

THE UNDER-REPRESENTATION OF WOMEN IN EUROPEAN CONSTRUCTION RESEARCH

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The construction sector plays an important role in economic growth, yet has a poor performance record in research and innovation. At the same time, the construction sector remains male-dominated and women's growing role as decision-makers and buyers is not reflected by their input into construction innovation and creativity. The WOMEN-CORE project (co-funded by the European Commission's Research Directorate General under the Sixth EU Framework Programme) was established against this background to address the under-representation of women working in construction research. Given the nature of both the construction sector and scientific research cultures, examined elsewhere, construction research appears to represent a 'double hurdle' for women seeking a career in this field. This paper presents initial findings from the WOMEN-CORE project, with a focus on exploiting existing sources of data to establish the extent of women's participation in construction research. Specifically, it investigates women's participation in construction education, construction research employment, construction publications and citations, construction patents and EU funded construction research projects. Key datasets in this analysis include: the Community Labour Force survey, the Education database; the EC CORDIS project database, the European Patent Office database and the ISI Web of Knowledge. The paper also has a particular emphasis on comparing the UK with Europe and concludes that women in the UK are, on average, participating less in construction research than women in Europe.

Keywords: construction research, Europe, gender, women.

INTRODUCTION

This paper reports on the development of the WOMEN-CORE (Women in Construction Scientific Research) project, established to address the under-representation of women in construction research. The premise of WOMEN-CORE is to determine whether women are under-represented and how women's experiences may differ from those in other research sectors. Given the nature of both construction sector and scientific research cultures, it may be that construction research represents a 'double hurdle' for women seeking a career in this field. This paper begins by examining the need for research, development and innovation, both generally and within the construction sector and, the need for diversity within R&D, again both generally and within construction. It then uses existing data sources to establish women's representation in construction research. Within this there is a particular emphasis on comparing the UK with Europe. Specifically it focuses on: the potential supply of construction researchers, using data from the Education database and the Community Labour Force survey (CLFS), and; women's role in construction research, based on construction scientific publications, patenting related to the construction

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sector, and coordinators and scientific managers in EU-funded construction research. The paper also has a particular emphasis on comparing the UK with the EU average in these criteria.

RESEARCH, DEVELOPMENT AND INNOVATION

R&D activities are often considered as a main driver of economic development, innovation and growth. The Lisbon (2000) and Barcelona (2002) European Councils both aimed to turn Europe into "the most competitive and dynamic knowledge based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion" by 2010 (EC, 2008a). Their strategies also aimed to raise research investment in the EU from around 1.9% of GDP to almost 3% (EC, 2008a). Similarly, a recent UK Government White Paper has stated that innovation is essential to the UK's future economic prosperity and quality of life (DIUS, 2008). Eurostat figures indicate that in 2004 the R&D expenditure as a proportion of GDP was 1.8% in the EU27 and 1.7% in the UK, showing that R&D intensity is significantly lower than among the main competitors, US (2.6%) and Japan (3.2%), and the 2010 target of 3% (EC, 2008a).

The construction sector is one of the most important industry sectors in terms of economic growth and employment. In 2006, construction in the EU27 totalled €1,196 billion and 10.4% of GDP (FIEC, 2007). This makes it the largest industrial sector in the EU (ENBRI, 2005), accounting for 7.2% of the EU's total employment and 30.4% of industrial employment (FIEC, 2007). However, the construction sector also faces increasing competition, has a tendency for low profit margins, is dominated by small firms and has a poor safety record (ENBRI, 2005). The cost of non-quality as a proportion of total output is high, estimated at 5-10% (COM, 1997), a possible consequence of the industry's low R&D intensity; in the UK the DTI (2006) estimates construction R&D is less than 1% for the top 20 companies. It is therefore important that the industry embraces research and innovation in order to develop new structures, processes and relationships that promote innovation and meet the needs of clients, users and society more effectively (ENBRI, 2005). On a European Level, this has been supported by the establishment of the European Technological Construction Platform (ECTP) in 2005. Within the UK, the Fairclough Report (2002) has stressed the need for R&D to improve all aspects of the sector's performance in terms of productivity, value for money and strategic issues.

WOMEN AND RESEARCH

A recent report on women's research careers suggests that diversity provides an opportunity to increase creativity, increase quality, bring science closer to society, optimise human resources, improve efficiency and increase international competitiveness (EC, 2008b). Yet the ETAN report (EC, 2001) found that gender plays a disproportionate role in the likelihood of being able to enter, remain in and succeed within the scientific community. Women account for a minority of all researchers (28% in 2004; EC, 2008a). Rubsamen-Waigmann *et al.* (2003) argue that employers across Europe need to become more competitive by investing in staff for R&D, and by using staff more effectively. This means it is vital to retain women at every stage of their careers.

