The Future(s) of Construction: a Sustainable Built Environment for Now and the Future

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The global construction industry creates high-profile structures and critical infrastructure systems, yet is frequently rebuked for its frequent poor performance and lack of forward thinking and future planning. Looking to the future, the industry is likely to be driven by a combination of evolving national and international policy on sustainability, the legacy of the local and global economic problems and the increasing pace of technological innovation.

In the longer term, a more complicated and inter-related collection of drivers is at play, including demographic shifts, policy and societal evolutions, energy and water security, as well as sustainability pressures such as the changing climate and its effect on the resilience of our critical infrastructures.

A more futures-orientated and inter-connected approach to global construction, projects and practices, is therefore required in order to create a truly sustainable industry, and hence planet, for all. Only by planning ahead for the longer term, and working together at a local and global level, can the global construction industry hope to move forwards collectively to creating a truly sustainable and resilient built environment, fit for purpose, fit for now, but also fit for the long term.

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ABSTRACT: The global construction industry creates high-profile structures and critical infrastructure systems, yet is frequently rebuked for its frequent poor performance and lack of forward thinking and future planning. Looking to the future, the industry is likely to be driven by a combination of evolving national and international policy on sustainability, the legacy of the local and global economic problems and the increasing pace of technological innovation.

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1 INTRODUCTION

The global construction industry currently faces significant challenges, some long-standing and others triggered by the economic downturn. Some factors, such as changing demographics, are external to construction, while others, such as increased standards and legislation, come from within the sector itself. It is assumed that external macro-drivers, such as climate change, will have an impact on the global construction sector in the future, but little consideration has been given to how these might intersect with internal dynamics, such as the organisation of the sector, or the skill requirements of the construction process.

This raises questions about the extent to which construction firms and practitioners are able to intervene and influence the processes of change – e.g. what can be done to take into account the problems of a changed future climate in decades from now?

The most significant barriers facing the global construction industry include climate change, energy, resilience, sustainability, and the take up of new technologies, materials and methods, with the exact order always being debatable.

Construction and civil engineering as an industry creates high-profile structures, critical infrastructure and transport systems, yet has frequently been berated for its lack of forward thinking and poor performance, ironic since it aims to deliver projects with intended service lives of 100s of years (Foresight, 2008; Goodier et al., 2007). The industry is often perceived as lagging behind in adopting novel technologies, materials, practices and processes (Foresight, 2008; Goodier and Pan, 2010), yet designers are often prevented from taking advantage of novel solutions because when these are developed, their journey into the marketplace and into specifications is slow, often tortuous, and often blocked. In contrast, conventional materials, codes and standards are based, in many cases, on more than 100 years of use and experience, such that there is confidence in their general behaviour. This principle remains true for innovation in respect of sustainability; while there may be a strong ethos to innovate to minimise environmental impacts, there may be a range of practical, regulatory or cultural challenges to doing so (Glass et al, 2013).

2 LOOKING TO THE FUTURE, AND WHY

The motivation for looking to the future is to think about how the industry, climate, firms and other actors might respond to a range of potential influences in the future. Preparedness (which is often likened to organizational agility) is therefore central to forecasting and strategic planning as methodological approaches (Goodier, 2010).

Forecasting exercises are often carried out as an aid to decision-making and in planning the future. They typically work on the premise that if we can predict what the future will be like then we can modify our behavior now to be better positioned for the future than we otherwise would have been. Example applications include inventory control/production planning, investment policy and economic policy. Global construction projects such as dams and national transport systems involve similar planning.

Forecasts are sometimes future values of a time-series e.g. the number of houses sold in a year, or the likely demand for electric cars. Forecasts can also include one-off events such as the opening of a new power station, or a new energy policy. Forecasts can also be distributions, such as the locations of wind farms or the installation of solar panels among different age groups. It also includes the study and application of judgment as well as of quantitative (statistical) methods (Goodier, 2010).

