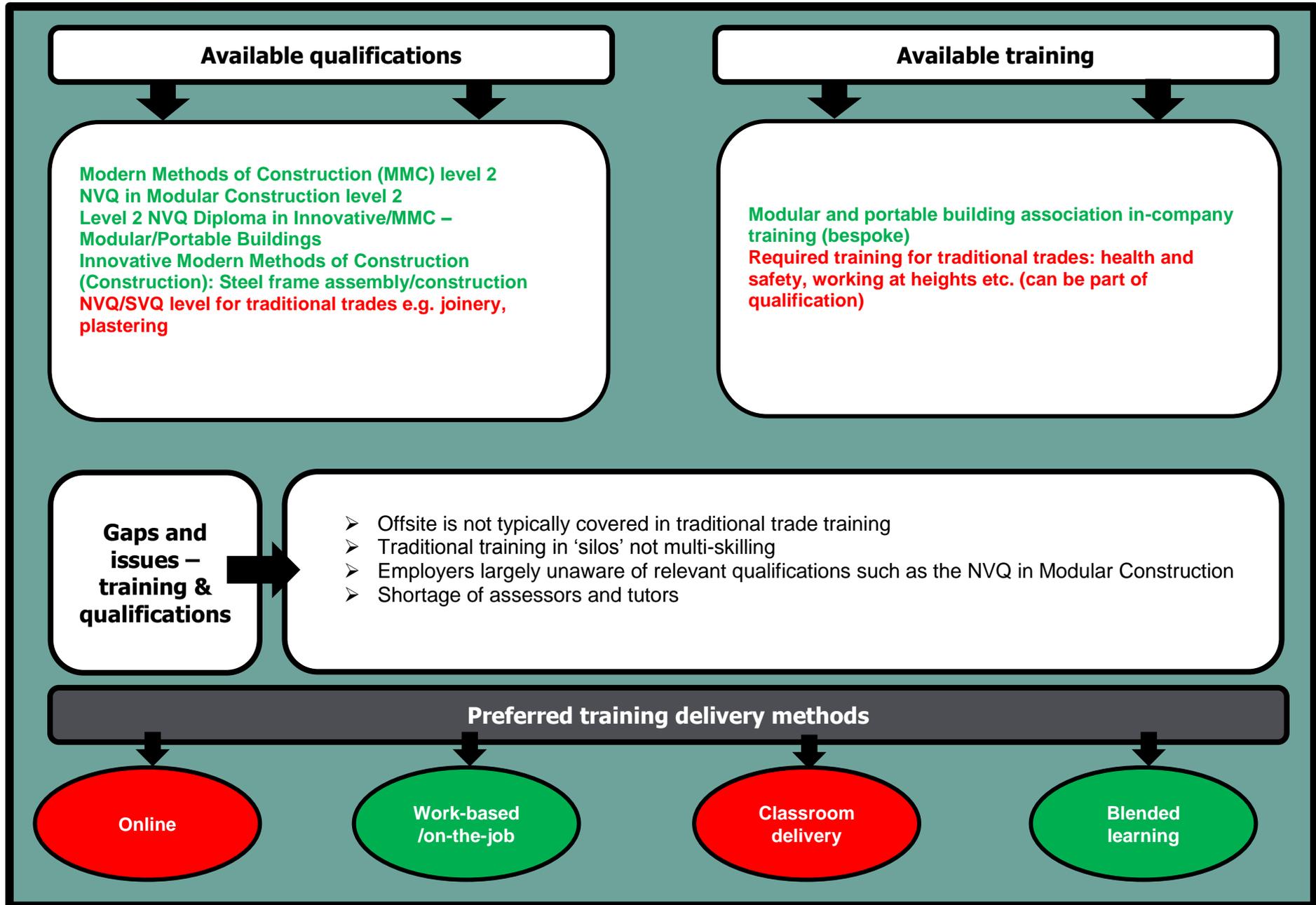


7. Onsite placement and assembly

7.1 Onsite placement and assembly persona

Onsite construction requires precise, accurate placement of components, modules and buildings prior to full assembly. This level of precision is the nucleus of a successful project.







7.2 Overview of the onsite placement and assembly function

“It’s like lego for grown-ups”

Onsite construction company (commercial and house-building sectors), UK

Onsite construction requires precise, accurate placement of components, modules and buildings prior to their full assembly. This level of precision is the nucleus of a successful offsite project. Even one small component that is placed incorrectly (even if this is only slightly out of place, for example) can compromise the entire build in terms of speed, accuracy and cost. In practice, this frequently results in a need for problem-solving skills, to deal with the fallout of errors of this nature, but respondents acknowledge that with the right skills and knowledge, many problems would be avoided.

7.3 Skills and knowledge needs – onsite placement and assembly

The onsite placement and assembly function relies on core “tradespeople” skills – it is a highly physical role, moving components to the right place, fixing, checking, levelling etc. Skills are needed in reading technical drawings, use of hand skills, accurate measurement etc. However individuals in placement and assembly roles also require technical understanding of the products and materials, i.e. at least some working knowledge of offsite construction rather than just working on traditional construction.

“It’s like assembling a flat-pack bookcase. These people need to know how to make sure things are vertical, plumb and are in the right place – it’s the tradesmen’s skills”

Offsite manufacturer and assembler, Scotland

In practice, some offsite companies only use onsite assembly teams that have this understanding and experience of offsite construction, but it is not always possible to find sufficient numbers of people for all projects. One respondent addresses this issue by using larger assembly teams with a combination of the right skills and experience, but this incurs higher costs:

“Assembly teams can often work in pairs: one with technical knowledge and one with the muscle”

Offsite manufacturer and assembler, Wales

Onsite assembly also requires knowledge of quality assurance, checking and process management; this means knowing which tests to undertake on which product (e.g. pod, panel) and how to do them. It is also necessary to know how many to sample and the frequency of testing within a managed process.



Problem-solving skills are acknowledged to be very important for onsite assemblers and the site supervisors. An understanding of offsite construction makes it easier to recognise what the problems might be and how to solve them. A good example of this (which also illustrates the need for a collaborative approach between all functions from the outset) is the groundworks. At design phase, there can be an assumption that the ground is fit for the purpose of onsite assembly if the groundwork has been adequately prepared; foundations must be right to a certain tolerance for instance of 5mm. If this has not been done correctly, to the right tolerance, it has to be corrected – but by this point typically the groundworks installation team have already left the site. This also emphasises the importance of up-skilling of traditional construction roles – on paper the groundworks operative is not directly involved in onsite assembly in offsite projects, but their work, if not fit for purpose because of inadequate skills and knowledge, can undermine the project adding cost and time to rectify the issue.

