

<b>Institution: University of Wolverhampton</b>
<b>Unit of Assessment: C13: Architecture, Built Environment and Planning</b>
<p><b>1. Unit context and structure, research and impact strategy</b></p> <p><u>a) Context and structure</u></p> <p>The School of Architecture and Built Environment (SoABE) is a multidisciplinary School, embracing staff with expertise that spans subject areas of Architecture, Civil Engineering, Construction Law, Surveying, Construction Management, Environmental Sciences and Urban Geography. SoABE is part of the Faculty of Science and Engineering (FSE) - one of three Faculties at the University of Wolverhampton (UoW). SoABE has continued to grow and has recently moved to a new £45m state-of-the-art building at the £110m Springfield campus. Research is governed and managed through the Construction Futures Research Centre (CFRC), with work strategically distributed through two main Research Groups (RGs): 'Digital Construction' [DIGITAL] and 'Smart and Sustainable Construction' [SSC] (Figure 1).</p>  <p><b>Figure 1: Research Organogram: Research Centre, Research Groups and Themes</b></p> <p>This structure actively promotes and accelerates cross-cutting research through thematic clusters that engage wider participation with UoW's non-cognate Research Centres and inter-disciplinary Institutes. This arrangement not only provides additional critical mass (and focus), but also strengthens our research enquiry to deliver world-leading research impact.</p> <p>Post-REF2014, we reflected widely on emergent research themes, strategic priorities and industry direction. From this, a decision was made to coalesce critical mass into clear cogent themes operationalised through one Research Centre (CFRC) and two RGs (DIGITAL; SSC). This replaced the three previous RGs 'Construction Management', 'Technology and Environment' and 'Land and Property Management' presented in the REF2014 submission. This new structure not only provides greater transparency and external visibility, but also promotes sentient organic growth across UoW's wider research provision.</p> <p>The DIGITAL RG consolidates our digital research through six core areas, all of which support industry demand for rigorous and relevant research. This is evidenced through eight successful Knowledge Transfer Partnerships (KTPs) in Building Information Modelling (BIM) and Digital Construction. For example, work with Severn Partnership Ltd (2010-2016) has continued to transform workplace practices, leading to the creation of a new department within the business focussing on the delivery of 3D BIM information and exploitation of Virtual Reality (VR)</p>

technologies. Other success stories include the award of a Research Fellow grant from the Royal Academy of Engineering, and engagement with several high-profile grant capture projects such as Sustainability and Construction Futures Research and Innovation Centre (SCFRIC) [European Regional Development Fund (ERDF)] and STELLAR [UK Research and Innovation (UKRI)]. The SSC RG focuses on developing a range of technologies, systems, processes and frameworks needed to deliver smart and sustainable infrastructures. This underpinning research has been extended and applied thematically in data analytics, knowledge-based technologies and innovative business modelling. Evidence of this work can be seen through ERDF-funded projects such as *Built Environment and Climate Change Innovations* (BECCI); the *Brownfield Innovation and Research Centre* (BRIC); the *Environmental Technologies and Resource Efficiency Support Service* (EnTRESS); along with the Spatial and Transport Planning for a new Mobility Era (HARMONY) project [EU Horizon 2020], the Multi-source Big Data Fusion Driven Proactivity for Intelligent Mobility (OPTIMUM) [EU Horizon 2020], and through several British Council (BC) projects.

Research focus and investment decisions are governed through emergent needs and strategic drivers (highlighted by governmental policies, demand-driven practice-based priorities, and international trends/initiatives) and by our existing research strengths, capacity and ability to build future strategic capability. For example, recent emerging priority areas include brownfield regeneration and sustainable construction to support Wolverhampton City's vision of being at the forefront of urban regeneration. Other areas include smart productivity improvement measures for offsite design, manufacture and assembly. Priority areas are informed through a number of routes, including the UK Government's Construction Sector Deal, (2019); Grand Challenges, (2019); Digital Built Britain, (2015); Construction 2025 (2013); Midlands Engine Strategy (2017); and Farmer Review (2016). Internationally, the United Nations (UN) Sustainable Development Goals Report (2020); the UN Office for Disaster Risk Reduction's Sendai Framework for Disaster Risk Reduction 2015-2030; and the UN Framework Convention on Climate Change [Paris Agreement] 2016 stimulate new project developments. These directives and strategic challenges provide fertile grounds for research discovery and contributions in such areas as geo-BIM, heritage BIM, offsite manufacturing, brownfield regeneration, green technologies, the circular economy, energy economics, intelligent urban transport systems, disaster resilience and recycling technologies. Given this, our multi-disciplinary research with beneficiaries is focused on three tiered solutions. First-tier beneficiaries include direct project investors and end users; second-tier beneficiaries include supply chain services underpinning projects (for example, design, procurement, manufacturing, servitisation), and third-tier beneficiaries are wider economy and society (including wider societal impact stemming from publicly-funded research *cf.* social, cultural, environmental, economic measures).

Post-REF2014, growth in research expertise and capacity led to the creation of CFRC in 2017 as the main conduit for the Unit's work. Since its launch, CFRC has fostered a number of outward facing industrial collaboration events, including the 'Construction Futures Forum' series (December 2018; February 2020). This was complemented by the launch of its international conference event 'International Conference on Construction Futures' (ICCF) (December 2018; July 2020), and supported by the International Council for Research and Innovation in Building and Construction (CIB); including the following Working Groups: W055 Construction Industry Economics; W089 Education in the Built Environment; W102 Information and Knowledge Management in Building; W113 Law and Dispute Resolution; and W121 Offsite Construction.