Forecasting the future of technology can be a hazardous enterprise. There is often a shortsightedness, even among experts, that causes them to focus upon the future in terms of present conditions. One famous example is the call by the US Commissioner of Patents in 1899 to abolish the Patent Office on the grounds that there was nothing left to invent. Futures studies also sometimes suffer from being perceived as an attempt to forecast or foresee the future. Prediction is not their purpose however– their usefulness is in helping people and firms prepare for an uncertain future by producing a range of possible futures and identifying potential risks and opportunities in order to inform current decision making.

Examples of recent forecasts include the UN, who report that millions of new jobs will be created worldwide over the next few decades by the development of alternative renewable energy technologies, with those working in biofuels rising from one million today to 12 million by 2030. Another report from the American Solar Energy Society shows that as many as 1 out of 4 workers in the U.S. will be working in the renewable energy or energy efficiency industries by 2030. These industries already generate 8.5 million jobs in the U.S., and with appropriate public policy, it is forecasted that this could grow to even 40 million jobs by 2030.

2.1 What about the construction industry?

Many of today's problems cut across disciplines and sectors, particularly in industries as broad and diverse as construction, especially globally. 'Joined up' thinking and avoiding 'silo mentalities' are advocated as necessities for cross-sectoral working, progress and innovation. However, for both practical and historical reasons, expertise traditionally remains concentrated within sectors or disciplines. Relatively few examples exist of construction companies engaging in futures studies and there is a marked reluctance to plan for the long term due to the relative volatility of the market and a perceived lack of control over factors external to the organisation which dominate (GOS, 2008; DTI, 2001; Egan, 1998).

Construction is an example of a sector which has frequently been berated for its poor performance and lack of forward thinking (e.g. DTI, 2001) and is frequently perceived as lagging behind in adopting new technologies, working practices and processes (Egan, 1998). Recent future-oriented reports and studies have called for the construction industry to expand their planning horizons by looking beyond their next project to help prepare themselves for potential future events and trends (GOS, 2008). However, construction organisations are highly dependent on externalities, often with complex inter-dependency. Perhaps as a result, most construction companies are reluctant to engage in planning beyond a few years and there is little evidence of a formal process in the formulation of long-term strategies, or even to reflect on the long-term. This is often attributed to inadequate resource capacities, instability of employment, the unpredictability of the construction market, and the predominance of small-sized companies operating within the sector (Brightman, 1999).

3 THE GLOBAL CHALLENGES AHEAD

The most significant barriers facing the global construction industry, both now and in the future, include climate change, energy demand and supply, resilience, sustainability, and the take up of new technologies, materials and methods - with the exact order being always debatable.

3.1 The changing climate

One of the main challenges facing construction globally in the present, near and more distant future is the need to engage fully with climate change, both mitigation (reduce carbon emissions) and adaptation (to cope with it). The UK government for example, has an ambitious long-term goal to reduce carbon emissions by 80% by 2050 (DECC, 2008). Furthermore, with the housing sector accounting for around a quarter of the UK's carbon emissions, and the built environment overall responsible for nearly half, it is obvious that we will need to drastically adjust the way we design, build and use our homes and infrastructure, as well as to modify (even curb and/or restrict) the way we live and work. Adapting to this changing climate will impact on the design, construction, location, cost and operation of all new homes and infrastructure over decades to come.

The global climate is changing in ways that are likely to have a significant impact on society and the natural and built environments. Extreme weather events all over the world are increasing in frequency and severity, and the consequent cost of managing them and their impacts will also increase. Increased preparedness and resilience measures are needed to help mitigate impacts and associated costs to both infrastructure and to people (Goodier et al, 2008).

Threats to the built environment are extremely diverse and include extreme natural and human-induced hazards (Goodier et al, 2007), which, as well as infrastructure, can disrupt the economy and society. It has been suggested that with socio-economic progress the built environment becomes more vulnerable as settlements become more reliant on their increasingly extended supply lines (Menoni, 2001), as well as the ever-expanding critical infrastructures of transport, water, power generation and distribution, and information and telecommunication systems. Furthermore, with growing globalisation, major conurbations are also increasingly inter-connected, on a number of levels, and a disruption in one can initiate significant problems in many others (Ofori, 2002).