Within the construction sector specifically, however, women only represent 10% of the UK (EOC, 2006) and 8% of the EU workforce (EC, 2008c), despite their growing role as decision makers and clients. Specific issues have been cited as discouraging or

limiting women's entry into the industry, including: differential socialisation, poor careers advice and lack of knowledge about the sector, a lack of role models, lack of support from friends and family and the poor image of the sector (Dainty *et al.*, 2000). However, women that are employed in construction also face various difficulties which have resulted in their segregation within the sector. Such segregation has been both vertical, with women over-represented in more junior roles, and horizontal, with women over-represented in the public sector (Fielden *et al.*, 2001). Dainty *et al.* (2000) also found that women are likely to progress through their careers at a slower rate and face more obstacles in their development than their male colleagues. While the industry has sought to address the under-representation of women, through various initiatives, many within the sector seem reluctant to change (Fielden *et al.*, 2001), and it remains "culturally, normatively and numerically male-dominated" (Watts, 2008).

Numerous studies have addressed the barriers women face in scientific research and within science and engineering, many of which may also apply within the construction sector. Some of these barriers include:

- Sexualised cultures: women are often equated with biologically determinist definitions of gender, which mean they are perceived as women first and scientists second (see, Etkowitz *et al.*, 2000; Faulkner, 2006);
- Organisational cultures: despite an increase in policies designed to tackle inequalities in the workplace, there is often an inconsistency between organisational policies and workplace practice and norms (see Etkowitz *et al.*, 2000; Bagilhole, 2006);
- Long hours culture: the dominant culture in scientific research is long working hours and the expectation of total availability. This is particularly significant for women given that they usually have more domestic responsibilities than men (see Davis, 2001; Grant *et al.*, 2000; Watts, 2008);
- Gender stereotyping: the association between masculinity and technology can mean that women are pushed into 'softer' research areas, deemed more suitable for women, but often with less opportunities for career advancement (see Cockburn, 1985);
- Gendered networking: despite the significance of networking for career success, women in science are often excluded from existing social and professional networks (see Davis, 2001; Faulkner, 2006; Etkowitz *et al.*, 2000).

This complex web of cultural and structural issues are a clear expression of the dominance of masculine cultures and together create problematic careers paths for many women (and some men) pursuing scientific careers (Bagilhole *et al.* 2007). Furthermore, women that do succeed often adopt male success criteria, as both a strategy for survival (Watts, 2008) and a result of assimilation, reinforcing the existing masculine cultures (Powell *et al.* 2006). Greed (2000) in her study of women in construction, for example, suggests that if such women succeed they do so as individuals, failing to question the status quo and failing to promote the interests of women in the sector.

METHODOLOGY

The WOMEN-CORE project has been established to address the unequal representation of men and women in construction research in Europe by enhancing the knowledge and strengthening women's participation in construction research. This is particularly important given the lack of women in both the construction sector and

scientific research and the lack of investment in construction R&D. The data presented in this paper aims to enhance the knowledge on women in construction research by establishing the exact nature of women's participation in construction research, addressing both horizontal and vertical segregation. The project examines a number of core disciplines within its definition of construction research, including: architecture; building physics; building structures; construction and economic management; construction technology; environmental engineering; heating, cooling, ventilation, electricity and networks; geotechnics and underground studies; IT; transport organisation and structures; urban planning; water management and structures; and, mechanics, including fluid mechanics and dynamics.

The project has undertaken a secondary analysis of data sources, compiling relevant statistics from, the CLFS, the education database, the EC CORDIS project database, the ISI Web of Knowledge, and the European Patent Office database in order to build a picture of: gender education segregation; gender segregation in R&D personnel; women's construction scientific research publications and citations; the role of women as patent originators in construction; and, women's participation in EU funded projects in construction research.

As some of the databases used in this analysis do not collect data on gender (ISI Web of Knowledge, European Patent Office database and EC CORDIS project database), a first name database (FNDB) was created using a similar methodology to Naldi and Parenti (2002). The FNDB is a comprehensive collection of European first names, divided by country and gender. It is derived from a combination of government sources, internet searches and language experts and contains a total 46,619 names in 20 European languages. Of these, 25,135 were identified as female, 21,107 were male and 377 were 'double-gendered' in that they could be applied to both genders. First names listed in the databases were then cross-checked against the FNDB to establish gender. The FNDB was successfully used to identify gender of 91% of publishing authors, 76% of patentees and 86% of people involved in EU funded construction research.

