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Analyzing the need for Offsite construction and standardization in the UK Water and Environmental Management sectors

V.K. Vernikos¹, C.I. Goodier¹, A.G.F. Gibb¹, P.C. Robery² and T.W. Broyd³

¹*School of Civil and Building Engineering, Loughborough University,
Loughborough, UK*

²*Halcrow Group Ltd, London, UK*

³*University College London, London, UK*

The benefits of Offsite construction have been well documented. However, it is mainly the building sector that has been systematically employing such techniques, rather than civil engineering sector such as water and environmental engineering. The whole construction industry is under extreme pressure to reduce cost and deliver more sustainable infrastructure. This, coupled with increasing high flood risk problems, has increased the need for overall improvements. This increasing strain is reflected in the water authorities, who are considered as 'clients' for the construction industry supply chain. During the past year there has been a great interest from leading UK water and environmental management (W&EM) firms to develop and implement Offsite in their processes. The objectives for this initiative were to minimise cost, reduce disturbance to the public and manage the environmental impact in a more sustainable way. Recently, a number of new products have entered the water and wastewater market. Such solutions, in conjunction with the re-evaluation of decision making processes within the firms, create a fertile environment for Offsite implementation. The supply chain appears to reflect this need and is working collaboratively in order to provide competitive services to its clients. This paper reports and analyses the market inclination towards Offsite construction and standardisation. Through a critical literature review, an analysis of corporate research and development strategies and an examination of specific solutions, the reasons for increasing Offsite innovation are revealed. The findings identify innovative procurement methods and strategic planning as the primary drivers for the uptake of Offsite construction and standardisation in the sector.

Corresponding author: Vasileios Vernikos, v.vernikos@lboro.ac.uk, +44(0)1214560643

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ABSTRACT: The construction industry is under extreme pressure to reduce cost and deliver more sustainable Infrastructure. During the past year there has been a great interest from leading UK water and environmental management (W&EM) firms to develop and implement Offsite in their processes. The objectives for this initiative were to minimise cost, reduce disturbance to the public and manage the environmental impact in a more sustainable way. Recently, a number of new products have entered the water and wastewater market. Such solutions, in conjunction with the re-evaluation of decision making processes within the firms, create a fertile environment for Offsite implementation. The findings identify innovative procurement methods and strategic planning as the primary drivers for the uptake of Offsite construction and standardisation in the sector.

1. INTRODUCTION

Many experts in industry and academia have seen Offsite as the future for the construction industry (DTI, 1998; Harty et al, 2007; Soetanto et al, 2006; Pan et al, 2007). There is significant research identifying and analyzing drivers and barriers for Offsite (Goodier and Gibb, 2007; Blismas et al, 2005). In this paper the importance of key government targets is described and reasons for realizing Offsite construction in the W&EM sector are established. The W&EM sector has a history of adopting best practice methods in the UK (Anglian Water, 2010; Southern Water, 2012). Accordingly, the paper focuses on what W&EM clients recognize as Offsite, their misconceptions and how they attempt to incorporate such solutions in their processes.

2. BACKGROUND

With most of the water supply and sewage infrastructure in the UK having been built in the nineteenth and early twentieth century, the network is in need of major improvement (HM Treasury, 2010a). During the past fifty years there has been a change in industry's perception of how infrastructure assets should be managed. Nowadays, they are not seen as unconnected structures but rather an interconnected network that directly affects the operability of other assets (HM Treasury, 2010b). Extremely conservative estimations indicate that Britain will

spend £45-50 billions in the W&EM sector by 2020, which is 10-11% of the total expenditure towards its infrastructure (Helm et al, 2009). The current annual spend in the sector is £4 billion for 2010-2015 but is expected to increase as projects such as the Thames Tideway commence. The construction industry is under extreme pressure to reduce costs, since according to the Eurostat Construction Price survey (Figure 1) the UK has the fourth highest civil engineering costs (Eurostat, 2009).

