

Institution: University of Huddersfield
Unit of Assessment: UoA13 Architecture, Built Environment and Planning
<p>1. Unit context and structure, research and impact strategy</p> <p>1.1 Context</p> <p>Architecture and Built Environment research at Huddersfield has grown rapidly since REF 2014. This is Huddersfield's first submission to UoA13 and we now number 16.6 FTE, with 3 ECRs and a head count of 18. For the period 2014-2020, all staff in the Unit were part of Huddersfield's School of Art, Design and Architecture (ADA). In 2014, we set a clear ambition to transform from having only sporadic and limited research activity, to one that is internationally leading and recognised for research, and whereby research informs teaching and underpins enterprise activities. In supporting this aim, we have developed an environment, in terms of its vitality and sustainability, that is conducive to securing significant research income from prestigious sources, promoting strong international and inter-disciplinary partnerships, and attracting and developing high calibre postgraduate researchers. It also enables extensive end user engagement in our research, the producing of world leading quality outputs and developing outstanding impacts that contribute to economic, social and cultural development.</p> <p>1.2 Structure</p> <p>The rapidly growing Unit has three internationally recognised centres of excellence and vitality: Centre for Urban Design, Architecture and Sustainability (CUDAS), Global Disaster Resilience Centre (GDRC), and Innovative Design Lab (IDL). The Centres were established in 2014/15 to bring together staff from diverse disciplinary and cultural backgrounds and to form inter-disciplinary groupings. They provide critical mass to address the complexity of social, physical, technical and economic challenges confronting our cities and their built environment. They also act as bridges to our UK and international stakeholder constituencies in the construction industry, government and third sector. These collaborative links to end users inform our understanding of these challenges and support us to co-design, conduct and implement our research.</p> <p>1.3 Research strategy: 2014-2020 and looking ahead</p> <p>In 2014, we set our strategic goal to build capacity, expertise and reputation for integrated architecture and built environment research that can enable a high-performance industry, a more sustainable built environment, and a more secure, disaster resilient society. This aligns with the University's Area of Strategic Research Importance (ASRI) on sustainable environments (see REF5a institutional level statement [ILS section 2]). This goal has been supported by strategic objectives that reinforce the University's research strategy:</p> <ol style="list-style-type: none"> 1) Grow research activity in the areas of disaster resilience, innovative design, and architecture, cities and sustainability 2) Increase research income and diversify sources 3) Promote international and inter-disciplinary research 4) Attract high calibre, UK and international postgraduate research students 5) Develop links with UK and international industry and research users, and contribute to economic, social and cultural development 6) Grow the number of ECRs and staff with doctorates

1.3.1 Implementing our strategic goals in the current cycle

All our strategic objectives have been met or exceeded, leading to exceptional growth since 2014, as represented in Table 1.

Table 1: Summary of annual research income and postgraduate activity

	13/14	14/15	15/16	16/17	17/18	18/19	19/20	Total
Research income (£K)	3	152	224	349	637	999	970	3,336
PhD completions	0	3	2	6	6	5	6	28

15 of the Unit's staff have been recruited since 2013, including:

- 3 Professorial appointments (Amaratunga, Haigh and Tzortzopoulos) who were recruited to establish and lead 2 new research centres (GDRC, IDL);
- 4 further Professorial appointments to strengthen expertise in construction management (Kagioglou, Koskela), construction economics (Ruddock), computer modelling (Wu);
- 1 Reader appointment in urban design (Delsante); and,
- Significant investment in new talent, with 8 Lecturer/Senior Lecturer appointments (Delzendeh, Di Mascio, Gohar, De Oliveira Gomes, Malalgoda, Talebi, Tezel, Ziada), and a Research Fellow (Dias), to add depth and provide a platform for growth.

ADA invested in 33 doctoral scholarships, which subsequently led to the employment of Gomes, Talebi and Delzendeh as academic staff. 3 of the submitted Unit staff are ECRs (Delzendeh, Dias and Talebi) and 7 gained doctoral qualifications during the assessment period. These investments joined staff with existing strengths in architectural history (Temple) and sustainable architecture (Pitts).

