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New build: Materials, techniques, skills and innovation ☆

Jacqueline Glass *, Andrew R.J. Dainty, Alistair G.F. Gibb

Department of Civil and Building Engineering, Loughborough University, Loughborough, Leics LE11 3TU, UK

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ABSTRACT

The transition to secure, sustainable, low-energy systems will have a significant effect on the way in which we design and construct new buildings. In turn, the new buildings that are constructed will play a critical role in delivering the better performance that would be expected from such a transition. Buildings account for about half of UK carbon dioxide (CO_2) production. So it is urgent to ensure that energy is used efficiently in existing buildings and that new building stock is better able to cope with whatever the future holds.

Most energy used in buildings goes towards heating, lighting and cooling, but a growing percentage is consumed by domestic appliances, computers and other electrical equipment. Actual energy consumption is the product of a number of factors, including individual behaviours and expectations, the energy efficiency of appliances and the building envelope. This review focuses on the third of these, the building itself, and its design and construction. It discusses the issues faced by the construction industry today, suggesting that major changes are needed relating to materials, techniques, skills and innovation. It moves on to consider future advances to 2050 and beyond, including developments in ICT, novel materials, skills and automation, servitisation (the trend for manufacturers to offer lifetime services rather than simple products), performance measurement and reporting, and resilience. We present a vision of the new build construction industry in 2050 and recommendations for policy makers, industry organisations and construction companies.

1. The state of current science—pressures on buildings today

For the UK's building stock to deliver better performance, a range of important problems must be addressed. Some have plagued construction for many years and some are unlikely to change for many more.

The first problem is that the rate of replacement of buildings in the UK, particularly in housing, is low. About two-thirds of the buildings that will exist in 2050 are already built and being used today. Only about a third of building stock will be new and will have been built in response to issues such as climate change. The crux is what any new stock could and should be expected to contribute. One could argue that all new buildings should be super-efficient or carbon-negative, and should be designed and constructed in such a way that they effectively 'make up for' all the energy-laggard stock that will still be in use in 50 years. But this alone will not offer a panacea. There will also need to be major changes to existing buildings through refurbishment, envelope improvement and equipment replacement.

Secondly, within the domestic sector at least, significant changes to address sustainability are afoot. Building regulations have changed to respond to European legislation on energy efficiency, and the Code for Sustainable Homes sets new standards up to 'carbon neutral' (DCLG, 2006). There are calls for such schemes to be extended to non-domestic properties to widen the benefits and spread environmental accounting. Sustainability assessment tools such as BREEAM, the Building Research Establishment Environmental Assessment Method, are growing in popularity. In some cases it is mandatory to attain certain levels of achievement to satisfy new procurement requirements, particularly for public sector projects. Clearly this challenges designers, materials providers and constructors. Specifiers are becoming more interrogative in their decision making as a result.

Thirdly, the construction industry as a whole has been subjected to decades of criticism for its lack of innovation, poor safety record, inconsiderate operational environment and general under-performance (e.g. Egan, 1998; Fairclough, 2002). Recent initiatives call for significant culture change in the industry, such as better team working, procurement practices and sustainability (Egan, 2002). Unfortunately, a substantial, unsophisticated section of the industry barely meets existing requirements. It creates environmental problems, kills people on unsafe sites and does little more than provide the physical actuality of the building itself. This under-performing legacy cannot continue. To their

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* Corresponding author. Tel.: +44 1509 228738; fax: +44 1509 223981.
E-mail address: j.glass@lboro.ac.uk (J. Glass).

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credit, many companies can no longer be described in such terms, but achieving new targets on safety (Defra/DTI/DCLG, 2007) may still be difficult.

Fourthly, there are still inadequate skills, and too few skilled operatives and professional staff to serve the industry's needs. The skills shortage in the UK has been mitigated to some extent by migrant labour. But there are specific skills gaps, for instance in developing sustainable communities (Egan, 2004; Pearce, 2003). This creates vulnerability and it is understandable that government and industry are again examining the viability of off-site construction and prefabrication, and on-site advances such as mobile communications and robotics, as means of reducing the reliance on site labour (e.g. ECTP, 2005). But even these proposals do not address professional skills shortages.