Another example is the difference between light gauge steel and hot-rolled steel. The former is manufactured to be flat and square, but hot-rolled contains gaps, resulting in different tolerances. Without this understanding, onsite assemblers may not realise these gaps need to be accounted for.

7.4 Training and qualification needs – onsite placement and assembly

Onsite placement and assembly relies largely on existing training such as health & safety, manual handling, working at heights, operation of cranes, abrasive wheels and other technical skills necessary for onsite installation. Usually S/NVQs are required in order to obtain CSCS cards to go onsite. Traditional construction workers who have undertaken the relevant training can therefore transition into onsite assembly roles with appropriate knowledge training to equip them with the understanding of offsite construction.

There may also be a need in the future for a qualification in multi-skilling; in Scotland there is a route to up-skilling in this way via Industry-Approved Training. This forms part of the Modern Apprenticeship, and enables training providers to develop courses (potentially in conjunction with industry) that are approved by industry to meet their specific needs. Some form of industry approved approach may work well for the rest of the UK across all offsite functions.

Training needs to focus on some form of ‘overview’ of offsite, including knowledge of materials, basic design knowledge, and quality assurance testing and checking. Respondents’ preference is for some form of on-the-job training if possible.

7.5 Job roles and career pathways – onsite placement and assembly

Site operatives are able to progress to supervisory and managerial roles. With the relevant training and skills there is scope to move into other functions such as logistics or commercial roles. Training that enables development and progression is likely to be job-role specific rather than specifically focused on offsite (on the



assumption that individuals progressing down offsite career pathways would already have received relevant knowledge training).

Looking ahead to the future, job roles may evolve as dictated by the market. For example a considerable shift into panels would make the industry less reliant on bricklayers – but they could upskill in cladding. They would need to have a different knowledge base in order to upskill.

There are differences between job roles by nation, notably in Scotland, where it is more typical to have multi-skilled operatives onsite. If this approach was adopted in the rest of the UK, then this would require traditional tradespeople to up-skill via training. In Scotland apprenticeship frameworks are designed to enable multi-skilling.

“In Scotland the chippy does the dry lining, timber lining and finishing. In England the brickie does the masonry, then a dry liner comes in, then someone else for the insulation and then a carpenter. All separate trades”

Offsite manufacturer and assembler, Scotland

7.6 Key issues for consideration – onsite placement and assembly

- Use of multi-skilled assembly operatives is far more prevalent in Scotland, notably for timber frame which is a mature market. Respondents consider there is more relevant and more accessible training in onsite assembly for timber frame in Scotland than in other nations. In England, Wales and Northern Ireland the tendency is still to use traditional trades working in silos. This may change in the future, but at present this suggests training needs to be designed to take into account the differences between nations.
- Training for traditional trades which are often involved in onsite placement and assembly does not typically have coverage of offsite (at least not to the extent respondents deem to be fit for purpose).
- Training for traditional trades usually focuses on separate, distinct trades, rather than allowing for multi-skilling, suggesting there may be a need for a qualification and/or knowledge units in multi-skilling.
- Awareness of the NVQ in modular construction, which would be a means of providing the offsite ‘overview’ is extremely limited; nearly all respondents are unaware of this. Once informed of the content, respondents broadly acknowledged that this qualification appears to offer a good grounding in the necessary skills and knowledge. However there are strong concerns from industry that a) there are not enough appropriately skilled/experienced tutors to be able to deliver the programme, and b) there is a shortage of assessors.



Given the number of units it does not seem to fit the bill in providing a standalone overview – although aspects of the qualification could feasibly be extracted into a separate course.

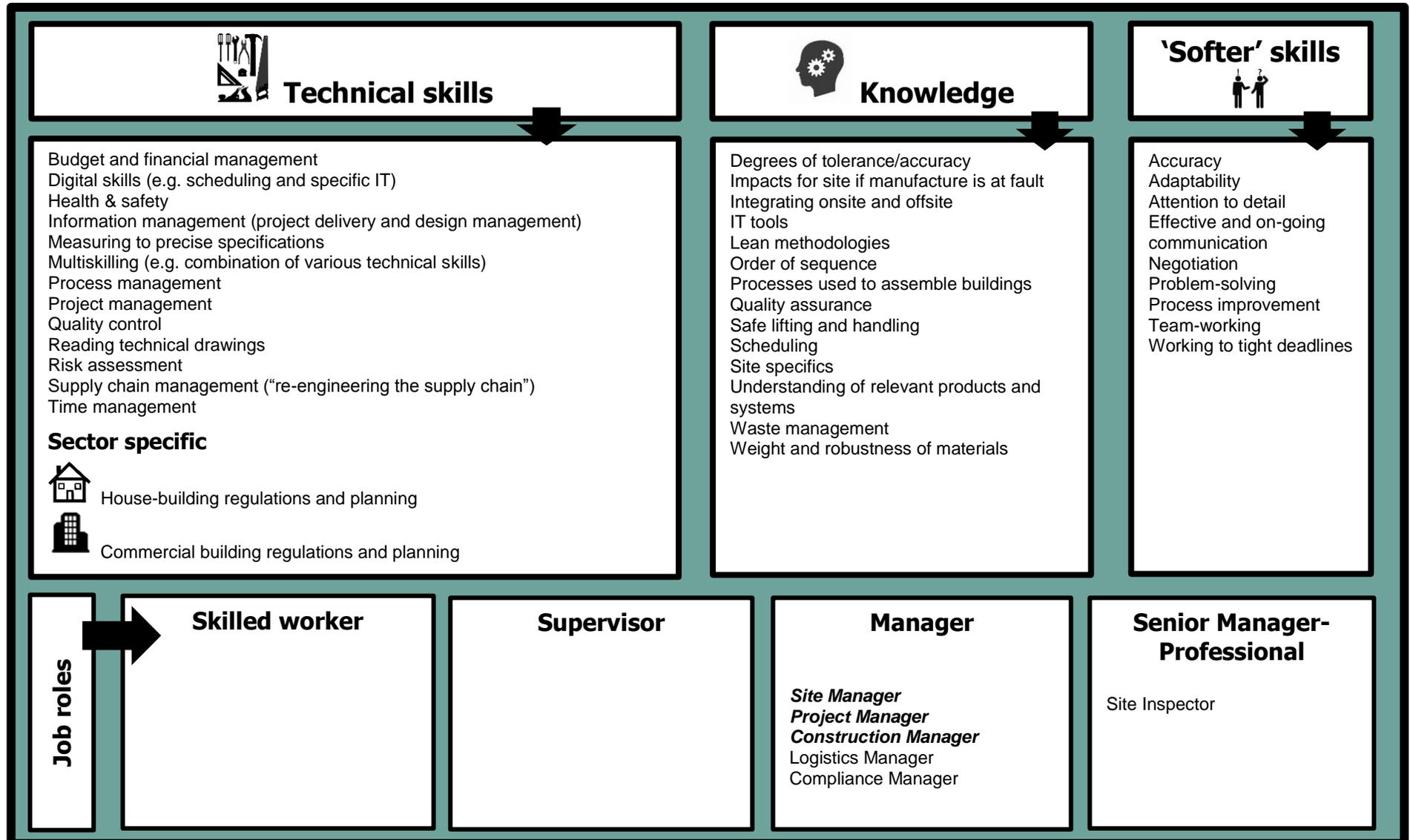
- Few respondents were aware of the assembly technician trailblazer apprenticeship and expressed similar concerns about a lack of appropriately skilled/experienced tutors to be able to deliver the programme, and a shortage of assessors.