It is a measure of the stimulating intellectual environment created in our research centres that we have collectively secured £9.3m in external research grants and published 322 peer-reviewed outputs during this REF period. We also convened or co-convened 26 international conferences and 67 international workshops, chaired 9 conferences and 26 conference panels, gave 98 invited keynotes and lectures, and had representation on 23 national and international committees (section 4.3).

Objective 1 - Grow research activity**Disaster resilience**

GDRC (4 FTE), led by Amaratunga and Haigh, is an international leader in research and advocacy that combines the built environment with other disciplinary perspectives to tackle disaster risk in cities. Since 2014, it has secured 26 external grants with 145 international partners in 45 countries (grant value of £5.1m).

Amaratunga and Haigh led a series of EU funded international, multi-disciplinary, researcher capacity building projects (ASCENT, CABARET), while their Newton Prize winning project (British Council) examined the integration of disaster risk reduction and climate change adaption, and interface arrangements in tsunami early warning. This work is being taken forward with grants on transboundary river management in Indonesia (NERC) and localising tsunami warning (BEIS). Their body of tsunami early warning research has led to changes in early warning and informed policy development in 28 Indian Ocean states (see impact case study).

Amaratunga's EU-Asia study of the professional skills required to increase disaster resilience through the construction industry (CADRE) was the basis for informing policy on a global UN campaign and changes to construction industry practices in Sri Lanka (see impact case study).

Amaratunga and Malalgoda are now leading an EU funded international study on displacement

(REGARD). Amaratunga and Haigh have also partnered on other EU funded research, including the research-policy interface (ESPRESSO) and climate change consumer behaviour (BECK).

Architecture, cities and sustainability

CUDAS (5.3 FTE), led by Pitts, has secured 11 external grants and considers the interconnections between cultural, social, urban and sustainable aspects of architecture and the city, exploring their historical contexts and meaning within contemporary urban and rural environments.

This embraces an extensive body of collaborative work on urban and rural China, including Pitts and Gao's British Academy/Leverhulme award, and Sustainable and Creative Villages Research Network in SW China, and Gao's Chinese Natural Science Research Funding on Construction Culture of Houses. These were carried out in collaboration with Chinese Universities, recognised with the appointment of Pitts and Gao as Distinguished Professors in China. The breadth of work in China is illustrated by Delsante's research on rapid urbanisation in Shanghai, and Temple and Gao's investigation of traditional building crafts. These formed the basis of an exhibition jointly curated by Gao, Delsante and Temple, and Pitts and Gao's publication of a Design Manual in China to promote sustainable design and construction.

Temple has carried out extensive work in architectural and urban history and theory, including the history and theory of architecture and urbanism, and with Gao on Chinese perspectives on architecture and heritage.

Innovative design

IDL (7.3 FTE), led by Tzortzopoulos, has secured 27 external grants (£3.7m), and conducts theory based and applied research into design and the built environment, pushing the impact of design thinking and practice to new areas. It cuts across the areas of architectural design, construction management, digital technologies, new product development, engineering, social sciences and healthcare.

The centre's strong focus on real world problems and industry challenges, especially infrastructure, are illustrated through Tezel, Koskela and Tzortzopoulos's research alliance with Highways England (HE). A subsequent KTP with Arcadis has improved highways design planning and control. Wu and Tzortzopoulos's KTP with Waldeck, to develop digital information capture for bridges, has resulted in related infrastructure projects using technology, including Wu's Network Rail R&D, Wu and Talebi's EU/Network Rail In2Track2 - Bridge Health Monitoring, and Wu's EPSRC Industrial Case studentship with Network Rail.

In the Innovate UK funded S-IMPLER, Koskela and Tzortzopoulos collaborated with government and industry on retrofit of solid wall housing, while the ESRC U-VITAL project has facilitated the co-design of social housing refurbishment solutions. Tezel has an emerging body of work around Blockchain technology in construction (CDBB). Wu's leadership of game development in the UKRI GCRF funded Ni3 project exemplifies the centre's willingness to integrate disciplinary perspectives, contributing game development expertise to help prevent gender-based violence.