#### b) Performance against REF2014 research objectives and objectives for the next five years

##### i) Research objectives from REF2014 and unit performance

SoABE continually aligns and readjusts resources to support the strategic direction of the CFRC. In this respect, objectives are set and measured against the strategy with the explicit purpose of measuring performance. These indicators allow refinement to measure impact, whilst enabling opportunities for further strengthening our research portfolio mapped against: i) digital construction

technologies; ii) smart and sustainable construction. This includes cross cutting themes of green technologies, energy economics, environmental economics and the three pillars of sustainability (economic, social, environmental). Core achievements against objectives post REF2014 include:

- Attracting and retaining multi-disciplinary staff with excellent research track records and research potential

Significant investment in staff appointments has been made to support CFRC. This includes four new professorial appointments (Arif, Goulding, Pathirage, Sheng) and seven additional academic staff recruitments with Significant Responsibility for Research (SRR), supported by funding from the Research Investment Fund phase 3. This increased staffing from 13.5 FTE to 19.2 FTE, and enabled CFRC to both broaden and strengthen its research base, particularly in areas such as offsite manufacturing, brownfield regeneration, disaster resilience and infrastructure management. These investments have also enhanced our PhD completion rates, income generation, and wider capacity to engage with larger research projects.

- Providing strong leadership throughout the research process

SoABE has clear management systems and reporting lines to provide leadership and deliver effective governance. This helps facilitate maximum opportunities for research engagement at all levels and provides clear pathways throughout all stages of the research process. This includes a range of initiatives, from structures and mentoring schemes to support Early Career Researchers (ECR), through to high-level peer support mechanisms for senior members of the professoriate. To support these systems, SoABE appointed an 'Associate Head of School' with specific responsibility of providing research leadership. This has not only helped create ladders of opportunity for staff, but has also provided clearer conduits of communication between the two RG's (DIGITAL/SSC). Further support to leadership includes the appointment of a dedicated Postgraduate Research (PGR) coordinator role to optimise the PGR portfolio in line with increased demand and capacity.

- Vigorously pursue opportunities for grant capture

Additional appointments made post-REF2014 significantly increased our grant capture success rates. All staff are encouraged and supported to establish strong links with government, industry, professional and other external bodies. We provide support for bid writing, facilitate industry partnering, and engage in internal coaching and mentoring in order to increase bidding success. Funding calls are routinely distributed and teams assembled. Staff are also encouraged to work collaboratively and explore opportunities for external funding from various streams. During this REF reporting period, the total research income (£2.3m) has quadrupled, supported by a wide range of major UK and EU funding bodies such as ERDF, EU Horizon 2020, UKRI and BC.

- Review and update the directions of our research in response to emerging priorities

Research direction and response to emerging priorities are continually reviewed in line with our capacity and governing research strategy. SoABE's current research portfolio focuses on two main areas: digital construction technologies, and smart and sustainable construction. Both allow cross-fertilisation of themes such as green technologies, energy economics, environmental economics, sustainability and regeneration. Research restructuring post REF2014 allowed for these to be more actively supported through the CFRC and two RG's. This led organically to the development of the two Impact Case Studies (ICS) supporting this submission. Our forward plans over the next five years are to prioritise research and impact in brownfield regeneration and sustainable construction, working closely with Wolverhampton City Council, the Black Country Local Enterprise Partnership (LEP) and West-Midlands Combined Authority (WMCA) to establish a National Brownfield Institute (NBI). In this respect, we have just secured a £14.9m capital grant from the Government's 'Getting Building Fund' to support this priority area.

- Use our expertise to maintain the currency of taught postgraduate courses and to offer new and innovative courses

SoABE continues to reflect upon its postgraduate provision in line with market drivers, emergent issues and research capacity. Over the REF reporting period, we introduced several new and innovative postgraduate taught courses, including an MSc Offsite Housing Construction and MSc Demolition Management. All these programmes stemmed from market demand, underpinned by enviable industry support from regional, national and international stakeholders. For example, the MSc Offsite Housing Construction programme was designed to address housing demand through innovative and modern methods of construction with offsite production and design technologies, supported through SCFRIC; and the MSc Demolition Management programme stemmed from the need to meet the growing demand for richer and deeper understanding of the management of the demolition process, supported by our expertise in brownfield regeneration research. Combined, these new programmes cover the full spectrum of construction and the circular economy, from cradle to cradle.

- Design and deliver training and Continuous Professional Development (CPD) events in collaboration with appropriate professional institutions and societies and training organisations

SoABE has clear and direct collaboration and impact pathways with a range of external stakeholders, from professional institutions and industry partners, through to wider research and trade organisations. This close collaboration enables us to deliver research-informed training and CPD events in line with need/emergent issues. Examples include 'Local Authority Building Control' (LABC) training, including the provision of a Building Control Surveying degree apprenticeship programme. A total of 130 employees from LABC have received training so far. Training and CPD events have also included topics on offsite manufacturing, BIM, visualisation, and over 300 attendees have been trained. In addition, SoABE has also been at the forefront of designing and delivering several degree apprenticeship courses and has been championing several trailblazer groups responsible for developing apprenticeship standards. These measures have been strong exemplars of unit performance and research benefitting industry.

#### ii) Objectives for the next five years

CFRC's vision is to be an innovative and agile centre of excellence engaged in integrated architecture, built environment, and civil engineering delivery; applying an industry facing people-centric approach to research which applies outputs with real impact to local, national and international communities. The *raison d'être* underpinning this is the need to create maximum impact from our research investment. This vision also underpins the ethos of Goal 11 "*Make cities inclusive, safe, resilient and sustainable*" of the United Nations Sustainable Development Goals Report 2020. In this respect, our objectives are framed to shape and inform decisions, policy and practice, and enhance societal impact for all. SoABE's research strategy is, therefore, divested through three main conduits: "Facilitation", "Creation" and "Dissemination" (Figure 2); where "Facilitation" is delivered through the CFRC, NBI and Construction Futures Incubator; knowledge "Creation" is leveraged through the DIGITAL and SSC RG's; and "Dissemination" is operationalised through the CFF, ICCF and SoABE provisions (professional practice boards/committees).