POTENTIAL CONSTRUCTION RESEARCHERS

As shown in table 1, in 2004 women were found to account for 40.7% of bachelor and masters graduates and 33.9% of doctoral graduates in construction-related fields of study. While this is considerably lower than the average across all fields of study, for bachelor and masters graduates, it is higher than the proportion of women graduates in science and engineering. This may be because construction-related study includes architecture which tends to be less male dominated than other science and engineering subjects. The data also indicates that the proportion of women graduating in construction is increasing, albeit at a lower rate than the proportion of women graduates across all fields.

By country, the UK has a lower than average (compared to the EU27) proportion of women across all fields of study, although this difference is much less marked among phd graduates in construction. Interestingly, while most EU countries experienced an increase in the proportion of women bachelors and masters graduates between 1998-2004, the UK was one of six countries that witnessed a decrease.

Table 1: Proportion of Women among Graduates in EU27, 2004. Source: Education database, Eurostat.

	EU27		UK	
	Bachelors & Masters	Phd graduates	Bachelors & Masters	Phd graduates
All fields of study	58.8%	43.4%	55.8%	43.1%
Science and Engineering	33.9%	33.9%	31.8%	32.7%
Construction	40.7%	33.9%	36.6%	33.0%

Despite the increase in women among recent graduates, women only account for 21.5% of the highly qualified population (total population holding bachelor, masters and doctorate degrees) in construction, compared to 48.9% across all fields of study in 2005 (see table 2). Figures for the proportion of women among the highly qualified population in employment are slightly lower for all fields of study and construction fields of study. The UK had a lower than average proportion of women among the highly qualified population in construction fields of study (17.6%), almost half the proportion of women in Bulgaria (37.8%).

Table 2: Proportion of Women among Highly Qualified Population in EU27, 2005. Source: Community Labour Force Survey, Eurostat.

	EU27		UK	
	Total	In employment	Total	In employment
All fields of study	48.9%	47.7%	47.8%	47.0%
Construction fields of study	21.5%	20.8%	17.6%	17.0%

As displayed in table 3, women only account for 19.0% of construction scientists and engineers compared to 34.8% of scientists and engineers in general, although there has been a positive increase between 2000-2005. Scientists and engineers are understood to be employees working in the most R&D oriented occupations. In construction these are scientists and engineers working in occupations most related to construction research (architects, engineers, physicists, chemists and related professionals). By country, in 2005, Germany (13.9%) and the UK (14.7%) has the lowest proportion of women amongst construction scientists and engineers, compared to 38.7% in Bulgaria. Previous research suggests that many of the post-communist countries may have higher proportions of women than Western Europe, because research jobs have a relatively low status in these countries along with a high-prevalence of state-owned research institutions (EC, 2008b).

Table 3: Proportion of Women among Scientists and Engineers in EU27, 2000-2005. Source: Community Labour Force Survey, Eurostat.

	EU27		UK	
	2000	2005	2000	2005
Total	33.2%	34.8%	30.6%	34.5%
In construction	16.1%	19.0%	14.9%	14.7%

WOMEN'S ROLE IN CONSTRUCTION RESEARCH

Women and Scientific Publication

In total 918 articles from 20 journals were analysed, 454 in 2000 and 464 in 2003. The 20 most relevant international journals in construction research were identified based on a balanced coverage of scientific disciplines within the construction sector and impact factor. As some of the articles were co-authored, the total number of authors

addressed in this analysis was 2052, 962 in 2000 and 1090 in 2003. As shown in table 4, on average women represented 18% of authors, increasing from 14.7% in 2000 to 21.7% in 2003. Within the UK, women represented 11.3% of authors in 2000, lower than average, but 22.2% in 2003, above average.

Table 4: Proportion of Women Authors in Construction-related Journals. Data compiled by CVUT using ISI Web of Knowledge.

	2000	2003
Average	14.7%	21.7%
UK	11.3%	22.2%

There was also high variation between journals, ranging from 0% in HVAC&R (Heating, Ventilation, Air Conditioning & Refrigeration) Research to 30.3% in Water Research in 2000, and from 5.3% in Journal of Constructional Steel Research to 50.0% in Indoor and Built Environment in 2003 (see figure 1).

