Institution: University of Dundee

Unit of Assessment: UoA 14 – Civil and Construction Engineering

Title of case study: Predicting and improving construction labour productivity and whole life value

1. Summary of the impact (indicative maximum 100 words)

The Construction Management Research Unit (CMRU) has exploited its research into productivity improvement, whole life costing and sustainability assessment through a University spin-out company, Whole Life Consultants Ltd, that has achieved economic impact. With sales exceeding £1M since its inception, the company's post-2008 achievements include: the development of a labour forecasting tool that has generated contracts worth more than £100k to the Construction Industry Training Board in 2011-13; on-going implementation of a productivity improvement programme for Tayside Contracts that has produced an increase in turnover of £6.8M and a threefold increase in profitability since 2009; on-going support of the Croatian PPP/PFI programme that has contributed to the successful implementation of 11 projects since 2008.

2. Underpinning research (indicative maximum 500 words)

Since 1993, the CMRU's research led by Professor Horner, has focussed on improving labour productivity, developing Life Cycle Costing techniques to maximise whole life value and promoting a novel integrated, holistic approach to sustainability assessment.

A series of external grants since 1993 has supported CMRU to quantify the relationship between labour productivity and the factors that affect it. This has led to the discovery and application of the property that items in a bill of quantities whose value is greater than the mean, the so-called 'cost significant' items, account typically for 80% of the total value but number less than 20% of the total number of items. Moreover, for projects of similar types, the cost-significant items are all the same and represent a consistent proportion of the total value. The property is generic and can be applied to any set of numbers (e.g. labour costs, labour hours), allowing the derivation of a small number of significant activities that can be taken to be representative of overall project performance. This finding has allowed the execution of extensive site data collection programmes, leading, in turn, to a deeper understanding of where the opportunities for increasing productivity lie[1][2]. The CMRU has, for the first time, quantified the relationship between productivity and delays and disruptions, overtime working and size and skills of the labour force[3]. It has demonstrated conclusively the role of site management in improving productivity and developed a protocol for collaborative planning drawing on lean principles and involving the whole supply chain that is similar to (but pre-dates) "last planner".

In whole life costing, CMRU developed a generic approach to life cycle costing and explored the potential for adopting a risk-based approach to maximising whole life value by applying Integrated Logistics Support (ILS) to construction projects in both the design and operation phases[4]. Two techniques were identified, namely (i) Failure Modes, Effects and Criticality Analysis and (ii) Reliability Centred Maintenance that could be tailored for and applied successfully in the construction industry. The research demonstrated how the application of these techniques reduces the maintenance costs of existing housing stock by up to 20% and the whole life costs of selected components of houses, hospitals, schools and prisons by up to 40%. The research also led to the development of an elemental whole life cost breakdown structure consistent across all phases of the project, allowing, for the first time, an analysis of the impact of alternative design solutions on the capital, maintenance and operating costs of any building project[5].

Since 2005, the CMRU has developed an Integrated Sustainability Assessment Toolkit that allows the holistic assessment of the economic, environmental and social dimensions of sustainability throughout the life of any construction asset or group of assets. From the 1000 or so sustainability indicators in use worldwide, the research has identified 19 principal sustainability impacts of

buildings and 27 principal impacts of urban developments that practitioners and academics considered to be the most important. It also identified the most appropriate tools for assessing the impacts and developed a multi-criteria decision-making approach to aggregate the outputs across all the principal impacts[6].