The construction industry represents a significant proportion of every nation's savings, e.g. the Gross Domestic Fixed Capital Formation in construction has been shown to be between 45-60 % of a country's total value (Hillebrandt, 2000). Certainly, influential reports such as the Stern Review (Cabinet Office/H.M. Treasury, 2006) on the economics of climate change, recommended that it is everyone's concern to proactively deal with these increasing hazards that are likely to threaten our society, both local and global.

In the future, as well as general or average higher temperatures, changing patterns of precipitation and changing sea levels, we must also expect an increase in the frequency and intensity of extreme weather conditions, such as very high temperatures, or very heavy and quick downpours of rain. Some of these changes are already being felt; the 1990s was recorded as the warmest decade in central England since records began in the 1660s and 2006 was also the warmest year in the UK since records began. The UK summer floods of 2007 provided a stark indication of what may become a regular occurrence, with this was one experience costing the UK insurance industry over £3bn (ABI, 2007). This is in addition to the wider social impacts that continue to affect the local communities involved which have yet to be fully determined. The incidence of heatwaves and water resource drought are also projected to increase, both in the UK and across Europe, as climatic models predict wetter winters and drier summers (ABI, 2007). Indeed, water security and supply is a key challenge of the future, and not just in drier climates. Heavy storms during the last decades across Europe have also prompted severe human losses and extensive damage to the built environment.

Although the effects of the changing climate are generally being taken into account in the development of new building standards, recommendations are often lacking in other forms of current guidance, as well as implementation, particularly for the existing stock of building and infrastructure.

3.2 Resilience of critical national infrastructure

Resilience is often thought of as a long-term adaptive, transformative process (Coaffee et al, 2009). The resilience of any system, either human or natural or man-made, depends mainly on the capacity of that system to adapt its structure, although not necessarily function, to a new configuration when exposed to a specific threat (Sage et al, 2013). Thus, *enhancing* resilience often demands more than simply improving the ability of a system to recover to a past state, or to resist a specific threat. Many infrastructure planners and policies however, struggle to fully grasp, and thus improve, adaptive modes of resilience. Regarding infrastructure and the built environment, it is increasingly recognised that whilst it can never be totally resistant, it should be designed in a manner that allows recovery and adaptation following a catastrophic event (Coaffee et al, 2009), especially given the increasingly unpredictable and globalized nature of threats (Beck, 2002).

The UK's Civil Contingencies Secretariat (CCS) recently defined resiliency as the process through which *"assets, networks and systems anticipate, absorb, adapt to and / or rapidly recover from a disruptive event"*, sub-divided into four elements, *"resistance; reliability; redundancy; response and recovery"* (Cabinet Office, 2011: 15). With regards to infrastructure, the CCS defines a measure of resilience as security of the supply of a service, particularly within critical national infrastructure. The CCS prioritizes critical national infrastructure (CNI) as central to societal resiliency, wherein the *"loss or compromise of which would lead to severe economic or social consequences or to loss of life"* (Cabinet Office, 2010: 8). The UK's Cabinet Office (2011: 12) defines nine critical infrastructures: finance, health, food, government, emergency services, transport, energy, communications and water.

3.3 Energy – less centralised and more renewable

The UK's 2008 Climate Change Act set a legally binding target of reducing the UK greenhouse gas (GHG) emissions by 80% compared to 1990 level by 2050 (DECC, 2008). In order to reach this target, a shift has to be made towards more sustainable and renewable forms of energy, and the significant challenge of restructuring the energy system has to be addressed. The main drivers for this transition are the necessity to reduce GHG emissions as well as to increase the share of renewables in the energy mix and to make the use of energy more efficient, together with concerns over rising electricity demand and the price of fuel, energy market liberalisation and increasing concerns over energy security (GOS, 2008).

Indeed, a number of towns, cities and communities in the UK and worldwide have already pioneered unique and effective approaches to more decentralised energy (DE) systems leading to enhanced GHG emissions reductions. The implementation of these approaches, however, is (in the main) a long and complicated process that requires not only financial investments but also support from the authorities, community engagement and other factors that if underestimated can negatively affect the outcome of the project.