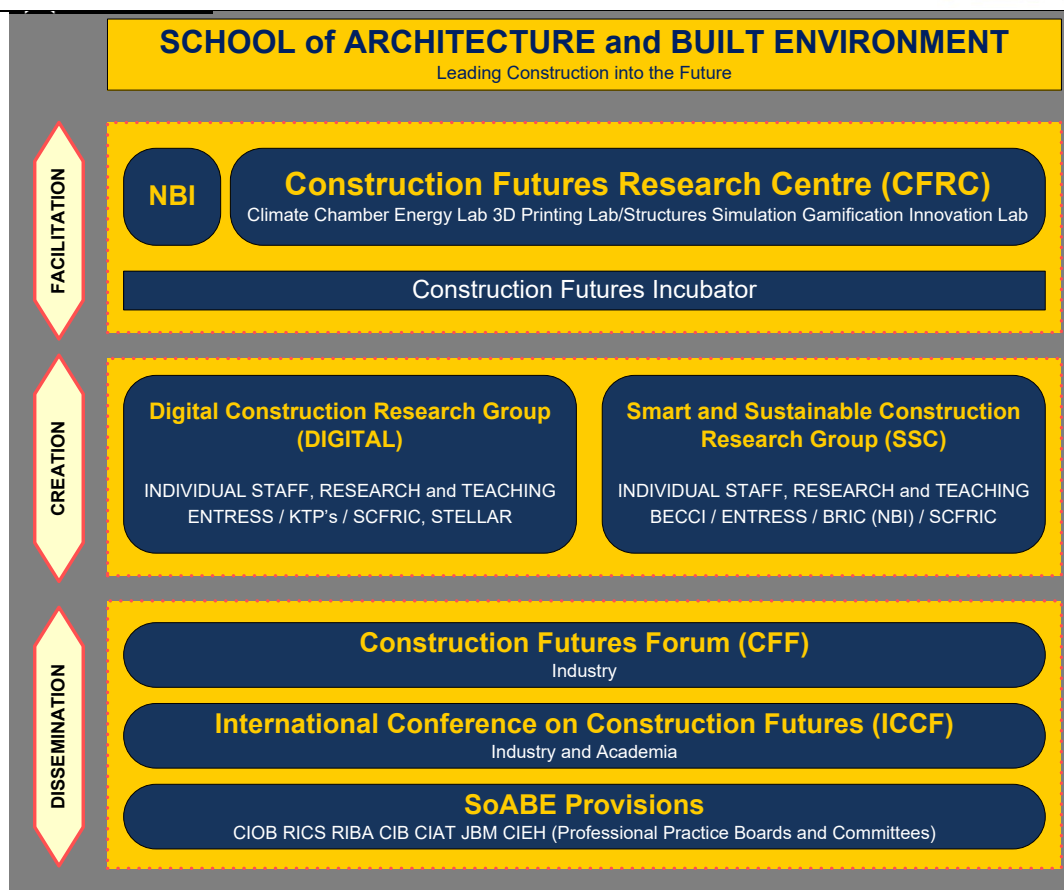


Figure 2: SoABE Research Strategy

SoABE's research objectives and impact strategy will focus on consolidating the UoA's position as a centre of excellence in our core areas of research. In doing so, we provide a turnkey portfolio which offers high impact solutions across the three-tiered delivery solutions of influence. This strategy was developed in close collaboration with our stakeholders, and includes the following objectives:

1. Critically evaluate the research landscape in DIGITAL and SSC to pattern match existing skills and expertise against current and future needs;
2. Create cogent systems for the exploitation and dissemination of research impact against the three-tiered delivery solutions [first-tier beneficiaries – (direct project investors and end users); second-tier beneficiaries (supply chain services underpinning projects), and third-tier beneficiaries (societal stakeholders)];
3. Systemically optimise all governance mechanisms to provide not only a vibrant, dynamic and sustainable research environment and culture for staff/students/stakeholders, but also provide clear, accessible and inclusive measures for wider inclusivity and engagement;
4. Ensure research is proactively managed and directly aligned to support teaching, knowledge transfer, and enterprise portfolios;
5. Provide clear pathway opportunities for all SoABE staff, with clear mentoring and support systems which underpin and promotes research excellence; and
6. Promote increased engagement with funding bodies, research organisations, professional bodies and industry not only to create synergies and critical mass, but also help strengthen and increase future grant capture opportunities.

c) How the unit has enabled and facilitated the achievement of impact from research

CFRC is firmly committed to maximising all impact achievements across its research investments. In doing so, it carefully considers and evaluates all pathway to impact conduits, along with



mitigation strategies and methods for securing maximum visibility. This approach aligns with UoW's Strategic Plan 2016-2021, its Impact Statement (Innovation and Opportunity: our Impact), and wider external drivers.

Our reach is designed to be achieved through thematic collaboration and geographical extension. Over the course of the REF period, we have engaged with over 200 businesses, more than 25 governmental institutions in 18 different countries. All these are central to our two Impact Case Studies. The first (ICS1), led by Georgakis, is entitled 'Delivering smart and sustainable infrastructure' and the second (ICS2), led by Heesom, is called 'Delivering optimal solutions to enhance organisational capability'. ICS1 is based on research in developing technologies, systems and theoretical frameworks that can support the realisation of smart and sustainable infrastructure. It represents the themes and research done within SSC RG and key beneficiaries included policy makers on sustainable and intelligent transportation systems, emergency service providers, energy companies and communities. ICS2 relates to bespoke activities and holistic interventions covering the three core pillars of people, process and technology and it represents the research themes within DIGITAL RG. The freshness of the approach is that it spans people, process, technology, systems and theory. Practise change emerges from these, as beneficiaries use research findings to improve culture, design, manufacture and construction. The achievement of impact is strategically facilitated and supported through research workload allocation, annual performance reviews, publication of staff profiles and operationalised dissemination pathways such as CFF and ICCF.