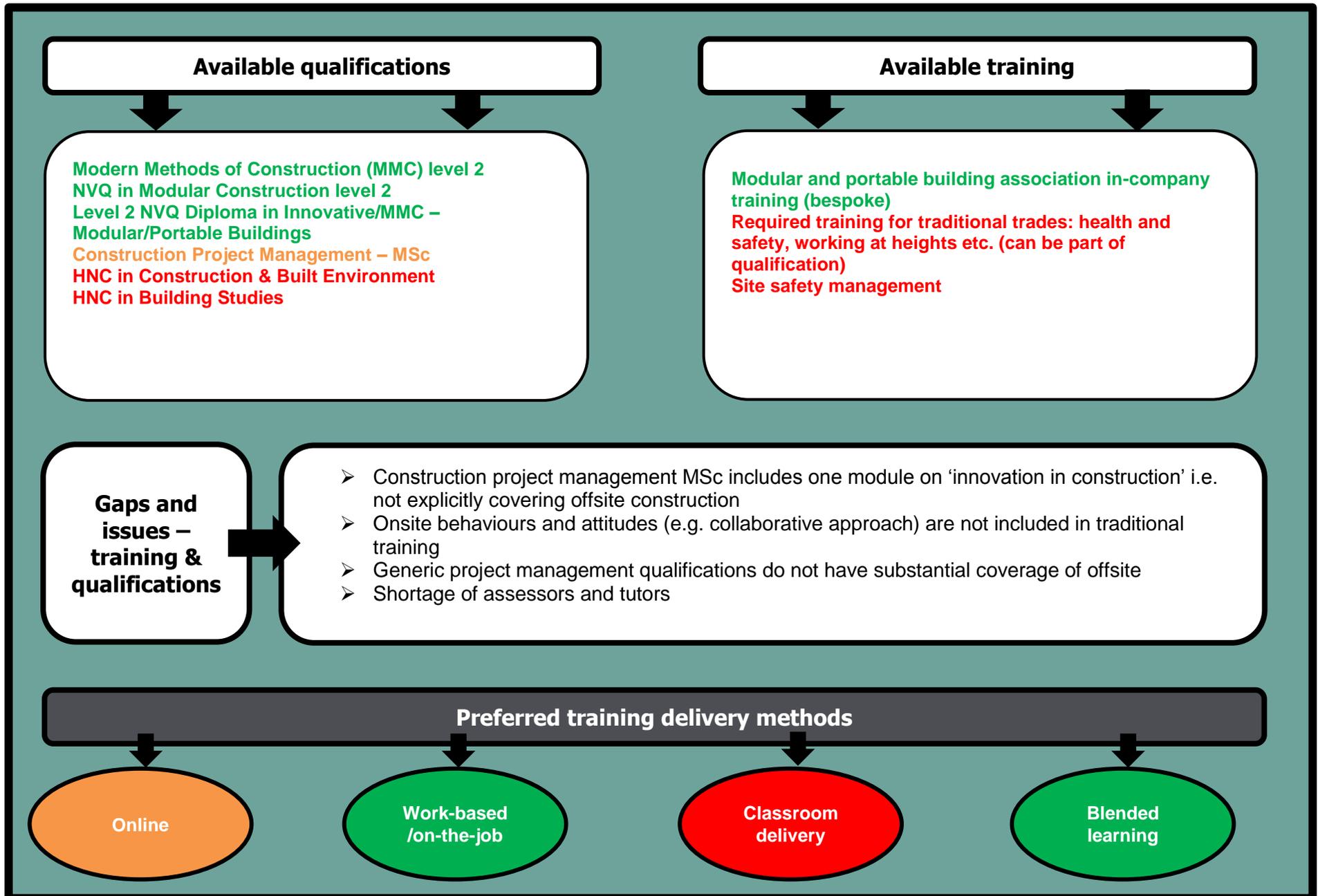


8. Site management and integration

Offsite construction site management hinges on being able to integrate the offsite and onsite functions, which requires a comprehensive understanding of both aspects.

8.1 Site management and integration persona







8.2 Overview of the site management and integration function

Offsite construction site management hinges on being able to integrate the offsite and onsite functions. This means supervising the installation onsite, of products/components etc. manufactured offsite, and therefore having a comprehensive understanding of both functions, to bring them together effectively.

Many respondents say there are not enough appropriately skilled and qualified site managers available to fulfil this function.

8.3 Skills and knowledge needs – site management and integration

“Installer site managers supervise the installation. They don’t tend to get their hands dirty. They need to be adaptable if things go wrong”

Offsite company, England

At the crux of managing the installation is following the correct processes, and a commitment to on-going process improvement. The site supervisor/manager needs to ensure drawings and manufacturer instructions are followed – this is key to ensure correct installation and requires an understanding of the products and systems used.

Those working within this function need to be resilient and remain calm under pressure. This is important when responding to and dealing with problems that may arise. The site manager must ensure that installation takes place to the appropriate quality standard, whilst concurrently delivering to the agreed timescales i.e. without compromising on quality or health & safety. This can be a more challenging task when there are multiple separate trades on site, compared to where there are fewer numbers of multi-skilled operatives.

Site managers need good IT and time management skills – for example to plan and organise an online diary management system - and maintain site records. Digital skills are required in reading and understanding technical drawings. Strong communication and negotiation skills are essential for day-to-day management, external liaison and dealing with problems.

8.4 Training and qualification needs – site management and integration

Most respondents agree that site or project managers must have a generic skillset in construction, supplemented by training in the specifics – products, materials, software. This would include a specific qualification in construction management. Some form of project management qualification may also be necessary.