The current UK electricity system, like many in Europe, is highly centralised and relies greatly on fossil fuels. Although this centralised model is historically established, it has substantial disadvantages (Allen et al, 2008) whereas more decentralized energy systems frequently claim to be more resilient, reliable, efficient and environmental friendly, as well as more affordable and accessible, whilst offering greater levels of energy security (e.g. Coaffee, 2008). Decentralised generation and supply is, however, yet to play a significant role in the UK's energy systems, although development is increasing faster in similar developed countries such as Denmark, Germany, Sweden and others. In 2008 the UK Government Office for Science published a report into sustainable energy management and the built environment to investigate this issue of lock-in to centralization (GOS, 2008). Based on future scenario development and commissioned expert review papers (all available at www.bis.gov.uk/foresight), this report argued that the UK should make better use of the full range of energy systems.

3.3.1 Energy and the environment

Energy and climate change are only two facets of wider sustainability, and it is imperative that as we look to the future and the changes that we impose, we must also maintain and take care of the ecological and environmental systems on which all societies depend. The benefits (and dis-benefits) that we all gain from these ecological systems are termed ecosystem services (Ehrlich and Ehrlich, 1981) and we must be careful to fully understand how changes in energy demand, production and supply affect environmental and human services such as these (Howard et al, 2012).

There is growing awareness that the increasing number of renewable decentralised energy technologies may have significant impacts on a range of these ecosystem services in the locality where they are deployed (Omer, 2009). Most renewable energy systems have a lower energy content than fossil fuels and subsequently have much larger spatial footprints. In parallel with this, human population growth and increasing per capita consumption places further demands on available land to provide food and potable water and housing. Inconsiderate alteration of any of these services may inadvertently compromise the delivery of others and the risk of such impacts must be monitored if conflicts between policies, goals and the wider environment are to be minimised.

3.4 Technological innovations and materials

The need to reduce the carbon footprint of construction projects is becoming increasingly recognised. The UK's Environment Agency for example, has committed to reduce carbon in all its future projects, and even share their experiences with others (EA, 2010). A more detailed materials-focused example has shown that 25% of the carbon footprint associated with construction work relates to the use of concrete, particularly Portland cement, which has a high embodied environmental impact (Mason et al., 2011). The two main environmental impacts related to CEM I are the depletion of extracted resources such as limestone, and GHG emissions from burning fuels during production. Although supplementary materials such as fly ash and ground granulated blast-furnace slag (ggbs) can help, opportunities must be taken to reduce environmental impacts in other phases of the life-cycle of a structure e.g. via a life cycle assessment (LCA) or similar. As countries demand for raw materials increased resource efficiency also becomes more important, as does the responsible sourcing of these materials.

Wolstenholme (2009) argues that the construction industry is resistant to innovation and the implementation of new ideas. However, in order to increase competitiveness and address some of the challenges above, many firms are moving towards more innovative construction approaches. The segmented composition of the sector does not always allow the straightforward and widespread implementation of new innovations, even if they are adopted from similar sectors (e.g. housing). Nonetheless, it is imperative for companies at all scales and all along the supply chain to engage with innovative to help minimise costs and to deliver an efficient product (Vernikos et al 2012). Recent initiatives – such as building information modeling (BIM), lean construction and offsite assembly –aim to reduce costs through improved planning, resources and enhanced data management. Offsite construction methods and standardisation are worthy of consideration for infrastructure due to their successful track record in other engineering sectors. Many parts of the commercial building and housing industry have already embraced these methods for some years now to help increase efficiency, raise quality and reduce costs (Goodier and Pan, 2010).

If the global construction industry is to help address the challenges of increased renewable energy, resilience, and the changing climate, then it must also, alongside this, engage strongly with ongoing technological and organizational innovations, whilst resourcing its materials in a responsible and efficient manner.