Objective 2: Increase research income and diversify sources

Our grant application plan (section 3.1), led through our research centres, set out to grow income, increase the number of staff applying for and securing grants, and diversify funding sources. Our annual research income has grown from just £3.4K in 2013, to £970K in 2020, with

a total research income of £3.4M over the period. 15 of our staff were principal investigators for external grants and our research was supported by diverse sources, including the UK Research Councils (£1.08M), European Commission (£4.5M), industry (£1.04M), government (£2.63M) and charities (£77K).

Objective 3: Promoting international, inter-disciplinary and collaborative research

Problem led research centres and the recruitment of international staff from diverse disciplines, as well as competitive, internal seed funding and travel grants, has led to a wide portfolio of collaborative research (sections 3.1.1 and 4.1).

Objective 4: Attract high calibre, UK and international postgraduate research students

Recruitment of experienced research active staff with doctoral qualifications significantly increased supervisory capacity, while 33 funded scholarships were linked to the new research centres. A Director of Postgraduate Research was appointed by the School and research training provision increased (section 2.2). Doctoral completions increased from 0 in 2014 to 6 in 2019, with a total of 28 over the period.

Objective 5: Develop and strengthen links with research users, and contribute to development

Links with external UK and international institutions have been advanced through targeted support (section 3.2), which has helped to build established research partnerships with major industry, government and third sector organisations (section 4.2). 39 of our external research grants have end user organisations as collaborative partners, including CADRE with UNISDR, CABARET with IOC-UNESCO, and NERC with six Indonesian government ministries and authorities. The S-IMPLER project collaborated with five UK construction industry and client organisations and the U-Vital project involved international collaborators and UK industry, clients and public bodies. Our KTPs with Waldeck and Arcadis (£375K) have addressed current industry needs. Collectively, these have helped the Unit contribute to economic, social and cultural development (section 1.5 and impact case studies).

Objective 6: Grow the number of ECRs / staff with doctoral qualifications

As part of the University strategy (since 2013), all academic staff at Huddersfield with contracts of 0.5FTE or above are required to have a PhD or enrol into PhD studies. In 2020, 100% of submitted staff in the Unit are PhD holders, which has increased the strength of our research base and provides a foundation for development. Dias, Delzendeh, Gohar, Gomes, Malalgoda and Talebi have gained doctoral qualifications since 2014. A further 9 staff recently completed or are due to complete in the next two years, which will increase our future research base.

1.3.2 Future strategic plans: research

Our future strategic plans seek to consolidate and build upon our growth in CUDAS, GDRC and IDL. We will continue to address the current and emerging challenges confronting our cities, including the need to develop and protect sustainable built environments, but that also address the impacts and systemic risks exposed by the COVID-19 pandemic. The complex, interconnected and transboundary nature of these challenges will require us to build upon our collaborative relationships with end users and other disciplines, within the University and externally, in the broad area of Sustainable Environments, a University ASRI (ILS section 2).

Over the next five years:

- GDRC will strengthen its links with the University's physical and environmental geography expertise. This will increase our ability to tackle complex challenges linked to

urban development and climate change, including systemic risks. It will bring together expertise in construction and governance with human and physical geographers. GDRC will also expand their early warning work to address biological hazards.

- IDL will continue to collaborate with key clients and public organisations in the infrastructure sector, applying lean thinking to improve the efficiency of infrastructure and develop a thematic focus on design for healthcare. IDL will also grow provision to create a centre of excellence in doctoral studies in innovative design and build upon strong industry links in the infrastructure sector to become a well-known centre for innovation and IP generation.
- CUDAS will establish a new research group dedicated to the culture and architectural practices of China and SE Asia. At the heart of this new research group will be an investigation of the heritage of Chinese architecture and crafts, and the significant tensions that exist between precipitous urbanisation, the region's material culture and accelerating ecological destruction. The Centre will also build upon recent recruitment to develop a new area of specialism around landscape architecture.

In order to facilitate this, our strategic goals are to:

1. Continue supporting and developing existing staff, including those currently studying for PhDs, with the aim of enhancing our 'critical mass'.
2. Continue appointing staff with excellent related research experience in the ASRI Sustainable Environments.
3. Continue focusing on inter-disciplinary research and new strategic collaborative relationships with top 300 universities and business.
4. Apply existing expertise to address emerging UK and International priorities, such as the impacts of COVID-19 on our cities and industry.
5. Co-produce high-quality impactful research and maintain or establish links with businesses and end users in the UK and internationally.
6. Improve the quality of research outputs, including citations and co-authorship with end users.