“The site manager [coming from a traditional background] would need to learn about modular building...they really need training to need to understand how all the methods fit together...they would have to learn the products and techniques”

Offsite company, England

A concern for respondents is that behaviours and attitudes are not embedded into training for offsite site management, and as the culture demands a collaborative approach to working, this is a crucial omission:

“It’s not about knowing, it’s about doing – it’s about the mindset”

Offsite company, Scotland

8.5 Job roles and career pathways – site management and integration

Site managers are more typical in house-building, but in other sectors notably infrastructure, this function may be undertaken by a project or programme manager. A project or programme manager may start in an entry level role as a recent graduate, whereas site managers (who may or may not be graduates) may have risen through the ranks, having begun their career as entry level site operatives. Depending on their entry level, therefore, some managers may require additional training in order to progress. For example, managers that started out as site operatives are likely to need training in project and time management to be able to oversee sites effectively.

In the immediate future some respondents anticipate a transition to a more highly skilled and knowledgeable programme/project manager who would oversee everything from design to completion. This would emulate what happens in market leading offsite countries such as Japan.

“In Japan, they have project managers, not engineers. The project manager is king. The industry has the manufacturing background [i.e. lean started by Toyota], it’s focused on value, and they have huge investment in training and R&D”

Offsite manufacturer, UK

8.6 Key issues for consideration – site management and integration

- Site or project managers coming from a background in traditional construction need to have a knowledge and understanding of offsite construction, but offsite is not typically well served within the existing suite of project management qualifications.
- The right attitudes and behaviours for site operatives and site managers are just as important as technical skills, but again these are not typically included



in current training, and as such it may be difficult to design and implement the most appropriate culture onsite.

- There is a shortage of appropriately skilled and qualified tutors and assessors to support bespoke offsite training in site management.



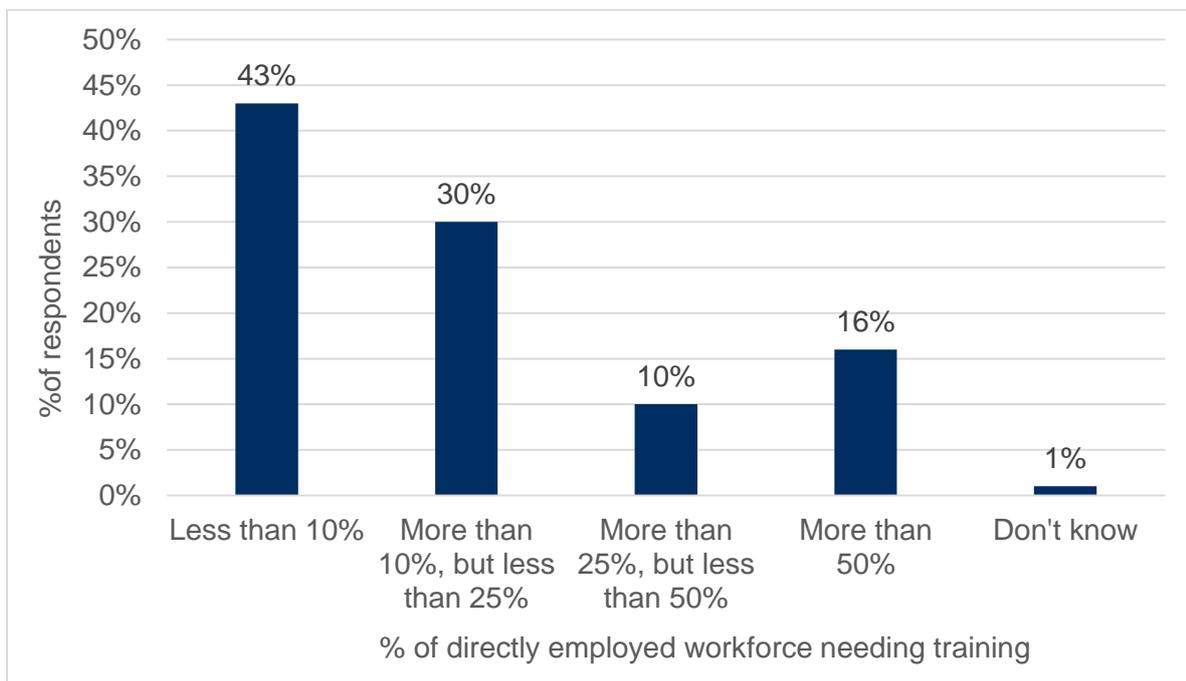
9. Supply and demand for offsite training and qualifications

9.1 Demand for offsite training and qualifications

CITB's research with employers in the construction sector⁴⁹ asked businesses expecting to use offsite construction over the next 3-5 years whether they think they will need new or significantly improved offsite construction skills⁵⁰. Nearly two-fifths (38%) of respondents say that they will. Businesses were also asked which offsite construction skills their workforce was likely to need during the next 3 to 5 years. Handling and assembly skills are the most commonly mentioned (81%), while seven in ten businesses or more mentioned skills relating to the operation of powered equipment, site health and safety and welfare, site preparation, disposal of waste, team working and quality control⁵¹.

Just over a quarter of respondents say that more than 25% of their directly employed workforce will need training in offsite over the next 3-5 years, however 43% say less than 10% will need this (Figure 11).

Figure 10: % of directly employed workforce needing training in offsite construction next 3-5 years



Base: 78

Primary research for this report points to a strong demand for training in offsite construction knowledge and 'softer' skills, to bring about behavioural and cultural change necessary for the holistic approach to working for offsite; and to enable

⁴⁹ Employer Attitudes and Motivations regarding Learning and Training, Wave 16 Unpublished research prepared for CITB by IFF Research October 2016

⁵⁰ Approximately 16% of a sample of 1,248 construction sector employers said they use offsite construction

⁵¹ Base: 114. Construction Panel Wave 16. Respondents could select more than one response.



upskilling of those coming from a traditional construction background. Types of softer skills tend to be very similar regardless of offsite function, sub-sector or nation. There will be differences in knowledge needs, largely linked to the types of materials used in different projects, different markets (e.g. housing) and nations. For example, timber frame is a mature market in Scotland and as such the need for training in other materials like concrete and steel may be a lower priority compared with the rest of the UK.