The government aims to reduce the greenhouse gas emissions by 80% by 2050 (Climate Change Act, 2008). The construction industry, especially the water and environmental management sector is under pressure to contribute to this goal by optimizing their processes to deliver low cost, low carbon footprint and good quality infrastructure (Water UK, 2006). In addition, the sector has the main responsibility of safeguarding UK infrastructure from extreme weather events. The Meteorological (Met) Office and the Chartered Institute of Water and Environmental Management consider extreme weather phenomena and the socio-demographic challenges derived from climate changes to be the greatest risk of critical infrastructure. Since Peter Hansford took over as chief construction advisor, the pressure for not only value for money but also value for carbon has increased (Hansford, 2011).

There has been an initiative to improve the regulatory regime for the water sector in order to assist with the current industry demands. The Council for Science and Technology (CTS) instigated changes in mechanisms aiming to reward innovation through new technologies, resulting in stimulating the supply chain to develop more sustainable and efficient solutions. Currently the development of innovative solutions is hindered by a five-year regulatory review period (HM Treasury, 2010c). Furthermore, the CST report urges for a reward process for the water and sewerage firms that commit investment for developing long-term sustainable, low-carbon solutions (CST, 2009). The above recommendations also concur with the findings from reports of the Institution of Civil Engineers (ICE, 2009; ICE, 2011).

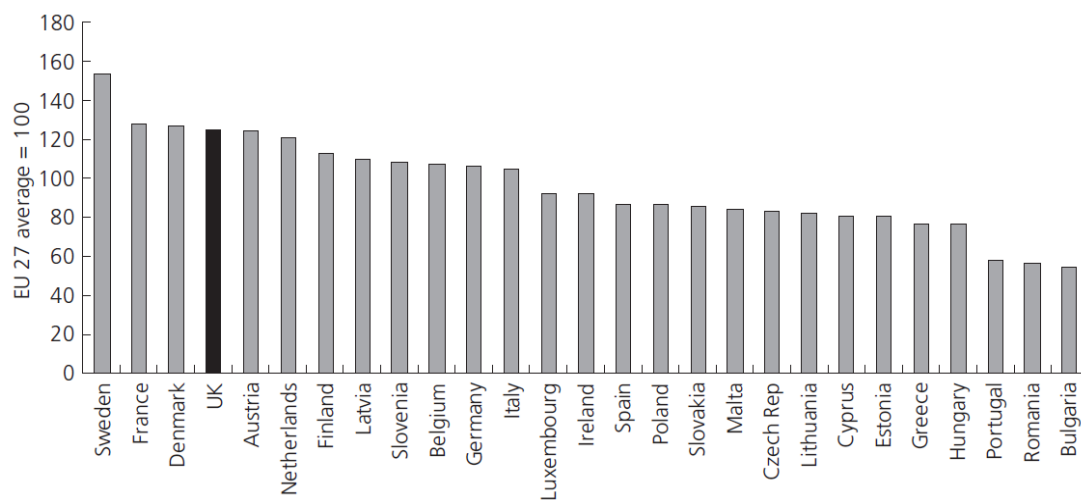


Figure 1. 2009 price level index for Civil Engineering (Eurostat, 2009).

3. METHODOLOGY

The research method for this study was based on a combination of quantitative and qualitative analysis (Dawson, 2009) and the reasoning of the research was inductive (Fellows and Liu, 1997). This blend of methodological approaches allowed the researcher to be flexible with the

emergent data collection process and ongoing literature review (Glaser and Strauss, 1999). Background research identified previous similar projects. Internal company reports were reviewed including bids, project descriptions and other relevant documents such as industry-facing publications along with academic publications such as conference and journal papers. Lessons learned from other industries and sectors were deemed relevant for the field under investigation.

The raw data collected was based on three case studies reflecting water and environmental management firms' interest and demand for increase in standardisation and Offsite solutions throughout their works. The analysis was based on Eisenhardt's (1989) approach to building theory from case study research. A combination of semi-structured and unstructured interview methods enabled maximum input from the six interviewees whilst allowing data to be collected uniformly (Glaser and Strauss, 1999). The interviews were recorded and transcribed. A group discussion followed with the three client directors, three project managers of major projects and the global innovation director. Drivers and barriers and the potential for Offsite solutions in the W&EM sector were discussed.