1.4 Interdisciplinarity

The Unit supports multi- and interdisciplinary research through its three research centres, which combine architecture, design management, construction management, quantity surveying, civil engineering, product design, architectural history and urban design. We also work with other Schools, such as Wu's work with behavioral and social sciences in the School of Human and Health Sciences. Much of our work is aligned to the University's ASRIs, including railway engineering, big data, analytics and visualization, sustainable communities and societies, disaster resilience, construction processes and digital technologies (ILS section 2). The University has supported a number of interdisciplinary initiatives with pump-priming grants, including to establish IDL, Pitts with disease control specialists in Applied Sciences, and Amaratunga and Haigh with health experts in Sri Lanka on biohazards. In order to promote inter-disciplinary research, the three Centres have also organised 102 major events in the current period, as detailed in section 4.3. The effectiveness of these efforts is reflected across the research centres.

Amaratunga and Haigh have led a very strong portfolio of collaborative projects that integrate disciplinary perspectives. ASCENT, CABARET and REGARD combined social sciences with engineering and built environment to address disaster risk and displaced populations. CASCADE brought together diverse disciplines around the EU's H2020 societal challenges.

Collectively these grants brought together 69 Universities across Europe and Asia. Their transboundary river research brings together coastal engineering with urban planning, governance and the social sciences. The strength of their inter-disciplinary collaborative research was formally recognised when the CADRE project won the UK Universities Association for Lifelong Learning (UALL) International Award for 2018 as the best innovative partnership for change in an international context.

CUDAS involves multiple disciplinary fields, such as the social sciences (sociology, anthropology, geography), the history and philosophy of science, fine arts, art history, linguistics, theatre studies, archaeology, environmental design, games technology and critical theory. Temple has an extensive body of work that links architecture to language and history. Gao and Pitts's Network in China is centred around design, construction and skills.

Koskela's work with design theory involves expertise from architecture, construction management and product design, while Tezel's work with blockchain brings in expertise from computer scientists, business analysis, and construction managers.

1.5 Impact

1.5.1 Impact strategy 2014-2020

Our impact strategy has been guided by the University's focus on delivering 'user-inspired and applied research with impact' (ILS section 2). This includes to:

- Embed a research impact culture into our research and partnership activities
- Increase the volume and quality of engagement
- Engage with various stakeholders and potential research users throughout the research life cycle

1.5.2 Implementation of impact strategy and 2021 case studies

Research impact culture

Our approach to enabling and facilitating impact included a range of measures. Research impact was embedded into staff recruitment (Amaratunga and Haigh who are involved in both impact case studies), as well staff development processes and training (see section 2.1). This included additional researcher time and QR/GCRF funding for Amaratunga, Haigh, Pitts and Gao to plan for impact alongside conception of research projects (see section 3.2).

Volume and quality of research and engagement

Much of our research and its resultant impact is facilitated through our strong relationships with end users, for example the United Nations focal point for disaster risk reduction, UNDRR, who have adopted and embedded DRR practices into their guidance for Mayors and codes of practice for development. The breadth of engagement is demonstrated by Pitts and Gao's work with provincial actors on the revitalisation of rural communities in China, Delsante's research on the impact of rapid urbanisation on the metropolitan region of Shanghai, as well as Koskela and Tezel's work on construction to production with Highways England and Tzortzopoulos' work on BIM and social housing with government and industry.

Stakeholder engagement

Strong engagement with research users is exemplified in Amaratunga and Haigh's work with the Intergovernmental Oceanographic Commission of UNESCO Indian Ocean tsunami warning system, which informed policy on early warning in 28 countries (see impact case). This

excellence has been recognised by winning the 2019 Newton Prize for Indonesia, for 'best research that promotes economic development and social welfare'. Several staff have also gained visiting/adjunct appointments in China (Gao and Pitts), which linked them into live projects in the neighbouring areas.