9.2 Issues with current supply of offsite training and qualifications and actions suggested by respondents

Most existing training doesn't cover specific offsite skills because of its generic nature

“The biggest stumbling block is getting trades and onsite to accept offsite. There could be sections in current courses to improve knowledge. There should be modules of offsite embedded so learners studying bricklaying for example, also gain knowledge in the application of other methods like modular construction”

Offsite company (commercial sector), Wales

Issue	What needs to be done?
<p>Generic sector training and qualifications: The majority of existing training in the construction sector does not include explicit/comprehensive coverage of offsite. Given the need to integrate knowledge of traditional and offsite, this is a barrier in terms of upskilling the supply chain.</p>	<p>Creation of knowledge units and CPD Respondents acknowledge that individual companies need to take a certain amount of responsibility for training employees on their own specific products and projects. However they point to a need for a more generic knowledge of offsite, thinking about a) an overview/introduction to offsite that would be a bolt-on knowledge unit and b) a knowledge unit focusing on understanding of products and materials such as cross-laminated timber e.g. their uses, tolerances in different contexts etc.</p> <p>Crucially, new units would need to form part of an industry-developed, standardised set of training for offsite that provides confidence and portability across the industry.</p> <p>Such standalone units could be embedded into existing courses (including apprenticeship frameworks) or as part of a CPD offer.</p>
<p>Gaps in offsite knowledge training units: There is a lack of standalone, ‘bolt-on’ training specifically focusing on knowledge and understanding of offsite construction: the ‘overview’ of offsite. These could be applicable to office-based workers including salespeople for example, not just to those predominantly working in onsite and offsite roles.</p>	
<p>Training specific to offsite is not always available: Whilst relevant training is available⁵² this does not mean it is readily accessible on a nationwide basis. Many providers are unable or unwilling to offer training and it may be</p>	

⁵² For example the NVQ in modular construction, trade federation training offered, in-company training offered by the Modular and Portable Building Association and other courses. A range of learning outcome frameworks were also developed, part-funded by CITB and UKCES that could be more widely used.



<p>particularly difficult to find training in rural areas, notably in Wales and Scotland. It should be noted however, that there is already a strong collaborative approach in Scotland to develop and offer relevant training, spearheaded by the Construction Scotland Innovation Centre⁵³.</p>	<p>These would therefore form part of accredited training delivered by providers and employer/manufacturere-providers.</p> <p>If part of an apprenticeship, the units would attract public funding.</p>
<p>Traditional training model lacks focus on behaviours: The typical mode of training does not have a major focus on behaviours and attitudes; for offsite behavioural change and understanding the “mindset” is considered as important as technical skills and knowledge. This tends to stem from coaching/mentoring and collaboration to understand each function and role, rather than something that is taught in a classroom.</p>	<p>The ‘hub and spoke’ model A hub and spoke training model is pertinent here as could provide access to materials and facilities to comprise blending learning (within ‘spokes’) with more traditional teaching methods. This could accommodate bolt on units and ensure greater accessibility via regional ‘spokes’.</p>

Shortage of tutors and assessors skilled in offsite

“A lot of educationalists have never worked in industry”

Offsite manufacturer, England

Issue	What needs to be done?
<p>Shortage of skilled tutors: Respondents believe it is unlikely training providers will be able to recruit sufficient numbers of tutors who have the necessary knowledge base and understanding of offsite construction. Companies</p>	<p>Utilise manufacturing facilities One opportunity for the construction sector is to make use of manufacturing facilities and expert tutors for training. Whilst currently tailored to the needs of the manufacturing sector, there is clear</p>

⁵³ A range of future skills programmes intended to address projected skills gaps including in DfMA Design for Manufacture & Assembly, Digitisation, Building Information Modelling, Automation, Industrialisation, Leadership are currently in development.



<p>offering training in-house use their own employees to deliver training; even this can be a challenge as it can be difficult for these people to take time out from the day-to-day project delivery.</p>	<p>potential for overlap into offsite construction, to train in relevant manufacturing techniques, principles of lean manufacturing and use of appropriate tools. Some manufacturing facilities⁵⁴ have pools of skilled tutors and access to industry experts to help overcome the issue of the shortage of tutors and assessors. This option may be more pertinent in the future as more, newer and expensive technologies are introduced and as such, increase the need for training in the likes of 3D printing and robotics held at some manufacturing training centres.</p>
<p>Shortage of skilled assessors: Respondents also say there is a general shortage of skilled assessors who would be in a position to undertake onsite training and assessment (OSAT) for the likes of the NVQ in modular construction, making it difficult to offer sufficient training to meet demand.</p>	<p>The ‘hub and spoke’ model Again, the hub and spoke training model is relevant here as a central resource for tutors to access knowledge and materials to help teach them to teach offsite training content. Regional ‘spokes’ could access regional manufacturing facilities to help deliver training.</p>
<p>Uncertainty over apprenticeships: Changes to the specification for apprenticeship in England - from frameworks to standards - and the ongoing uncertainty surrounding the apprenticeship levy create challenges in predicting demand and in preparing for end-point assessment.</p>	<p>Links into industry and mentoring Experienced people from industry could help to plug the shortage of skilled trainers and assessors via secondment roles working with learners in colleges/training providers. For example, TDS Midlands developed its own training academy in 2012, seeking to plug the gap that existed in terms of formal training in steelwork design and detailing. Subsequently re-launched as CADCOE (Construction and Design Centre of Excellence), training is provided by a mix of industry experts and academics, which give students the necessary insight into industry needs and issues. The approach is based on following a project through from design to installation, and crucially, post-completion of training, industry mentoring is maintained for a</p>

⁵⁴ For example the University of Sheffield’s Advanced Manufacturing Research Centre (AMRC)



	<p>period of time. This model therefore addresses the need for skilled tutors/assessors whilst also providing real hands-on training for learners.</p>
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Demand for offsite training is not obvious

“I didn’t know about NVQ’s in modular. They need more promotion”

Offsite manufacturer/installer, England

Issue	What needs to be done?
<p>Companies typically training in-house: As companies tend to assume relevant training is not available/suitable via external providers, the typical stance is to undertake training in-house. From the perspective of providers therefore, the demand for training is not obvious.</p>	<p>Enablers for existing training and qualifications It is obvious that few offsite companies are aware of training and qualifications that already exist, and assume their only route is to undertake training in-house. It will be important to raise awareness, to stimulate demand for relevant training. However, providers may need support in order to respond to demand and ensure training is fit for purpose for employers</p> <p>There need to be enablers to overcome these issues. One such enabler would be a range of regional specialist providers, to improve accessibility and deliver standardised content, operating in a central ‘hub’ and regional ‘spoke’ model.</p> <p>A flexible, blended learning⁵⁵ offer Companies providing their own training in offsite tend to prefer a blended learning model because of the flexibilities this approach</p>
<p>Limited awareness of relevant training and qualifications: Although relevant training exists, the vast majority of respondents are unaware of specific offsite training and qualifications. The default position is to assume that no courses exist at all. Many respondents were surprised to hear that an NVQ in modular construction exists – but also pointed out that a shortage of assessors will make it difficult to offer to the sector (see point 7 below).</p>	

⁵⁵ A learning programme that combines different methods of learning and delivery, such as a mixture of online, self-directed learning and classroom-based delivery



Companies find it difficult to release employees for training: Dealing with the day-to-day, particularly when the sector is buoyant, makes it hard for companies to release employees to undertake training, particularly if the requirement is for blocks of training (e.g. for apprentices).

affords: i.e. it could involve a combination of on-the-job and off-the-job training, meaning less time away from the workplace/workstation than classroom-delivered training. The time issue is particularly pertinent for offsite, where time-efficiency is paramount for realising the benefits of offsite manufacture and construction. A 'menu of options' provides not only a more flexible offer, but also takes different learning styles into account.