Finally, there are external factors such as oil depletion, water supply problems, globalisation (Harty et al., 2007) and the broad 'resilience' agenda, which includes natural and man-made hazards such as climate change, terror threats, wind-storms and flooding (Arup, 2006; Bosher et al., 2007). Any or all of these has the potential to very significantly affect the way we build, but at the moment there is only localised and sporadic change, for example in response to specific incidents such as tidal and river flooding, or blast protection to critical infrastructure.

Replacement rates, sustainability, a lack of innovation, skills needs and external factors are five major pressures which demonstrate that to create more sustainable, energy-efficient and resilient buildings is a transition that requires wholesale change, both top-down and bottom-up. This suggests that a systems approach would be appropriate to address such a combination of supply and demand pressures. Indeed, Gann (2000, p. 195) reminds us of the danger of 'overemphasising the physical characteristics of construction'; considering the building in a detached way, separate from its environment and its social setting. In the same vein, Elzen et al. (2004) and others emphasise the importance of including an analysis of the socio-technical systems that surround new buildings when thinking about their future use. With this notion in mind, Table 1 presents a PEST analysis of relevant enablers and barriers faced by the industry in developing better new build. It indicates that there are key challenges ahead, some of which echo the ongoing concerns about the industry's performance cited above.

Today's pressures and these enablers and barriers suggest a clear need for change. Ultimately, it is the construction industry that must deliver the building blocks of a secure, sustainable, low-carbon society. However, in construction the normative position is overwhelmingly one of begrudging response. It is very rarely proactive. In the short term at least, change needs to be imposed top-down, and supported bottom-up with encouragement and reward. The transition that is needed is so large that visible change will almost certainly be needed in the new build sector.

Harty et al.'s (2007) review of construction futures literature offers useful insights in this regard. It confirms that we should expect imminent changes in:

- what we require materials to do (e.g. be low carbon, be resilient, or be adaptive to temperature change),
- what we expect of building techniques, production methods and construction sites (e.g. be more considerate, attract regional staff, or use more robotics),
- what we require people to know (e.g. be more informed on specification and design, or more IT-literate) and
- what we will expect of innovation, R&D and management (e.g. be much more revolutionary, rather than incremental, and reward change leaders).

One of the reports analysed by Harty et al. (2007) was the Australian *Construction* 2020 (Hampson and Brandon, 2004). It offers some useful insights and nine specific visions covering sustainability, client needs, welfare, ICT and processes in construction and product manufacture. Many of these are common to the majority of recommendations in other key texts on construction innovation. We can conclude that there are some collectively held concerns about the industry and a number of pressures being brought to bear, and that a systems approach could shed new light on the problem.

Table 1
PEST analysis of enablers and barriers in new build construction

Political		Social	
Enablers	Barriers	Enablers	Barriers
• Building regulations • Energy policy • Sustainable construction strategy • Planning policy • Waste reduction agenda • Climate change agenda • Security and resilience agenda	• 'Stick'-based legislation • Lack of teeth in legislation • UK seen as unnecessarily restrictive legislative environment for manufacture	• Rising consumer engagement • Interest in resilience to climate and man-made hazards • Inclusion in professional curricula • New taught courses on sustainability issues	• Regionality: diverse contexts • Skills shortage • Migrant labour • Need for CPD/skills development • Construction's reputation—dust and noise • Lack of capacity and know-how • Too much green 'spin' and marketing
Economic		**Technological**	
Enablers	Barriers	Enablers	Barriers
• Fiscal-based legislation (landfill tax, etc.) • Cost of moving goods by road • VAT • Carbon accounting methods • Sustainable procurement action plan	• Negative investor views of industry • Threat from imports, balance of trade • Cost of UK production • Land/house prices • Energy costs	• Drive for low carbon buildings • Carbon footprinting • Demand for ISO and EMAS • Mobile computing and ICT • Logistics solutions, materials consolidation centres • Change driven by health and safety	• Lack of R&D • Slow rate of change of building stock • Poor client knowledge base • Poor specification writing and estimating • Materials' cost and availability • Lack of data and evidence