#### d) Supporting interdisciplinary research in the context of the unit's research strategy

Our research strategy underlines the importance of interdisciplinary and collaborative research working. Interdisciplinary research undertaken is intrinsic to CFRC, as we integrate our research efforts with multiple research teams across the University. Nowhere is this more in evidence than our partnership with Engineering and Sciences.

Chinyio's and Suresh's work on how Small and Medium-sized Enterprises (SMEs) in construction manage risk led them to collaborate with colleagues in Engineering and secure funding from the EU-FP7 for the 'Risk Management Software Systems for SMEs in the Construction Industry' (RiMaCon) Project. Staff also work closely with colleagues in Engineering on the development and testing of materials, including novel bio-materials. Williams (School of Sciences) is part of the BRIC Project and supports SMEs in terms of chemical testing of materials, especially soil geochemistry. Several colleagues from both Schools (Engineering and Sciences) are joint-supervisors of many of our current PhD students and have done so for many years. Working closely together through shared facilities, joint seminars, bidding and regular sandpits to address interdisciplinary research challenges, enhances the vitality and sustainability of the work that these subjects do. The bond is sustainable and is set to last long into the future.

#### e) Progress towards an open research environment

The CFRC aims to exceed the REF's Open Access Policy requirements and encourages effective sharing and management of research data. In accordance with UoW's Open Access Policy, all staff and students are required to place research publications on the institutional repository within three months of acceptance for publication. UoW has introduced a research information system (Elements) to not only capture researchers' outputs and profile, but also consolidate its research data management presence to support safe sharing of research data. Library services are very proactive in helping the team to maximise the dissemination of their research outputs. Staff are required and supported to have an ORCID account and are strongly encouraged to add publications to appropriate academic websites such as ResearchGate, Academia, LinkedIn and Google Scholar. We also undertake the following, beyond the minimum:

- Enabling open access for outputs beyond the scope of the minimum policy requirements, for example, ERDF project reports, case studies;
- Wider activity to encourage the sharing and management of research data- we host several open access specialist scholarly archival collections that support research both within UoW and beyond. The database that holds the laser scans of buildings around the West Midlands region by bringing together data from BRIC, SCFRIC and work in heritage BIM, is one example for our open access databases.

#### f) Supporting research integrity

Maintaining a strong research culture in which staff are empowered both to conduct excellent research and conduct themselves according to appropriate ethical, legal and professional frameworks, obligations and standards, is imperative for the CFRC. There is strong support for a culture of research integrity and this is practiced throughout the Unit and its governance committees, such as the Ethics Committee. There is a stipulated process for staff to obtain ethical approval for their research and staff are required to undertake mandatory e-Learning modules every two years on topics including information security, the General Data Protection Regulation (GDPR), and unconscious bias. Most staff are members of many professional bodies (for example, the Royal Institution of Chartered Surveyors [RICS] and Chartered Institute of Building [CIOB]), that demand adherence to professional ethics, standards and Codes of Conduct. We are also supported by the UoW's Research Policy Unit (RPU), who have developed the 'Code of Good Research Practise' to articulate the importance of integrity and rigour in all research conducted at, and in partnership with, UoW.

## **2. People**

#### a) Staffing strategy and staff development

SoABE is committed to creating a vibrant, dynamic and sustainable research environment and culture for all staff and students. To support this, a new 'Associate Head of School- Research' was appointed post REF2014 to provide leadership and strategy to create an enviable research environment conducive of innovative and impactful research. Following REF2014, SoABE made a strategic decision to invest, attract and recruit senior research staff, and encourage and support ECRs to advance in their research trajectory. Four new professorial appointments and seven academic recruitments with SRR resulted in expansion of UoA up to 19.2 FTE's in total. From a staff base perspective, this includes: six professors (all male), four readers (three male/ one female) and nine lecturer/senior lecturers (seven male / two female) with SRR. In addition, our research is rigorously managed and supported by four project managers, six knowledge transfer managers, ten research assistants and dedicated administrative staff.

#### i) Staff development strategy

Demonstrating commitment to the career progression of staff, SoABE encouraged experienced researchers to apply for promotion to Senior Lecturer/ Reader positions, to ensure there is a smooth succession when more experienced researchers retire in due course. Chinyio, Georgakis and Suresh were promoted to Reader positions during the REF reporting period having demonstrated the appropriate level of research excellence, leadership and international recognition through external peer review. Qasim, who joined us as a research assistant, was recruited as a lecturer during the REF period allowing him to progress in his career pathway. Having a range of prestigious and competitive individual research profiles, including a strong portfolio of university degrees and professional fellowships, is a key strength of our staff. These enrich the profile and experience of SoABE and are especially valuable in developing collaborative research networks, in both national and international arenas and with academic, industrial and government partners. A mentor, a senior researcher, is appointed to all our new recruits and

ECR's, to advise and support development and career advancement. Staff are also encouraged and supported to undertake CPD training relevant to their career development.

#### ii) Early career researchers

Research targets are agreed with appraisers annually during personal development discussion and take into account the amount of research time allocated. In addition, colleagues are encouraged to apply for further research hours from UoW's 'Early Career Researcher Award Scheme' (ERAS). The Scheme is for any member of staff in UoW who has achieved a Doctoral qualification (or equivalent) within the last five years and who wishes to pursue an identified research project over a 12 months (or 24 months for part-time staff) period. In the REF census period, three colleagues (Bock, Gupta, Saini) have received ERAS awards and additional time to conduct research. UoW also operates the Lord Paul Fellowship Scheme to support ECRs by providing seed money for their research and a bespoke career development programme to nurture future leaders. Daniel won this Fellowship in May 2020 for his project on off-site and lean construction.