For example Stewart Milne has developed blended learning, in collaboration with Scottish universities. Training materials include a training rig – to take apart and reassemble, providing experiential learning. They also have animations of the build process e.g. 'how to' videos on building walls. These can then be used as method statements. More flexible assessment options (in light of the shortage of assessors) could include a range of approaches such as professional discussion, multi-choice testing, and project assignments, some of which could be submitted for assessment rather than relying on a personal meeting.



10. Conclusions and recommendations

10.1 Key conclusions

1. Offsite construction currently accounts for less than 10% of total construction output. However there are clear ambitions for growth and upscaling, underpinned by critical drivers including:
 - a need for more housing;
 - skills shortages in the construction sector and capacity of offsite to address issues faced in the sector, notably low productivity and inefficiency;
 - the ‘digitalisation’ of the construction sector, reinforced by greater use of Building Information Modelling (BIM),
 - emerging new technologies and a focus on ‘smart’ construction and greater automation in the future,
 - a strong impetus for upscaling of offsite construction outlined in the Farmer review.
2. At present the strongest drivers for growth are in the housing and commercial sectors of construction. The UK Government recently announced an additional £1.4bn for the affordable homes programme in the 2016 Autumn Statement⁵⁶. Offsite offers economies of scale for the healthcare, hospitality, retail, leisure and education sectors, which value reduced disruption to their business because of a faster installation.
3. Future opportunities for upscaling offsite may come from the likes of large-scale infrastructure projects, notably HS2 and Hinkley Point.
4. Clients that use offsite construction surveyed for this research say on average, offsite construction accounts for just over a quarter of all the work they commission. Nearly half of them expect this to increase over the next five years, with nearly a fifth saying this will increase a lot.
5. Offsite construction may be more appealing as a career option for new entrants to the construction sector, as a) the working environment is lower risk and more comfortable (compared to being onsite in all weathers), and b) career pathways can be more varied, offering opportunities to move between different functions, and with no discernible barriers to progression to senior roles (with the appropriate training and experience).
6. CITB, as the industry training board for the construction sector, does not have a sector footprint in manufacturing, but there is a clear case to show why CITB needs to have an interest in supporting offsite construction despite its

⁵⁶ <https://www.gov.uk/government/publications/autumn-statement-2016-documents/autumn-statement-2016>



overlap with manufacturing. Traditional construction trades are not only used in the manufacturing environment, but are also being affected onsite, with a need for more multi-skilled operatives for installation and assembly. As levy-paying construction companies shift their practices and the realms of construction and manufacturing become more integrated, so CITB needs to keep pace with the changes in order to continue to support the levy-payers' skills and training requirements.

7. Furthermore, following the closure of Proskills, there is uncertainty over ownership for employer-led qualifications development and oversight and support for training and qualifications in the manufacturing sector more generally. CITB may wish to consider the impact of this likely gap on the manufacturing capabilities of offsite companies.
8. In relation to the key functions of offsite in scope of this research, there are a number of issues for training and qualifications, namely:
 - i. **Most existing training doesn't cover specific offsite skills because of its generic nature**
 - Insufficient coverage of specific offsite content in relation to skills within the suite of existing training and qualifications for the construction sector;
 - Insufficient coverage of 'softer skills' i.e. behaviours and attitudes relevant for offsite within existing training and qualifications; there is no competency framework for offsite setting this out, for example;
 - Gap in standalone knowledge units to equip people with a comprehensive overview of offsite (not technical skills but the knowledge and understanding i.e. such units would be relevant for office-based as well as on/offsite roles)
 - ii. **Shortage of tutors and assessors skilled in offsite to deliver training**
 - Training that does exist which is specific to offsite may not always be readily accessible on a nationwide basis;
 - This partly stems from a shortage of skilled tutors and assessors
 - iii. **Demand for offsite training is not obvious which limits providers response**
 - Limited awareness among employers about training that does exist which is specific to offsite, hence tendency to assume relevant training does not exist and to train in-house, and to their own standard, instead. As a result this suggests to training providers there is limited demand.



9. If not speedily addressed, these gaps and issues will undermine the UK's ability to upskill its workforce required to deliver ambitions to grow the offsite construction sector, as outlined in the Farmer review and CLC innovation workstream.

10.2 Recommendations for CITB

The following actions are recommended for CITB as a result of this research:

Standards and Qualifications

- Conduct a review of National Occupational Standards (NOS), where required, to assess whether there is a need to develop new NOS or amend existing ones, in order to inform the development of new qualification units (see below);
- Seek to develop new qualification units (led by industry) specifically to meet the needs of key roles in the offsite sector where there are gaps, notably for the estimating function, logistics function, and for site supervisors and project managers. This refers to formal accredited provision rather than informal, non-accredited training (discussed below in 'Training and Development');
- Any new such units need to take 'softer skills', including behaviours and attitudes, into account, so that the recognised cultural ways of working for offsite construction are embedded into the mode(s) of delivery. It should be noted that this does not necessarily mean behaviours need to be formally assessed;
- Consider whether there is a need to develop a competency framework for offsite construction, focusing on skills, knowledge, and 'softer skills' (including behaviours and attitudes) that are specifically relevant for offsite e.g. the need to work in a highly inclusive culture with on-going communications between all roles;
- Consider whether there is a need for an offsite CSCS card, which could help to create and embed an industry-wide benchmark 'standard' for offsite construction. Potential disadvantages of this for the sector should be taken into account however – notably that this places the onus on achieving a relevant NVQ to obtain the card. This may be problematic (at least at the outset) in light of other concerns relating to a shortage of tutors and assessors. Introduction of a further CSCS card should only be done if it adds value, rather than burden, to the sector.