1.5.3 Future strategic plans for impact

Our impact strategy is guided by the University's commitment to delivering excellent research with impact and the Concordat for Public Engagement with Research (ILS section 2). We will mobilise our expertise in GDRC, CUDAS and IDL to address global challenges. Our impact goals are to:

- Mobilise our researchers to address critical priorities for the 2030 agenda on sustainable development
- Engage research end users, including industry, government, the third sector and communities, in the co-design of our research
- Measure the social and economic impact of research using impact tracking and evaluation
- Increase awareness and understanding of impact among ECRs and PGRs
- Increase public engagement in our research through participation and awareness raising

1.6 Open research and research integrity

Researchers have been actively encouraged to publish in high quality, open access journals or books, and £39K has been invested to support gold open access. Training sessions were held with library services and publishing houses such as Emerald to raise awareness. 100% of the Unit's submitted outputs have been uploaded to the University's repository with open access, and since 2018, to PURE. All staff have an ORCID ID and are encouraged to make outputs available on major academic social networking sites. Data management plans have been developed and implemented for major grants, which ensures data management, archiving and open access of data sets created, (e.g., NERC and hydrodynamic models in the British Oceanographic Data Centre, and qualitative data in PURE). The ASCENT and CABARET projects created and populated an open educational resource repository for disaster risk reduction with links to end user organisations such as UNDRR and IOC-UNESCO.

All research within the Unit is conducted to the highest possible ethical standards that are compliant with the Concordat on Research Integrity (ILS section 2). Research integrity is fundamental to the School Research and Enterprise Committee, which meets every two months. We have a Research Integrity Champion and a Research Ethics and Integrity Committee, which meets once per term and oversees ethics related aspects of the University's commitments and related policies (ILS section 2). A rigorous internal peer review process, which addresses research integrity and ethics, is applied to all applications for research funding. Research integrity and ethics are also addressed in staff and PGR inductions, incorporated into research training, and reviewed in performance appraisals. Research ethics approval is also a formal requirement of PGR progression monitoring.

2. People

2.1 Staffing strategy and development

2.1.1 Staffing strategy

The submitted staff FTE are 31.9% F1, 10.8% I0, 33.1% J0 and 24.1% K0 contract level. 92% of submitted staff FTE are on permanent contracts and 8% on fixed-term. 94% are HEA Fellows. As detailed in section 1.3.1, 15 (14.1 FTE) of the Unit's staff have been recruited since 2013. Our staffing strategy has focused on the recruitment of staff with international research reputations to establish and lead strategic areas of research, as well as three ECRs with great promise and a basis for long term growth. We have also sought to encourage and invest in existing staff to develop their research potential, with 7 staff obtaining a doctoral qualification during the REF period. 8 staff are currently studying for a doctoral level qualification with a view to being independent researchers within 3 years. This has enabled us to achieve our goal of having a broad range of experience that represents all stages of career development. The substantial investment in new staff over the period has allowed Architecture and the Built Environment to change from a group that is teaching led, to one that is internationally leading and recognised for research, and whereby teaching is informed by our research.

2.1.2 Staff development

The School Research and Enterprise Committee, working with the University Research Committee in line with the University Research Strategy (ILS section 2), has developed structures to support the career development of colleagues across all levels of seniority, and working towards the University's priorities to produce excellent publications, secure external funding, promote impact, and build multidisciplinary and strategic international research collaborations. The effectiveness of this development is evidenced by staff progression, with one female member of staff (Gao) promoted to Reader, and two staff to Senior Lecturer (Malagoda and Tezel) after external verification of their research profile.

Research performance is a priority, and all academic staff submit an annual research appraisal and plan, reviewed at mid and end year, which provides a basis for discussion about resource needs, as well as support for specific outputs and to enable impact. Generic research training (ILS section 3) and discipline specific research training at the School and research centre levels are tailored to specific individual needs through this process and in line with the research strategy and Vitae principles. The School's Research Leave and Sabbatical policy has enabled staff to take time to develop specific research-based activities, for example supporting the development of four of the returned outputs by Temple, Pitts, and Griffin.

Each member of academic staff joins one of our three research centres and has the opportunity to work alongside research mentors and produce, on a yearly basis, plans for the development of research activities in the short (12 months) medium (3 years) and long terms (5 years). Mentoring includes discussions and advice around quality of publications, new projects, grant applications, visibility and impact, and mid-career researchers acting as co-investigator in bigger grants (e.g., Malagoda with Amaratunga). Mentoring has resulted in an increase in publications, international networks established and a rise in grant applications (section 1.3.1).