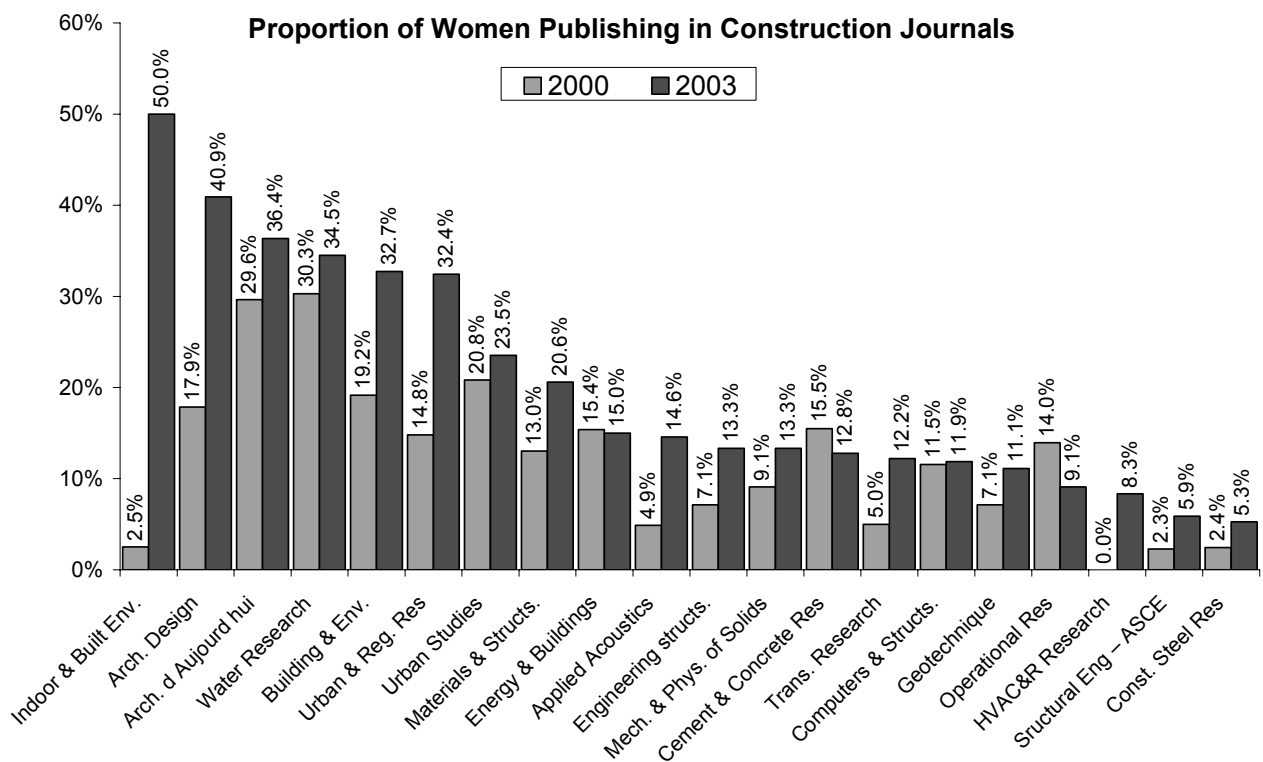


Figure 1: Proportion of Women Authors in Construction-related Journals, 2000 & 2003. Data compiled by CVUT using ISI Web of Knowledge.

For most journals there was an increase in the proportion of women authors between 2000 and 2003. Decreases in the proportion of women authors occurred in 3 journals: Cement and Concrete Research, Energy and Buildings, and the European Journal of Operational Research.

These results indicate that women may be more successful in subjects related to 'softer' issues within the construction sector, such as the environment and architecture, rather than the 'harder' engineering based subjects.

Women and Citation

The results also illustrate that citation of articles is high. In 2000, 71.5% of articles were cited and in 2003, 65.6% of articles were cited at least once. In 2000, 75.0% of

articles published with women authors were cited, compared to 70.4% of male-only authored articles. In 2003, this difference was even greater with 71.2% of articles with women authors being cited compared to 63.1% of male-only authored articles. This is encouraging and demonstrates that if women are accepted in construction research, their results are highly accepted. However, it may also indicate that women need to provide research findings of a higher quality than men in order to be accepted and successful.

Women and Patenting

While patenting was found to be less common in the construction sector compared to the chemical and pharmaceutical sectors, women patentees were found to be very poorly represented in the construction sector EU25, although there was an increase from 3.7% of patentees in 1994 to 4.9% of patentees in 2004. However, women fared less well in the UK, representing 3.3% of construction patentees in 1994, decreasing to only 3.0% in 2004 (see table 5). Countries with a high proportion of women patentees generally had a very low overall number of patents and vice versa.