Training and Development

- With industry, develop a menu (i.e. a variety to target different job roles) of standalone knowledge (rather than skills) courses, spanning as a minimum: a general overview/introduction to offsite including the different cultures and behaviours, and an introduction to materials typically used. This knowledge-specific, non-accredited training could be delivered as CPD, and/or by employers as well as training providers. Either standalone training courses and/or training materials should be able to be accessed by training providers;
- Knowledge training could offer blended learning to make the training more accessible on the job (e.g. video/audio tools on mobile devices). These courses could be delivered using a regional hub and spoke approach (also discussed in section 9.2 and under 'improving funding' below);
- Knowledge training could be delivered within existing qualifications, or as stand-alone courses of bolt-on CPD, to both train new entrants and help upskill the traditional construction workforce and underpin greater multi-skilling in the future.

Careers

- CITB's marketing team should ensure good coverage of careers in offsite construction remains a key focus, building on work already undertaken including:
 - Promotion of career opportunities and job profiles on Go Construct
 - Industry ambassador schemes which promote offsite roles in schools and colleges
 - Promotion and dissemination of information at key events and existing engagement activities
- Any products or materials should focus on features of offsite roles which are likely to attract wider groups of people to the industry such as:
 - Working in controlled conditions, rather than on-site subject to varying weather conditions.
 - The importance of digital skills which are both in high demand and will be a key hook for attracting younger generations
- Harnessing opportunities for links into the school curriculum, and the potential for creating tailored teaching materials and content that provides awareness and grounding in offsite techniques.



Building Influence and Engagement

- Create linkages and harness synergies where possible, in relation to the actions being taken by the Construction Leadership Council (CLC), further to their work in roadmapping to improve productivity, capacity and innovation in the housing sector and specifically in relation to their commitment to support and create Centres of Excellence for skills and knowledge;
- Promote the existence of relevant offsite training among the sector, to raise awareness and understanding of the types of training and qualifications on offer, notably the NVQ in modular construction and the multi-skilled assembly technician trailblazer apprenticeship;
- Consider how CITB may be in a position to absorb some or all of Proskills' remit to support the manufacturing sector. This needs to be taken into consideration as part of the on-going review of CITB led by the Department for Education. Skills and knowledge needs are evolving – the sector boundaries need to be more flexible as a result.

Improving Funding

- Consider using grant funding to support offsite in the following ways:
 - Fund in-company training schemes⁵⁷; possibly those which are aligned to the industry-approved offsite qualifications and units so as to support standardised training
 - Link new qualifications/units/training to CITB grant to incentivise training provision and uptake
 - Fund training and/or time for upskilling industry assessors and tutors. This could include:
 - Funding those still employed in industry to deliver face-to-face train the trainer courses. This could generate a 'pool' of appropriately skilled tutors and assessors. Such training would be relevant for further as well as higher education.
 - Related to the above, funding the development of a central hub of resources (e.g. videos, webinars, case studies) that tutors

⁵⁷ CITB are already offering funding for in-company training schemes through a training plan – but the scope may need to be expanded for example to provide more funds; it is also likely that awareness of this option will need to be raised among relevant organisations



and assessors could access remotely to improve their knowledge and ability to teach offsite principles and techniques. This may overcome the potential issue of industry professionals not having enough time to deliver face-to-face training.

- Consider the use of funding to help set up (potentially working with other partners in the sector) regional specialist training hubs (not necessarily a physical facility) for offsite construction, to improve accessibility to relevant training, share best practice and offer a flexible, blended learning model taking account of different learning styles (including training for trainers, as noted above). This should link to the work being undertaken by CLC, and should consider how existing manufacturing facilities can be harnessed for this purpose. Use of such specialist training hubs could also be a means of evidencing demand for training in offsite construction with which to potentially prompt local training providers to offer relevant courses as well.



Appendix 1: Methodology

In-depth interviews were undertaken UK-wide with:

- 25 employers;
- 12 manufacturers;
- 6 major clients;
- 8 trade federations; and
- 7 training providers.

Site visits were undertaken with:

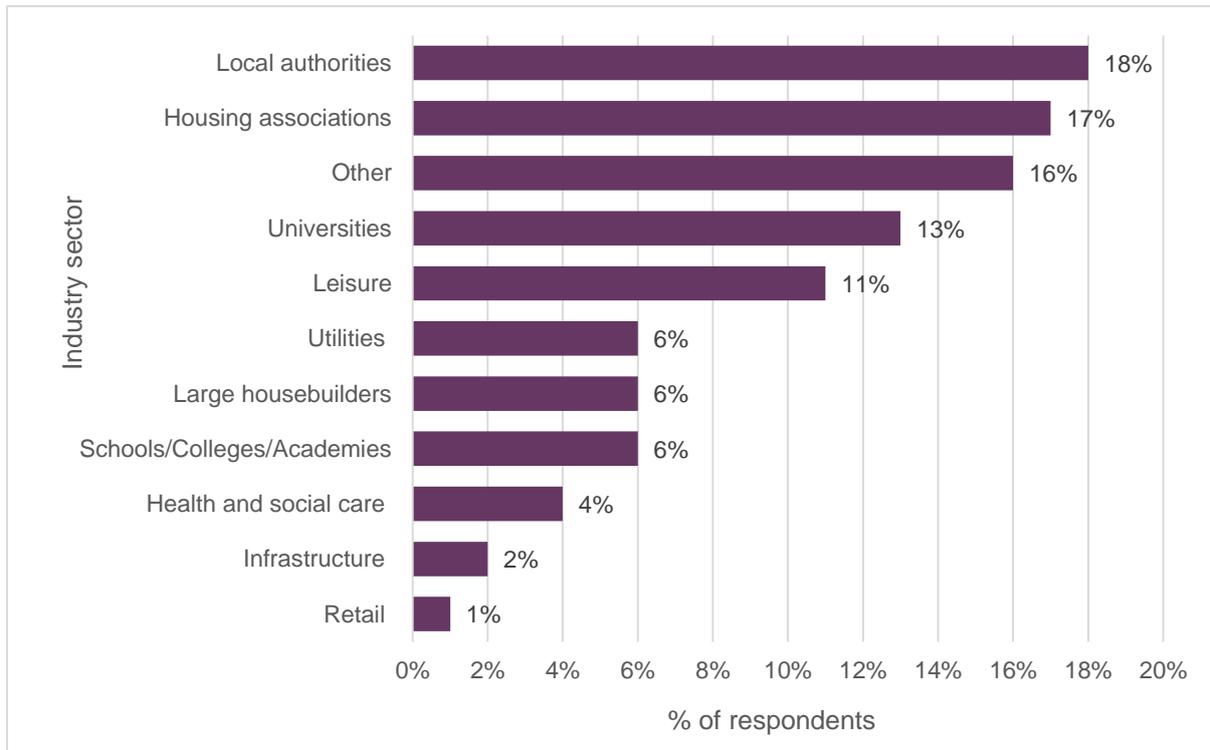
- Kingspan
- Eco Offsite Production
- Laing O'Rourke
- AMRC; and
- Stewart Milne.