There were significant challenges related to the data collection process. The Offsite construction projects that were analysed by this paper took place in different geographical locations and under complex frameworks, which made the comparability challenging. Many reports were not accessible due to company confidentiality concerns. The reports obtained used different terminology for Offsite solutions such as 'modularised units', 'the prefabricated elements', etc. The understanding of the term Offsite was also confused by many participants during the interview process as 'lean construction methods' or 'just-in-time management methods'.

4. DISCUSSION

Demanding and informed clients are often considered a driver for innovation (Gibb and Isack, 2001). The majority of practitioners in the construction industry are also familiar to the current capabilities, advantages and disadvantages of Offsite (Goodier and Gibb, 2007). In the W&EM sector in particular, client organizations at a corporate level comprehend the benefits and drawbacks of Offsite. Nevertheless, at the practitioner level there are limited examples of engineers that still see Offsite as solely a 'one fits all' standardized solution. This concurs with findings from Goodier and Gibb (2007), though this focuses predominantly more on the building sector. Offsite solutions such as precast concrete have been employed in the sector and are now considered common practice (Vernikos et al, 2012). Therefore, Offsite in the W&EM sector is not considered innovative by the supply chain. W&EM clients are increasingly taking a holistic and inclusive evaluation of Offsite and attempting to incorporate standardization and Offsite into their project processes.

4.1 Drivers

Time, quality and cost are considered the greatest advantages of Offsite by literature (Gibb and Isack, 2001; Goodier and Gibb, 2007; Venables et al, 2004). The main advantages of Offsite identified for the W&EM sector in this study were cost reduction, lower environmental impact and reduction of disturbance to the public due to minimisation of onsite works.

The clients consider that the supply chain could deliver its program far more efficiently if standard designs were used that could be 'pulled off the shelf' depending on the type of 'frontage' required. The participants in the research had difficulty in differentiating between Offsite construction and standardization. It is common for infrastructure projects to be considered as bespoke, nevertheless clients believe that creating standardised designs may not

have an immediate effect on savings but may result in cost reduction in future projects, agreeing with similar findings in other sectors (Gibb and Isack, 2001). Client organizations, mainly due to governmental pressures, claim that cost is not always a governing factor in their decision making, but environmental impact is. In practice however, the evidence collected here disagrees with this argument. This comes as no surprise, as in the past non-immediate benefits have been 'merely alluded to, or disregarded' (Blismas et al, 2006).

The sustainability aspect of Offsite construction has been seen by many as a driver (Blismas et al, 2005; Goodier and Gibb, 2007). The main areas identified include less waste, noise and disturbance (Blismas et al, 2005). These reductions are occurring due to the closely monitored manufacturing process in factory-like conditions although more research in the areas is needed (Gibb, 2001). Sustainability issues may incorporate environmental, social and economical aspects. The waste of materials is a common problem in construction. Offsite construction has the potential to reduce waste because the design focuses on manufactured elements therefore 'can reduce programmed wastage' (DTI, 1998). Notwithstanding, recent research has shown that the environmental benefits of Offsite construction are not considered as of great importance (Larsson and Simmonson, 2012). In the W&EM sector the reduction in environmental impact is related to the minimisation of rework but also because it is expected that through Offsite solutions the design will be more efficient. Some clients claim that, by using 70% Offsite construction in their product-based Water Treatment Works, they have achieved a 60% reduction in embodied carbon.

4.2 Barriers

W&EM clients have tried to address many of the documented barriers to standardization (CIRIA, 2001; Pasquire and Gibb, 2002). The clients' 'route to continuous improvement' loosely follows the CIRIA Client's Guide and Tool Kit (2001) to optimize benefits from standardization and pre-assembly. The clients claim to have developed a process where a product is developed and then followed by a 'standard work' manual in order to help product uptake (e.g. Midi Submersible Pumping Station, Product installation Guide). Approval processes in infrastructure have acted as a barrier to realize Offsite (Vernikos et al, 2011) and clients have been resistant to change due to the negative image of Offsite in the past (Venables et al, 2004). Industry organizations (e.g. Buildoffsite) have been promoting certification for Offsite products. In the building sector according to results from the prOSPa survey (Goodier and Gibb, 2007) the majority of suppliers have their products certified. This is not common for Offsite solutions in infrastructure as they are seen as 'one-off' solutions. Recently the adoption of volumetric (e.g. pumping stations pods, adjustable manholes) and non-volumetric (e.g. treatment tanks) solutions in the W&EM sector has flourished. Such innovative solutions were adopted by the sector after trial-construction, trial-assembly and conducting full scale testing. This increased the confidence of the client without the need of certification.