Table 5: Proportion of Women Patentees, 1994-2004. Data compiled by CIFS using European Patent Office database.

	1994	2004
EU25	3.7%	4.9%
UK	3.3%	3.0%

Women and EU-funded Research

This task identified a total of 497 construction related projects funded by the EU; 308 of which were funded by FP5 (1998-2002) and 189 (2003-2006) funded by FP6. Although fewer projects were funded under FP6 than FP5, the average budget per project was much higher (€5.2 million compared to €2.2 million).

On average (as shown in table 6), women represented 8.7% of all partners in construction related projects, including 10.1% of coordinators and 8.6% of scientific managers (partners named as leading the project within their organisation). Women's participation also increased between FP5 and FP6, with the proportion of women coordinators increasing from 6.2% to 16.4% and the proportion of women scientific managers increasing from 6.7% to 10.8%. The data from FP6 also show that there is a higher proportion of women coordinators than women scientific managers. This may indicate that women are more likely to participate in funded research if they have instigated the research themselves. Interestingly the UK had a much higher than average proportion of women participating in FP5 and a higher proportion of women coordinators in FP6, but a lower proportion of scientific managers.

Table 6: Proportion of Women Participating in EU funded Construction Research. Data compiled using EC CORDIS database.

	Average		UK	
	FP5	FP6	FP5	FP6
Total Women	6.6%	11.2%	10.3%	9.2%
Women coordinators	6.2%	16.4%	10.6%	17.4%
Women scientific managers	6.7%	10.8%	10.2%	8.4%

CONCLUSIONS AND RECOMMENDATIONS

This paper has focused on exploiting existing sources of information relating to women in construction research. Specifically, this was achieved by analysing women's representation in higher education, the highly qualified population and among scientists and engineers, and women's participation in publication and citation, patenting and EU funded construction research.

The data shows that women are severely under-represented in construction research and that in the UK, on average, women are participating less in construction research than their European counterparts. Some of the key findings of the research are: in 2005, women accounted for 19.0% of scientists and engineers in construction research in the EU27, but only 14.7% in the UK; in FP6 (2003-2006), women represented an average 11.2% of coordinators and scientific managers of construction research projects funded by the EU, but 9.2% in the UK; in 2004, women comprised only 4.9% of EU25 patentees in the construction sector, compared to 3.0% in the UK; and in 2003, women accounted for an average 21.7% of publishing authors in construction scientific journals compared to 22.2% in the UK.

The data suggests that vertical segregation may be apparent, with high proportions of women studying construction subjects in higher education (40.7% of bachelor and masters graduates), but much smaller proportions of women in more senior positions such as coordinating European research (16.4%). However, this difference is less pronounced in the UK where 36.6% of construction bachelors and masters graduates are women and 17.4% of coordinators of EU funded construction research.

Nevertheless, it is also important to consider that any increase in women in more junior positions will take some time to be seen in more senior roles, as they develop these women develop their careers. The difference in the proportion of women involved in publishing (21.7%) compared to patenting (4.9%) may also indicate that women are better represented in construction research in academia rather than industry, as the emphasis on publishing may be higher in academia, while industry has more focus on the commercial impact of research. While the high proportion of women publishing in the UK may reflect the importance of scientific publication to both career progression and research funding in UK academia.

Based on the analysis of existing data and the need for equality and diversity to ensure quality, efficiency and global competitiveness, a number of recommendations can be made. Firstly, given the relatively high proportions of women undertaking construction related degrees (bachelors and masters), but lower proportions of women in scientific and more senior construction research positions, it is important to consider measures for recruiting and retaining women in research-orientated careers in the construction sector, both in the UK and the EU more generally. Secondly, further research is necessary to explain the decrease in women's participation in construction research within particular countries. Additional research may explore whether this pattern is specific to construction research or a pattern reflected more generally within certain countries. Thirdly, analysis of women's rate of publication indicated that women may have a higher rate of participation in softer areas of construction research such as the environment or architecture. However, further analysis of women's horizontal segregation in construction research is necessary as this was not conclusive in other tasks. Finally, it is also necessary to further explore the significance of publishing and patenting in industrial and academic careers, and whether or not women are better represented in academia than industry. These issues will be further

considered in the data collection stages of the WOMEN-CORE project and will be reported in subsequent papers.

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