It should be noted that further site visits have been scheduled to take place in 2017 (as projects were not due to be installed on site until this time – in due course a number of case studies will be developed from these visits and added as an annex to this report).

A survey of 100 clients UK-wide was also undertaken – the breakdown of respondents is shown in Figure 12.



Figure 12: Breakdown of client respondents, by sector



Base: 100 respondents



Appendix 2: Glossary of terms

AMRC	Advanced Manufacturing Research Centre
BCIS	Building Cost Information Service
BIM	Building Information Modelling
BSI	British Standards Institution
CAD	Computer Aided Design
CDM	Construction Design and Management
CLC	Construction Leadership Council
CLT	Cross-laminated timber
CPD	Continuing Professional Development
CSCS	Construction Skills Certification Scheme
DfMA	Design for Manufacture and Assembly
ECITB	Engineering Construction Industry Training Board
HCA	Homes and Communities Agency
HNC	Higher National Certificate
HND	Higher National Diploma
IT	Information Technology
L&G	Legal & General Homes
MPBA	Modular & Portable Building Association
NVQ	National Vocational Qualification
OSAT	On-site assessment and training
PMV	Pre-manufactured value
Pre-fab	Prefabricated construction
R&D	Research and development
SIA	Security Industry Authority - the organisation responsible for regulating the private security industry in the UK
SIP	Structural Insulated Panels
SME	Small and Medium-sized Enterprises
SQA	Scottish Qualifications Authority
SVQ	Scottish Vocational Qualification
UKCES	UK Commission for Employment and Skills



Appendix 3: Materials used in offsite

Offsite material/item	Explanation
Building Module	Alternative name for 'Pod'. A full area of a room manufactured offsite. Can be one of many units to make a complete building or can be placed inside the main structure as one room.
Closed Panel System	Structural element fully insulated and finished in the factory.
Cross Laminated Timber	Timber boards laid and glued perpendicular to adjacent layers providing a strong and fire resistant structure that can be used for multi-storey builds.
Element	Items manufactured offsite and put together with other components to make a whole product.
Factory Engineered Concrete	Pre-cast concrete elements – walls, floors, ceilings etc.
Flat-Pack	2D elements of a building manufactured offsite (incl. walls, floors, ceilings) and transported to site.
Floor Cassette	Offsite manufactured load bearing floor panel. Usually steel or timber.
Hybrid Building System	Using both volumetric and panelised systems together.
Light Steel Frame	Structure made from galvanised steel. Factory made. Usually used for housing or lightly-loaded buildings.
Open Panel System	Structural element delivered to site to be insulated and finished onsite.
Open Panel Timber Frame	Forms the inner load-bearing part of the cavity wall. Includes timber studs and beams. Most common form of timber frame in the UK. Delivered to site to be insulated and finished onsite.
Pod	Fully finished room. Can include a bathroom or kitchen.
Precast Concrete	Columns, beams or panels, creating a structural frame, manufactured in a factory using moulds.
Roof Cassettes	Offsite prefabricated roof panel, usually timber or steel SIPs and similar to floor cassettes. They are generally used in residential. Fully insulated and ideal for extra roof space.
Structurally Insulated Panels (SIPs)	Complete panel of a building, incorporating the structural elements. Consisting of an insulating core layer sandwiched between two layers of structural board. They combine several components of a building including studs, joists, insulation, air barrier and vapour barrier.
Volumetric unit	Can be a pod or can be room-sized units that are joined together onsite to create the whole building with no additional structural support or frame.



Appendix 4: Selected bibliography

- ARV Solutions (2015) Explore Offsite: <http://www.arvsolutions.co.uk/news.php?id=39>
- Build Offsite (2012) *Buildoffsite Review 2012: the business case for offsite*
- CITB (no date), PowerPoint slide of skills and provision, *Evidence Mapping: Offsite*
- CITB (October 2016) *Employer Attitudes and Motivations regarding Learning and Training, Wave 16 Unpublished research prepared for CITB by IFF Research*
- Construction Leadership Council (no date), *Innovation Workstream: Roadmapping to improve productivity, capacity and innovation in the housing sector*
- Construction Leadership Council Innovation Workstream (Buildings; 2016), *Roadmap for Modern Methods of Construction (MMC) Workshop Report*
- Digital Engineering Technician, Trailblazer Apprenticeship Standard revision (February 2016) *Home Building Skills Partnership, The Size of the Challenge: Where we are now?* HMI Handout
- Farmer, M. (2016) *The Farmer review of the UK construction labour model: modernise or die*
- Gibb et al (2016) *Build Offsite Glossary of Terms (2nd Edition)*
- HM Government (2013) *Industrial strategy: government and industry in partnership Construction 2025* <https://www.gov.uk/government/collections/affordable-homes-programme-2015-to-2018-guidance-and-allocations>
- HM Government (2014) *Affordable Homes Programme 2015 to 2018: guidance and allocations*: <https://www.gov.uk/government/collections/affordable-homes-programme-2015-to-2018-guidance-and-allocations>
- HM Government (2014) *Offsite construction companies take a new approach to tackling skills shortages*
- Laing O'Rourke Learning Outcomes Framework for OC01, OC02, OC03, OC04 and OC05
- NHBC Foundation (2016), *Modern Methods of Construction Views from the Industry*
- OWG (no date), 12 Key Role Recommendations of the Occupational Working Group to the HBSP Skills and Development Activity Group
- RLF Building Futures (2016) *The Benefits of Offsite Construction*, blog: <http://www.rlf.co.uk/the-benefits-of-offsite-construction/>
- Scottish Government (no date) Building Standards information on 'Sustainability' <http://www.gov.scot/Topics/Built-Environment/Building/Building-standards/techbooks/Sustainability>
- Skyblue (2016), *The Case for Collaboration in the Homebuilding Supply Chain Report*
- UKCES (2013) *Technology and skills in the construction industry*
- UK Construction Week and Housebuilder Magazine launched a joint Survey, UK Housebuilder Survey (2016)



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Authors:

Jennifer Brennan, Associate Director
Clare Vokes, Research Manager

<p>Pye Tait Consulting Royal House, 110 Station Parade, Harrogate, HG1 1EP Tel: 01423 509433 Fax: 01423 509502 Email: info@pyetait.com Website: www.pyetait.com</p>	 <p>MRS Evidence Matters™ Company Partner</p>  <p>CERTIFICATION ISO9001:2008 Member of SN Registrars (Holdings) Ltd</p>  <p>UKAS MANAGEMENT SYSTEMS 8327</p> <p>Cert No: 76000/GB/Q</p>
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