A transparent and equitable workload model provides all staff with time to develop their research area. As a minimum this includes a day per week for research, while further time can be earned based on research performance on funded projects, outputs and other activities like organisation of conferences etc.

The research appraisal system also provides a basis for understanding development needs, including access to our staff development programme. For example, 7 staff in the Unit achieved the Chartered Management Institute's (CMI) Level 7 Award in strategic management and

leadership. The performance appraisal system also enabled us to identify emerging areas of research impact that required support.

2.1.3 Early career researchers

Postdoctoral researchers are treated in accordance with the Concordat to Support the Career Development of Researchers (ILS section 3). They each used their time here as a launch pad to permanent lectureships or further research positions. For example, Delzendeh, Dias and Talebi completed their doctoral studies at Huddersfield after 2014 and are included as ECRs (18% of submitted staff FTE). All three became professionally qualified teaching staff as HEA Fellows. They have also benefitted from additional seed funding and workload allowance for 3 years after completion to help them develop their research area, which has helped Talebi and Delzendeh to gain momentum and secure external grants. Capacity for collaborative and multidisciplinary research has been developed through senior researchers working closely with ECRs to write their first grant applications (e.g., Talebi with Wu). ECRs have been supported to take on wider research development opportunities, such as Delzendeh as Advisor to the CIB student chapter (section 2.1.3) and Dias for engagement in the tsunami early warning impact case study.

2.2 Research students

2.2.1 Approach to recruitment of research students

Since 2014, we have increased our recruitment of postgraduate research students in line with our increasing research profile and supervisory capacity. As shown in Table 1 (section 1.3.1), high-quality monitoring and support has ensured that this expansion has been accompanied by a corresponding growth in completions from 0 per annum in 2014, to 6 per annum in 2020.

The School provided 33 PhD studentships in 2014-2020. These awards were deployed strategically to secure the most talented students, irrespective of social background, gender, or age. Additional funding is set aside for each student, to enable them to undertake research and travel to conferences.

2.2.2 Monitoring and support mechanisms

Complementing the University's Graduate School management of graduate recruitment and wide-ranging support (ILS section 3), we provide a rich training environment for all our research students, along with excellent facilities and support. Each student is provided with a desk and PC in dedicated postgraduate research offices in a state-of-the-art building, as well as access to our laboratory facilities and workshops (section 3.2). Each research student is allocated two supervisors upon registration, which promotes inter-disciplinary and collegiate collaboration, and includes a primary expert in the chosen research and a second to provide additional relevant expertise, and continuity in case of illness, departure, and parental leave. Progress is monitored through regular supervisory meetings and a robust annual academic progress review by two independent examiners. Overall quality is assured by quarterly progress review boards chaired by the Director of Graduate Research Education.

All graduate students benefit from affiliation to one of the Unit's three research centres, aligning PhD students with our major research projects and resources, and exposing them to world-class research programmes. It also provides a gateway to experiencing interdisciplinary, multi-institution work in leading UK and overseas institutions. Each research centre coordinates twice annual, month long events that combine seminars, guest speakers, panel discussion and a graduate led activity. We also organise annual, multidisciplinary PhD summer Schools and all

returned staff contribute to our doctoral training programme, delivering mentoring and supervision. A large majority of the 49 postgraduate researchers in ADA who responded in the 2019 Huddersfield Postgraduate Research Experience Survey (PRES) 'definitely agreed' or 'mostly agreed' that their confidence and understanding of research skills had developed during their programme. This included in relation to research methodologies, tools and techniques (95.9%), critically analysing and evaluating (91.8%), creativity and innovation (91.8%) and research integrity (93.9%).

We have a CIB student chapter under the leadership of Delzendeh, which organises periodic research and social events for graduate students, including a Futures Symposium that encourages students to think creatively about the development of their field and how to address long term development challenges.

The vitality of our doctoral programme is demonstrated by the 28 students who completed their doctorates between 2014-20.