Visiting researchers make very important and welcome contributions to the research activities of CFRC and are actively encouraged to contribute to seminar discussions and to present seminars. An excellent exemplar is the 'Built Environment and Engineering Research Seminars' (BEERS) series, which is organised by CFRC. Most visiting scholars are from overseas, thus enriching the diversity and international perspectives of research within CFRC. Some of the visits during the REF census period included:

- Tanta University, Egypt, 2014-2016
- Universiti Sains Malaysia, Malaysia, 2018
- State University of Rio de Janeiro, Brazil, 2018-2019
- Yunnan Agricultural University, China, 2018-2019

#### b) PGR students: support mechanisms, training and supervision

##### i) Recruitment

The success of our PGR portfolio is key to quality and growth in research and creating a vital and vibrant environment for research student community is central to their success. SoABE has a dedicated PGR Coordinator, in addition to the Faculty level PGR Director, ensuring smooth running of PGR admissions, inductions, progressions, completions and skills development. A total of 127 (104 Full-time and 23 Part-time) PGR students was recruited during REF period.

Many PGR students are on secondment from their employment, often from overseas universities and their career progression is enhanced upon their return. Funders of prestigious and competitive studentships include: The Governments of Iraq, Nigeria, Saudi Arabia, the United Arab Emirates and the Commonwealth Scholarship Fund. During REF period, over 50% of completed PhD projects had received funding through sponsorships/ competitive studentships. These students make a valued contribution to PGR culture and research work. A good example is that of a Commonwealth scholar who joined from Ladoke Akintola University of Technology, Nigeria in 2014 to undertake her PhD research in Civil Engineering. The successful PhD was submitted within three years of study (January 2014-January 2017). She also completed a PGCert in Higher Education (HE) and became a Fellow of Higher Education Academy (FHEA).

##### ii) Monitoring and support

Experienced staff are selected to be the Director of Studies (DoS) of PhD programmes. This means the DoS has successfully supervised at least one PhD project to completion. The DoS is teamed up with at least one second supervisor. Inexperienced and/or new staff are provided training on the 'Research Supervisor Development Programme' of the UoW's Doctoral College



(DC), that consists of training sessions and workshops, before appointing them to supervisory teams with experienced supervisors.

Annual Progress Reviews (APRs) are conducted to monitor progress and provide a personal development plan to all PhD students. APRs are conducted by two academics independent of the supervisory team and students are encouraged to discuss any concerns they may have on any subject, providing a support mechanism, whether academic or pastoral in nature, for PGRs. There is strong evidence of the high quality of training and supervision of PGRs: 59 PhD projects completed during the REF census period, thus doubling the number of PhD completions compared to REF2014. We also improved the mean completion rate-per-FTE, whilst maintaining a healthy student satisfaction experience (Table 1).

Table 1: PhD completions in comparison to REF2014

Doctoral completions for REF2014	Doctoral completion per FTE REF2014	Doctoral completions for REF2021	Doctoral completion per FTE REF 2021	PRES2019 overall satisfaction
28	2.07	59	3.07	78.6%

The 2017 and 2019 Postgraduate Research Experience Surveys (PRES) reported a ca.79% satisfaction rating from our PGR students. Both 'supervisor skills and knowledge', and 'student skills development' scored over 90% satisfaction. This is further evidence of the high quality of PGR training and supervision.

### iii) Skills development

All SoABE PGR students are members of the UoW's DC that provides a comprehensive and holistic face-to-face and online development programme for Postgraduate Researchers. The personal and professional development opportunities for research students are spread throughout the duration of the research degree. The DC works in collaboration with other University services, including careers and employability, learning information services and the Students Union to enhance the postgraduate experience.

The BEERS seminar series is central to dissemination of good research practice by PGR students in the CFRC. It commenced in October 2006 and the seminar in May 2021 will mark the 100th seminar in the Series. Each PGR student is expected to make two presentations during the course of their research. The forum accommodates diverse researchers, from new starters to students near completion, and provides collective support and constructive criticism of individual research projects. During the COVID-19 pandemic, seminars are being held virtually.

PGR students presented and disseminated their research findings at International conferences. The two most attended conferences were the 'International Conference on Sustainable Futures (ICSF)', 2017 in Bahrain and the first ICCF (2018) in Wolverhampton, UK. Several of our PGR students have won prizes for their work at international conferences; for example, the paper entitled 'Evaluating critical success factors for implementing renewable energy strategies in the Dominican Republic' won the APM best paper award at ICSF. Each PGR student is allocated a total of £1,500 to attend an important conference in their second or third year or attend external training sessions.

Several of our PhD students have successfully completed their PGCert in HE and have subsequently become members of FHEA. This training, mentoring and subsequent membership has provided unparalleled opportunities for engaging in teaching or acting as Visiting Lecturers; which *inter alia* prepares them for future career opportunities. Annually, the DC runs a PGR employability conference, including workshops on preparing job applications and mock interviews and many SoABE students use these services.

c) Equality and diversity: support and promotion

The issues of equality and diversity are of paramount importance to UoW and SoABE. We are fully committed to the advancement of equality and the elimination of unlawful and unfair discrimination and to treat all staff and students with respect, in order to provide a positive environment free from discrimination, harassment or victimisation. SoABE values the benefits that a diverse student and staff population brings to its culture.

The commitment to diversity and equal opportunities is given a very high priority by SoABE. Examples of our commitment to equality and diversity are given below:

- We have increased the proportion of female staff submitted for REF. In this submission there are three female (16% of FTE) staff, compared to only one female (7% of FTE) staff submitted in REF2014. Obi joined as a Lecturer and was promoted to a Senior Lecturer and Suresh was promoted as a Reader in this REF census period.
- SoABE contributed to UoW's application for the Athena SWAN Bronze award, which was renewed in 2020. One of our female staff (Suresh) championed the UoW's Athena SWAN subject specific (Built Environment) group.
- The diversity of the staff (10 different national origins) submitted for REF2021 provides further evidence of the School's commitment to champion diversity and equality and see them as integral to the vitality of the Unit. Our submission is enhanced by its ethnic diversity and 75% of submitted staff are BAME.
- CFRC implemented a 'Gender Equality Action Plan' (GEAP) in 2018 and this plan is being actively promoted. The long-term aim is to achieve Athena SWAN Gold status.
- We have organised many seminars, events and workshops raising awareness on gender equality and career progression for staff, students and industry. Recent examples include:
  - 'Women in Property and Construction (2017)', 13 speakers shared their experience
  - International Women Day events held in 2018, 2019, 2020
  - Inclusive Careers Conference Workshop (2019)
- All staff undergo mandatory training (repeated every two years) for equality and diversity and unconscious bias.