4.3 Managing the Supply Chain

Latham (1994) may not have been the first to advocate partnership and collaboration as a means to drive improvements and innovations but he was the person that captured the construction industry's attention. Four years later Egan (DTI, 1998) continued to promote supply chain collaboration, drawing comparisons with the development of modularization and standardization in the USA as a means to reduce cost. In the early 2000s, following the recommendations of the two reports above, the W&EM sector attempted a series of projects under the Movement for Innovation (M4i, 2000a; M4i, 2000b). These case studies demonstrated improvements through collaboration without yet incorporating much Offsite in their processes.

In traditional construction the approach is linear, starting with the feasibility, design, tender, construction, handover and operation. Inherently this approach is insufficient in implementing innovation as benefits from planning, novel materials and solutions are not evident in the design phase unless the contractors or suppliers are involved in the early stages of the process. Another approach to construction is under a design-and-build contract. This ensures greater involvement from contractors but challenges occur when having bid on low margins the contractor seeks to increase profit from higher margins on any later change through the project (MacKenzie and Tuckwood, 2012).

Gibb and Isack (2001) discuss the clients' belief that the fragmentation of the supply chain poses challenges for Offsite. W&EM clients have progressively attempted to consolidate the supply chain (Anglian Water, 2012) through 'delivery partnerships'. This partnering arrangement model is aiming to increase collaborations throughout the supply chain. The collaboration encourages the understanding of all parties' needs at the early stages of the process. This model is approaching construction at a program-by-program rather than project-by-project basis. Similar examples have been seen in the building sector with great success. BAA's Terminal 5 is a prime example (Pryke, 2009). This has taken a long time to come to fruition as Offsite construction coupled with supply chain partnerships were identified as key to improve construction processes by Egan in 1998 (DTI, 1998).

The HM Treasury report (2012) on environmental networks states that smoothing the investment cycles in the W&EM sector could provide a better environment for innovation to flourish. The current investment process makes clients and therefore the supply chain adopt a project-by-project approach to solutions rather than a holistic and systemic approach. The supply chain claims that cyclical investment has been a hindrance to innovation and overall cost reduction, and although this HM Treasury report is addressing the problem more action should be taken. It is expected that a government report would be available in 2013 focusing on new infrastructure procurement routes that will address further the issue of cyclical investment (Water UK, 2012).

5. CONCLUSIONS

W&EM clients have been driving Offsite solutions by creating a platform for 'product-based delivery' and 'product integration'. W&EM clients claim that this can be achieved by creating a 'product catalogue' alongside a knowledge management system that ensures continuous improvement. Nevertheless, it is admitted that this is not yet the standard work process, although there are few 'best practice examples'. The success of the increasing usage of Offsite in the W&EM sector is yet to be confirmed as most of the data currently available are based only on anecdotal evidence. Significant steps have been made however, to standardise and homogenise the supply chain by improving the procurement processes. Modular Offsite solutions such as pre-assembled pumping stations are a good example of cross-sector fertilization of innovation as they can be compared with, and can find resonance with, solutions for the building sector (e.g. multiple service distribution modules).

Considerable challenges still exist when the program-by-program model is utilized. There are examples of linear infrastructure assets, such as river embankments, that are not monitored accurately. The large amount of data on each segment's location, type of solutions used and condition hinder the utilization of Offsite and standardization. Despite the current technological capabilities available (e.g. GIS, BIM etc) most data are still only in reports or paper format, which does not facilitate the simple identification of opportunities for Offsite.

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