4 THE FUTURE

Even if the global construction industry had the necessary technological skills and tools and information, there is the difficulty of forecasting what characteristics the future might actually involve for any given project. An understanding and appreciation of the future ahead should arguably be a central requirement in the global construction sector, because it is they who design, build, and increasingly manage and operate the infrastructure and buildings that will be used over the coming decades, with the design life of major infrastructure often being 100 or even 150 years. The global construction industry needs to expand its planning horizons to prepare for potential future events, trends and operating environments (Foresight, 2008; Goodier and Pan, 2010), yet construction companies appear reluctant to engage in planning beyond a few years, or past the next project, and there is *"little evidence of a formal process in the formulation of long-term strategies"* (Goodier et al., 2010). Basic strategic planning along the lines of a SWOT or PESTEL/ STEEP type analyses is often conducted, but usually focusing more on business or market strategy rather than that of the infrastructure being designed and built. Isolated examples exist, in the form of future scenarios for a place, a technology or a sector (e.g. Foresight, 2006; Goodier and Pan, 2010), but are rarely used to inform designs or company strategy or policy. Other sectors however, routinely use scenario planning and other futures techniques to help shape their long-range planning (Eden and Ackermann, 1998). The hesitancy in the construction industry to plan for the long term is often blamed upon the relative volatility of the commercial market and a perceived lack of control over factors external to their organisation (Goodier et al., 2010), but this entrenched approach is stifling the development of more future-focused design and construction approaches.

There is much to gain from a more future-focused approach. Kaethner and Burridge (2012) for example, suggest that on a typically sized non-domestic building, through careful specification, a structural engineer could save their lifetime's personal carbon footprint. It takes considerable time however, for traditionally conservative industries such as construction to embed and engage with these principles in day-to-day activities. In Sweden for example, one of the most forward looking and innovative construction countries, a regular survey on the construction industry's environmental attitudes and practices revealed that it takes at least ten years for companies to go from awareness regarding sustainability issues to having a collection of sustainability practices implemented in their business (Thuvander et al., 2011). It was noted that evidence of future life-cycle thinking was found mainly in materials databases, procurement procedures and as a decision-making parameter for source separation and other waste management practices.

One potential pathway suggested, is to *"combine the science of futures-based research with quantitative analysis mechanisms within life-cycle analysis to explore possible futures in a more numerical way"* (Glass et al, 2013), which would provide more engineering numerical rigor to the traditionally more qualitative approaches of futures thinking.

Many forward-thinking members of the global construction industry are able to identify current (and near future) important trends, issues and events, but are often poor at *"even acknowledging interdependencies, never mind identifying the potential consequences"* (Goodier et al, 2010). In addition, the majority stay within their domain of knowledge, and have weak relative appreciation of advances in related (never mind disparate) areas. This resistance is often intensified, especially in the construction industry, by the need *"to operate within strict industry and government codes and regulations which can often stifle creative and futures-orientated thinking"*. Identifying and exploring interconnected events helps to extend practitioners sphere of thinking, facilitate communication amongst key stakeholders, and enhance understanding of the context within which their strategic decision making takes place (Goodier et al, 2010).

Beneficiaries of a move towards a more futures orientated perspective would not only be clients, infrastructure and asset owners/managers and the public, but also the global construction industry itself, which needs to better prepare for its own individual future, through the creation of a more educated, informed and forward-thinking industry, accumulating and capturing the knowledge of its diverse participants, in order to stimulate creative thinking and hence deliver successful, and more innovative, construction solutions.

5 IN CONCLUSION

Despite the challenges outlined above, the future of construction is likely to be driven by a combination of evolving government policy on sustainability, the legacy of the local and global economic problems and the increasing pace of innovative technology (including decentralized and renewable energy technologies, offsite and standardization, new materials and advanced information technology) in the short and medium term.

In the longer term, the global construction industry is likely to be driven by a more complicated and inter-related collection of drivers, including demographic shifts, policy evolutions and the changing climate (at a global and local level). Additional drivers, such as the global market place, and sustainability pressures such as renewable energy, water security and supply, minimizing waste and the ecosystem, will all become increasingly dominant.

There are clearly a set of challenges currently constraining the development and application of a more futures approach to global construction, projects and practices, and as a result, the industries ability to create a truly sustainable industry is being slowed down. Only by planning ahead for the longer term, and working together at a local and global level, can the global construction industry hope to move forwards collectively to creating a truly sustainable and resilient built environment, fit for purpose, fit for now, but also fit for the long term.

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