2.3 Equality and diversity

We promote equal opportunities and fairness, for example by supporting flexible working practices, which have helped colleagues with young children, staff returning from maternity leave and a member of staff with a disability, to continue being active researchers and returned in this submission. We have also made fractional appointments to allow three colleagues (Delsante, Griffin, Ruddock) to maintain positions in external organisations.

Our successes as Principal Investigators across different layers of staff also demonstrates this, irrespective of protected characteristics, including sex, age, ethnicity and disability: professoriate (Amaratunga, Haigh, Tzortzopoulos, Wu, Koskela); senior lecturer (Malalgoda, Tezel) and ECR (Talebi). This was reaffirmed in the responses of the 14 ADA staff that took part in the 2019 JISC Principal Investigators and Research Leaders Survey (PIRLS), specifically when asked about whether 'staff at my institution are treated fairly irrespective of': parental leave (64.3% Strongly Agree/Agree, 36.7% Don't Know); pregnancy and maternity (71.4% Strongly Agree/Agree, 28.6% Don't Know); ethnicity (78.6% Strongly Agree/Agree, 7.1% Disagree, 14.3% Don't Know); disability (78.6% Strong Agree/Agree, 21.4% Don't Know).

Female staff have senior research leadership positions, including as Associate Dean for Research (Tzortzopoulos), UoA lead (Amaratunga), and leading two of the research centres (Amaratunga and Tzortzopoulos). Tzortzopoulos is also a CIB Board member and a board member of the GLF-CME (Global Leadership Forum for Construction Engineering and Management), leading the Women in CEM working group.

The outputs selected are in strong alignment with the UoA Strategic Priorities (see CoP). An equality impact assessment for the unit shows good gender balance, with a small variance (9.52%) in favour of females for SRR and IR Identification, and marginally in favour of female staff in the distribution of submitted outputs (32.4% female and 67.6% male).

The Unit's staff are also drawn from diverse ethnic and international cultural backgrounds, including Brazil, China, Finland, India, Iran, Italy, South Africa and Sri Lanka. This diversity enriches the subject base and adds value to the discipline in a more holistic way, not just theoretically or contextually but in application, illustrated in the global nature of our research (see section 4 and impact cases).

15 staff have benefited from the University wide strategy that sees academic staff without a doctoral qualification be supported to engage in PhD studies.

3. Income, infrastructure and facilities

3.1 Research income

3.1.1 Unit's research funding

The Unit has progressed from a very low research income per annum in 2014 (£3K) to £970K in 2020, showing sustained growth in research activity. This comprises income from grants including UK Research Councils (£1.08M), European Commission (£4.5M), industry (£1.04M), government (£2.63M), and charities (£77K). It includes prestigious grants such as GCRF Ni3 games (£1.2m), NSRF Construction Culture of Houses of Shi and Qian ethnic groups (180,000RMB), NERC/ODA Mitigating hydro meteorological hazard impacts (£750K), CABARET (£993K), ASCENT (£983K), CADRE (£569K), REGARD (£389K), ESPRESSO (£320K), Newton Mainstreaming Disaster Risk Reduction (£116K), CDBB Automated checking (£150K), Blockchain in construction (£51K), Innovate UK S-SIMPLER (£116K), ESRC U-Vital (£200K), Network Rail Bridge Management (£325K), and In2TRack2 (£103K). We have also generated £375K from KTP initiatives, including Lean construction tools (£234K) and Digital information for maintenance in bridges and BIM integration (£140K).

3.1.2 Strategies for generating research income

The Unit's grant and income strategy is founded upon the investment in internationally leading and high performing staff and combining this with an emphasis on collaborative working. We build capabilities that align with funding programmes by mobilising interdisciplinary teams around the needs of funding calls. These also demand inputs from colleagues from other disciplines and external partnerships. On demand calls are supported by the Pre-award Research Office (ILS section 4), which provides support on every aspect of bidding. Funds to stimulate new research ideas are provided to staff (ILS section 4) by means of sandpits (e.g., Pitts and Gao's Network in China was supported via internal funding). This coordinated but also agile approach has allowed us to exploit emerging funding opportunities and drive new research agendas, as demonstrated by our successful responses to calls by NERC on hydrometeorological hazards (£750K) and UKRI/GCRF on pandemic preparedness (£180K). We are very responsive to national and international research priorities and initiatives, and continuously develop new research income avenues around these emerging challenges (section 4.4.1).