Horner (Director, CMRU) was made an Honorary Fellow of the Royal Incorporation of Architects in Scotland for "Services to Construction" in 2007. He is Chairman of the CITB Technical Reference Group for Labour Market Intelligence and sits on Transport Scotland's National Roads Maintenance Review Technology and Innovation Working Group. He was appointed to the Board of the Tayside and Central Regional Transport Partnership (2008-2010) by the Scottish Minister for Transport

3. References to the research (indicative maximum of six references)

Publications

1. Horner, R. M. W. and Zakieh, R. (1996) Characteristic items - a new approach to pricing and controlling construction projects. *Construction Management and Economics*, **14**, 241-252. http://dx.doi.org/10.1080/014461996373494
2. Radosavljevic, M. and Horner, R. M. W. (2002) The evidence of complex variability in labour productivity. *Construction Management and Economics,* **20**, 3-12. http://dx.doi.org/10.1080/01446190110098961
3. Horner, R. M. W. and Talhouni, B. (1995) ***Effects of Accelerated Working, Delays and Disruption on Labour Productivity***. Chartered Institute of Building, 40 pp., ISBN 1 85380 068 6.
4. El-Haram, M. A. and Horner, R. M. W. (2003) Application of the principles of ILS to the development of cost effective maintenance strategies for existing building stock. *Construction Management and Economics*, **21**, 283-296. http://dx.doi.org/10.1080/0144619032000093774
5. El-Haram, M., Marenjak, S. and Horner, R. M. W. (2002) Development of a Generic Framework for Collecting Whole Life Cost Data for the Building Industry. *Journal of Quality in Maintenance Engineering*, **8**, 144-151. http://dx.doi.org/10.1108/13552510210430017
6. Thomson, C. S., El-Haram, M. A., and Emmanuel, R. (2011) Managing sustainability assessment within the project lifecycle. *Proceedings of Institution of Civil Engineers - Engineering Sustainability*, **164**(2), 143-157. http://dx.doi.org/10.1680/ensu.2011.164.2.143

External Grants awarded to support the underpinning research

EPSRC GR/K64471/01: Application of ILS to the development of cost effective maintenance strategies for existing building stock 1996 – 1998 (£102,369). Prof R. M. W. Horner (P.I.)

EPSRC GR/K77457/01: Improving construction productivity – a practical demonstration of a process-based approach. 1996 – 1998 (£150,505). Prof R. M. W. Horner (P.I.)

EPSRC GR/N01811/01: A generic approach to minimising whole life costs in the construction industry. 2000 – 2003 (£315,397) Prof R. M. W. Horner (P.I.)

EPSRC GR/S18311/01: SUE Scoping Study: Metrics, models and toolkits for whole life sustainable urban development - a scoping study. 2003 – 2004. (£207,024). Prof R. M. W. Horner (P.I.)

EPSRC EP/C004701/1: A Visual Map of Sustainable Urban Development Issues. 2004 – 2005 (£125,843). Prof R. M. W. Horner (P.I.)

EPSRC EP/C008030/1: Metrics, Models and Toolkits for Whole Life Sustainable Urban Development. 2005 – 2009 (£1,276,306). Prof R. M. W. Horner (P.I.)

4. Details of the impact (indicative maximum 750 words)

Whole Life Consultants Ltd (WLC)

WLC was established as a spin-out company from the University of Dundee (which owns a 10% share) specifically to commercialise the research outputs from the CMRU on the recommendation of the industrial steering committee for EPSRC Grant GR/N01811/01. Since January 2008, the company has undertaken work to a value exceeding £1M and currently employs 5 people. Clients include (i) CITB and, on its behalf, Salford City Council, 7 North East (England) Local Authorities, Lambeth & Wandsworth, Welsh Assembly Government, Waltham Forest, Fusion 21, EU Skills, (ii) UK Contractors Group, (iii) Croatian Institute of Bridge and Structural Engineering, (iv) PPP Centar Zagreb, (v) British Board of Agrément, (vi) Scottish Enterprise, (vii) O'Hare McGovern, (iix) Experian and, on its behalf, the Olympic Park Legacy Company, (ix) the EU and, on its behalf, Frederick University (Cyprus), FORSAS (Italy), Romanian Society for Lifelong Learning, DOCTUM (Spain), (x) 6ix Consulting and, through it, Scottish Water. The company has been awarded a major contract by HS2 in 2013 to predict the labour demands and skills gap generated by the HS2 project.