**3. Income, infrastructure and facilities**a) Research funding and strategies for generating research income

Research funding and income generation strategies are directly managed through CFRC. This not only envelops the current priorities of its two RG's, but purposefully divests effort to both long-term recurrent challenges, along with emergent themes that need specific focus. Funding strategies of late have focussed on: BIM/digital construction solutions, sustainable construction approaches, advanced off-site construction methodologies, smart cities and infrastructure development, and brownfield remediation and regeneration. Research income reported in REF2014 was approximately £562,000. However, in line with our strategy, SoABE invested additional resources to expand its critical mass, capacity and overall bidding capability, which resulted in a significant increase in research income of £2,325,621 (for this reporting period). This amount excludes some other income streams reported under different capital and revenue headings, some of which may have been omitted in the calculation of total research income. Our total revenue includes major funders such as UK and EU funding bodies, including ERDF, EU Horizon 2020, UKRI and BC. A selection of these projects can be seen as follows:

- BECCI (ERDF, 2013-2015) supports SMEs in developing innovative climate change solutions. In conjunction with Coventry University, BECCI was awarded £1.2m. Based on its success, BECCI-2 (2016-2018) and BECCI-3 (2019-2021) were awarded a further £2.85m in total. The main focus of the BECCI project is to decrease carbon emissions from

residential and commercial buildings through innovative solutions including the adoption of low carbon technologies developed by local SMEs.

- OPTIMUM (EU Horizon 2020, 2015-2018) focussed on the necessary data infrastructure for handling huge amounts of Intelligent Transportation Systems (ITS) related data. Data infrastructure contained adapters for all necessary data sources, such as open data sources. These include traffic data and points of interests, real-time transportation information, alternative mobility options, weather and air quality information. This project engaged 18 academic and industrial partners from nine different EU countries, with a total project value of €5.9m (UoW component £362,989.92).
- BRIC (ERDF, 2017-2022) supports Black Country SMEs involved in brownfield remediation and redevelopment. This coordinates brownfield data and develops innovative remediation technologies and solutions for brownfield land in order to provide positive long-term impacts on urban regeneration practices, to improve policy at regional, national and international levels. BRIC received £3.5m for its activities and provides a platform for the initiation of the NBI, which received £14.9m funding from the UK Government's Get Building Fund in 2020.
- SCFRIC (ERDF, 2019-2022) project provides a range of support measures, ICT solutions and business support to regional companies. This includes process improvement, BIM, strategies and platforms, innovation drivers/opportunities, all of which aim to improve organisational performance and capability. This project received £1,425,514.
- STELLAR (UKRI, 2020-2022) accelerates research into Modern Methods of Construction (MMC) using 3D 'digital twins', parametric modelling, simulation, logistics, and advanced automation/production approaches. Whilst still relatively in its infancy, this work has received positive attention from the MMC supply chain, housing associations and the House of Lords. This project received £1.95m (UoW component £243,469).

In addition, eight KTPs (totalling £546k), predominantly in BIM and Digital Construction, have been secured during the reporting period.

CFRC researchers have established strong links with government, industry, professional and other external bodies to not only work collaboratively, but also explore opportunities for capturing additional funding. For example, Georgakis's academic links with partners across the EU [for example, TU Delft (Netherlands), National Technical University of Athens (Greece) and Austrian Institute of Technology (Austria)] and industry [for example, Intrisoft International (Luxembourg) and TRT Trasporti e Territorio (Italy)]; led to our engagement with several EU Projects (totaling £1.2m). Research discovery from these projects include Multi-source Big Data Fusion Driven Proactivity for Intelligent Mobility; End-to-End Approach for Mobility-as-a-Service tools; and Spatial and Transport Planning Tools. Findings from these projects have helped inform policy on the adoption of sustainable transportation systems and standards.

CFRC proactively shares its knowledge, experience and findings to industry and broader society (*cf.* third-tier beneficiaries) to maximise discovery, dissemination and wider uptake. For example, Hampton and colleagues secured funding to support SMEs in developing climate change solutions to address construction industry CO<sub>2</sub> emission problems. This included work on resource efficiency drivers and development of innovative environmental technologies, culminating in the design and deployment of renewable energy and sensory systems that had a positive impact on energy efficiency, whilst also helping to reduce carbon emissions from infrastructure and housing projects. Energy-cost saving of 20% (at household level) were achieved, which as a corollary, led to a 19% decrease in property arrears. This work also helped inform policies at national and international levels by reporting findings to the Ministry of Housing Communities and Local Government (November 2018), including advising both the Black Country LEP and European Structural and Investment (ESI) Funds Sub-committee. 39 LEP areas support the delivery of the ESI Funds programme for 2014 to 2020 in England, including the Black Country LEP. The reach and significance of this impact was due to the high-quality research, the strategic approach adopted, high levels of engagement and commitment of the team to ensure high relevancy of findings to technical and practical challenges.

A further example of the success of our funding strategy includes Arif, Heesom and colleagues' support to SMEs in developing new methodologies and processes to deliver efficiency improvements in the construction, housing and infrastructure sector using MMC and offsite techniques. This incorporates Goulding's and Arif's expertise in offsite manufacturing as joint Coordinators of CIB's W121 Working Commission (Offsite Construction) and earlier work in TG74 (New Production and Business Models in Construction). The combined efforts (in conjunction with Heesom's expertise in BIM) have helped secure ERDF funding to further support industry improvements. Work to date has helped SME's improve their product offering and identified new innovative products and services. It created new opportunities for national and international markets through such avenues as the development of a new panelised-based extensible, high volume residential buildings system; creation of new process simulation techniques; and design of new model-driven platform strategies.