Productivity

In 2008, CITB commissioned WLC to develop a labour forecasting tool to predict the amount of labour required in each trade on a monthly basis, given no more than the type of project, its value or floor area and the start/end dates of construction. This tool is used throughout the CITB Skills Academy programme and is recognised by CITB as being unique from a commercial perspective and providing a leading edge in strategic discussions with government and industry[7]. During the past 2 years, it has been licensed to the Olympic Park Legacy Company, Salford City Council, 7 North East of England Local Authorities, Lambeth & Wandsworth and Waltham Forest, generating contracts worth more than £100k to CITB. It is used principally, but not exclusively, in determining the number of jobs created in unitary authorities as a result of construction activity[7,8].

Dissemination of the CMRU's underpinning research to industrial stakeholders has been accomplished through the monograph "More for Less" published by CIRIA. It is used currently throughout the construction industry as a guide to productivity improvement and supports a productivity training programme delivered by WLC and a lean training programme delivered by 6ix Consulting Ltd. These programmes have been delivered to more than 100 practising professionals, with typically 1 in 4 participants reporting a consequent reduction in costs. Farrans Construction estimates £100ks in savings[9] achieved in 2013 through a radical overhaul of its procurement method using WLC's *Productivity Portal*.

In 2011, CMRU completed a Knowledge Transfer Partnership with Tayside Contracts to embed its research in lean thinking across the whole organisation. The KTP has been rated "outstanding" by the TSB, having delivered an increase in turnover of *ca* £6.8M, cost reductions of £650k, a threefold increase in profits and an increase in the percentage of partnering contracts from 25% to more than 45%[10]. The partnership is a finalist for the best UK KTP Partnership Award.

Whole Life Costing and ILS

The CMRU's research into whole life costing and ILS has had a wider reach, extending particularly to PPP/PFI contracts executed in Croatia. Memoranda of Understanding between WLC and the Croatian Institute of Structures & Bridges and the PPP Centar, respectively, to provide support for the Croatian PFI programme have led to the engagement of WLC since 2008 in the formulation of 12 PFI projects in Croatia, 11 of which have now been implemented successfully[11]. Between 2008 and 2012, WLC supported O'Hare McGovern in the preparation and delivery of 5 successful bids for PFI Schools in Northern Ireland. It was responsible subsequently for preparing the optimum Life Cycle Replacement cost profile.

Sustainability

In 2011, WLC was awarded a €300,000 Leonardo de Vinci grant to transfer its expertise in sustainability assessment to 4 European countries. The programme is delivering training to 50 professionals so that the results of the CMRU's research can be adopted in practice across Europe.

Scottish Construction Centre (SCC)

Horner directed the SCC between 2008 and 2009 and took the academic lead in delivering its £2.7M programme until its successor body (Construction Scotland) was launched in 2011. He had initially put together the winning consortium and written much of the successful bid to Scottish Enterprise for the Centre and in 2008, he was responsible for winning a supplementary ERDF grant of £706k for it, using EPSRC funding as part of the matching component. Under the SCC banner, the Dundee team administered Workshops on whole life costing (attracting 61 participants from 42 companies) and lean thinking (178 participants from 100 companies). It provided one-to-one support to 47 companies. An independent evaluation has estimated that this work produced an increase in added value of £28.8M, created 250 new jobs and protected a further 750[12].

5. Sources to corroborate the impact (indicative maximum of 10 references)

7. Factual Statement: Commercial Strategy Manager, CITB
8. Factual Statement: Regeneration Manager, London Legacy Development Corporation
9. Factual Statement: Commercial Director, Farrans Construction
10. Factual Statement: Managing Director, Tayside Contracts
11. Factual Statement: Director, Croatian Institute of Structures and Bridges
12. http://www.evaluationsonline.org.uk/evaluations/Browse.do?ui=browse&action=show&id=468&taxonomy=CON
    Web site link to the Scottish Construction Centre Evaluation Report to Scottish Enterprise by GEN Consulting