Other examples of research funding and strategies for generating research income include the creation of CFRC as the primary conduit and optics for our collective research offering. CFRC is used to coalesce research capability with industry need, through government initiatives, industry grand challenges, professional bodies' foci, and wider societal issues. This arrangement has not only helped CFRC maximise its research interventions (value, impact, reach, significance), but also helped identify new/emerging priorities and funding opportunities. In this respect, UoW is now considered to be at the forefront of urban regeneration research and is actively delivering the City of Wolverhampton's vision. Arif, Pathirage and colleagues have worked closely with Wolverhampton City Council, the Black Country LEP and the West Midlands Combined Authority (WMCA) to secure funding from ERDF to support BRIC, and subsequently £14.9m funding from the UK Government for the NBI. This funding will also be used to deliver projects that create jobs in urban regeneration, thereby generating further investment to support economic recovery post-Covid-19. Given this, the NBI is expected to grow and evolve into a world class Research Institute, located within SoABE's new state-of-the-art Springfield Campus. NBI will provide facilities to: (1) develop advanced skills, technologies and methodologies through innovation and partnership with the construction industry; (2) focus on practical applications of future brownfield regeneration through targeted research; and (3) lead policy development, research, innovation and commercial services in brownfield regeneration.

#### b) Organisational infrastructure supporting research and impact

Infrastructure supporting research and impact of CFRC is available at School, Faculty and University levels. An impact officer in the RPU is assigned to CFRC and works very closely with our members to ensure we maximise the research impact. We are also ably supported by six knowledge transfer managers in optimising research impact by carefully considering and evaluating all pathways to impact. The Faculty's dedicated project and bidding support manager provides pre-and post-award support to costing of proposals and the financial management of research grants and associate financial reporting.

#### c) Equality and diversity

SoABE members are a mixture of experienced and ECRs and work as teams, so that the benefit of experience, expertise and connections can be passed onto the next generation of researchers. Therefore, research bids frequently involve a balanced team in terms of experience. Several ECRs (Kaushik, Obi, Qasim) have been part of successful bidding teams during the reporting period. In particular, Qasim led the bidding teams that secured a total of £144,640 funding in 2019 from the BC Newton Fund Researcher Links Workshop Scheme to organise workshops in Brazil, Jordan and the Philippines on several themes, including environmental resilience, energy efficiency and climate change.

d) Research infrastructure

SoABE laboratories have been significantly enhanced, in terms of space and facilities, with the move to the new Springfield Campus. The brand-new state-of-the-art building with 7,900m<sup>2</sup> space offers specialist teaching and social learning spaces, design studios, specialist laboratories, multi-disciplinary workshops, lecture theatres, a cafe, offices, meeting rooms, ICT rooms and a top-floor super studio. Both staff and students use the laboratory facilities with controlled access. Most materials research and geotechnical investigations are undertaken within these laboratories. SoABE also have a full range of geotechnical research equipment. Facilities and equipment include: FARO 3-D laser scanner, field XRF analyser, Ground Penetrating Radar, drones, and dedicated field survey equipment, all of which are supported by advanced VR and GIS facilities and a dedicated small team of expert technical staff.

**4. Collaboration and contribution to the research base, economy and society**

CFRC staff have established a number of high profile successful collaborative partnerships with industry, the research community, academia and wider societal beneficiaries. These long-standing arrangements span a range of disciplines, and designed to maximise impact and further promote continued engagement. This approach, our differentiated positioning and use of substantiators have strengthened our core offering and impact.

a) Research collaborations, networks and partnerships

Developing, nurturing and enhancing partnerships are pivotal to the research activities and professional standing of SoABE. Given the applied nature of our research, CFRC's raison d'être centres on the delivery of transparent communication and engagement platforms throughout the research process, from need, through to discovery, development and impact. This collaborative approach is vital for shared and collective ownership from the outset, and underpins effective and timely delivery of research targets, whilst ensuring CFRC maximises its ability to promote reflexive interpretation of research discoveries to both cognate and non-cognate audiences.

CFRC's research collaboration, networks and partnerships span micro, meso and macro pathways from single organisations, through to complex multi-tiered companies with global reach and significance. Success indicators include grant capture, journal publications, joint PhD supervision, conference hosting, and industrial workshop sessions. Fullen has been working closely with the Federal University of Rio de Janeiro (Brazil) since 2001 and this research collaboration has attracted funding from the Brazilian National Research Council. Similarly, Yunnan Agricultural University (China) has been a research partner since 1987. Indicators of success with this partner during the REF census period include a jointly supervised PhD project, one journal publication and a book chapter. The funders of this research collaboration include Yunnan Province Science and Technology Commission.

b) Wider contributions to economy and society

CFRC is actively engaged in a number of activities that directly and indirectly support socio-economic beneficiaries. This includes societal impact stemming from publicly-funded research; in particular, activities that enhance societal value through wider social, cultural, environmental and economic measures (for example, new jobs, services, reduced waste and pollution, increased mobilisation, new Government priorities), all of which form part of the Government's Grand Challenges (2019). Examples include brownfield regeneration (an emerging priority area of CFRC), which directly contributes to urban regeneration of the Black Country that contains a significant amount of derelict brownfield land. The new Springfield Campus (£110m regeneration project), now hosts SoABE's world-leading research centre (BRIC), which includes a dedicated



research institute (NBI) with £14.9m funding to develop new and innovative remediation technologies for brownfield land. This conjoined approach not only contributes to the long-term strategies for urban regeneration in the West-Midlands, but also helps deliver the UK Government's wider regeneration strategy. At regional level, we help authorities such as the WMCA and Wolverhampton City Council achieve their strategic goals. This strategy promotes, shares and delivers maximum impact, supporting UK economic growth, employment and concomitant underpinning societal infrastructure. This work is also promoted and shared through our partner networks to maximise reach and significance with other world-leading domain experts in urban regeneration and brownfield development.

### c) Indicators of wider influence

CFRC staff are active in multiple professional roles. We provide illustrative examples to demonstrate the breadth and depth of the contributions staff make.

#### i) Journal editorships

Over 10 CFRC members are Journal Editors, Guest Editors for Special Issues or act as Editorial Team Members. For example, Goulding is an Associate Editor for the *International Journal of 3D Information Modelling*, and was the Editor of *Construction Innovation* (1995-2016), now Honorary Advisory Board member. Fullen is the Associate Editor of the Journal *International Soil and Water Conservation Research*, and Georgakis is a Topic Editor for *Sustainability*.

Staff are frequently invited to be Guest Editors of special and themed journal issues, due to their standing in respective subject areas. For example, Arif and Goulding have acted as guest editors for special issues on 'Offsite Manufacturing: Industry Transformation and Future Landscape Development' for *Construction Innovation* in 2020 and on 'Off-site Construction' for *Architecture Engineering and Design Management* in 2018. Pathirage was the guest editor for the special issue on 'Disaster Management and Resilience in Building Construction' for *Buildings* in 2016; Sheng was the guest editor for a special issue on 'Textile Composites' for *Materials* in 2017. Heesom and Oloke are currently acting as guest editors for the *Journal of Engineering, Design and Technology* on 'Resilience and responsiveness of the AEC Sector'.

Our researchers also serve on over 30 Editorial Boards of leading journals. Examples include: *Construction Innovation* (Arif); *International Journal of Law in the Built Environment* (Ndekugri); *Smart and Sustainable Built Environment* (Goulding, Renukappa, Suresh); and *Journal of Environmental Engineering and Landscape Management* (Fullen).

#### ii) Prizes

In recognition of the high standing of their research, CFRC staff have been awarded several prizes and accolades. Recent examples include: 1) Emerald Literati Award (2019) for Outstanding Paper by Arif for 'Critical factors for transferring and sharing tacit knowledge within lean and agile construction processes', *Construction Innovation*; 2) Emerald Literati Award (2018) for Outstanding Paper by Adaku for 'Major causes of construction time and cost overruns', *Journal of Engineering, Design and Technology*; 3) Emerald Literati Network Awards for Excellence (2020) Highly Commended Paper by Goulding for 'Investigating the cost of offsite construction housing in Western Australia', *International Journal of Housing Markets and Analysis* 4) Fullen was the joint winner of the 'Gerold Richter Award' (2015) from the European Society for Soil Conservation.

#### iii) Fellowships

The majority of staff hold membership/fellowship of one or more professional bodies. These include CIOB (Arif, Chinyio, Daniel, Ndekugri, Oloke); RICS (Ndekugri, Oladinrin); CEng (Arif, Oloke); The Chartered Institute of Architectural Technologists-CIAT (Heesom). Additional membership includes overseas professional institutions such as the Institute of Quantity Surveying

in Sri Lanka (Pathirage) and the Council of Architecture in India (Kaushik). Almost all staff are Fellows of the HEA, including one Senior Fellow (Ndekugri).

iv) Membership of research councils or similar national and international committees

CFRC researchers actively contribute to professional associations and learned societies. Examples include CIB Co-ordinator for W102 Information and knowledge management in Building (Suresh), W113 Law and Dispute Resolution (Charlson) and W121 Offsite Construction (Arif and Goulding). Sheng is a Council Member of the International Masonry Society, and Fullen holds the role of Vice-President and UK Representative of the World Association of Soil and Water Conservation and Vice-President of the European Society for Soil Conservation.

v) Invited keynotes and conference chair roles

Goulding delivered a keynote speech during the Conference on Governing Mega-Projects: 'Towards Public Value Management' at the University of Central Lancashire, UK, 2014. Similarly Fullen delivered keynote presentations in China during the 'International Symposium on Poverty Reduction and Economic Development in Western China,' Yunnan Agricultural University, 2014 and 'Conference on Agricultural Ecology,' 2015. Arif has delivered several keynote speeches, including the Conference on 'Modular and Offsite Construction,' Canada, 2016.

Several staff members have chaired/co-chaired international conferences, including the first and second ICCF in 2018 and 2020 (Arif, Goulding, Heesom and Suresh) and the 13<sup>th</sup> International Post-Graduate Research Conference in 2017 (Pathirage). CFRC members have also chaired/co-chaired many national and international panel sessions, the engagement of which spans over 40 international events over the REF reporting period.

vi) Refereeing academic publications and research proposals

All staff contribute to the subject as referees for many Architecture, Built Environment and Engineering journals. Leading journals include: *Automation in Construction* (Heesom); *Building Research & Information* (Goulding); *International Journal of Architectural Heritage* (Heesom); *International Journal of Building Pathology and Adaptation* (Adaku, Heesom); *Construction Innovation* (Arif, Daniel, Goulding, Pathirage); *Construction Management and Economics* (Adaku, Chinyio, Daniel); *Engineering, Construction and Architectural Management* (Adaku, Chinyio, Daniel, Oladinrin, Renukappa); *Journal of Cleaner Production* (Renukappa) and *Journal of Management in Engineering* (Daniel). Fullen has refereed 305 journal papers for 59 journals.

Our staff have also been referees for numerous applications for research funding. These include the Qatar National Research Foundation (Arif); the British Council (Georgakis); National Science and Engineering Research Council of Canada (Heesom, Goulding); Engineering and Physical Sciences Research Council-EPSRC (Goulding, Heesom, Pathirage); the EU (Frameworks 5, 6, 7 and Horizon 2020) research programmes and expert panels (Fullen, Goulding, Pathirage); the Biology and Biological Sciences Research Council (Fullen); and the US National Science Foundation (Fullen).

The above list of activities in terms of journal editorships, memberships, keynotes, conference chairing and refereeing is not exhaustive but gives a flavour of the extensive work our team members are performing. We are committed to conducting research, which is impactful, vital, and sustainable.