3.2 Infrastructure supporting research and impact

3.2.1 Organisational infrastructure supporting research and impact

Our three research centres (section 1.3.1) are based within ADA, where research is led by its Associate Dean for Research (Tzortzopoulos), who provides strategic research leadership. She is supported by the three centre leads. Tzortzopoulos sits on the University Research Committee, thus aligning the Unit's activities with the University's research strategy and promoting collaborative research with other units and ASRIs (ILS section 2). Internal funding has been provided for staffing, computation, travel, laboratory equipment and consumables. There is a transparent system in place for allocating funding via a committee, comprising representatives from the three research centres. This is in addition to the centrally managed University Research Fund, which provides competitive funding for staff to pursue their research (ILS section 4) and from which our unit has received £453K across 13 projects during the REF period.

The vitality and sustainability of our unit is supported by excellent institutional infrastructure (ILS section 4). Research development, bidding and contracts are supported centrally via the University's pre- and post-award units. There are research training workshops, both centrally and at UoA level, addressing discipline specific training.

3.2.2 Operational and scholarly infrastructure supporting research and impact

We have a strong and sustainable scholarly research infrastructure that supports better transparency, higher quality research and engagement, and a faster pace of scientific discovery. There are centrally supported systems that all staff have access to, including Elsevier PURE, Microsoft Dynamics for tracking collaborative R&D, and Box Data Storage (ILS section 4). Supplementing central support (ILS section 4), we hold workshops on different funding calls including European funding, providing bid writing support, and planning and embedding impact within research. Our research and impact are also supported by our ICT systems and 18.53 FTE technician and laboratory staff in ADA. There is also dedicated support, both internally and externally to the unit, for archiving (Office365 OneDrive; stream), referencing (EndNote; RefWorks), describing (Library Summon, Teachthought, Bristol Online Surveys), and crediting (APA 7th, Research Portal). There is a dedicated research office, led by a Research Manager, who helps staff manage research projects and client relationships. Two additional staff deal with PGR activities and a Business Development Manager provides support to stimulate and facilitate exchange between academia and business. Impact activities are further supported with the appointment of 1.5 FTE researchers. Staff have access to funds to engage end users and conduct dissemination events. Research teams also use the University's PURE system to systematically record research impact.

3.2.3 The nature, quality, provision and operation of specialist research infrastructure and facilities

Investment in our estate and facilities has significantly enhanced our research environment. The £30M Barbara Hepworth Building has been established as a beacon of innovation, with the open studio environment empowering researchers through the co-location of disciplines within the same learning spaces. The Hepworth Building was named as the Building Project of the Year 2019 by Constructing Excellence for its design, construction, educational vision and contribution to the local community. It also won the Annual Northern Design Awards. Its Phidias Lab (281m²) is a state-of-the-art digital facility encompassing state of the art visualization, simulation and high-resolution digital media environments. It has been used, for example, for Wu's work with Waldeck on a new digital workflow from scan to offsite inspection of railway bridges, and to support GDRC's collaborations with overseas partners in Sri Lanka as part of tsunami early warning described in the impact case study. It is equipped with technology, including the latest Shogun motion capture facility and specialises in conceptualising, developing, prototyping and simulating 3D designs and models. Its state-of-the-art wide 3D VR Cave allows users to experiment with emergent visualisation technology and showcasing of work in a controlled environment with opportunities for collaborative learning and high-end presentation. The facility can accommodate up to 100 researchers. It also allows researchers to enjoy and showcase work in virtual design disciplines, with high performance visualisation and motion capture.

Other bespoke facilities include the workshop areas, postgraduate research space, and studios for design, with CAD computer laboratories. The Market Gallery operates as an exhibition platform for social events in the form of 'happenings' and these have created an opportunity for informal gatherings between staff, students and external audiences. It was the venue for our

research exhibitions, such as “Making a Difference to Rural Village Regeneration” (curated by Pitts and Gao), and “Temporary Contemporary Happening Evening” (Delsante).

3.3 Equality and diversity issues in relation to support for acquiring research funding

Our positive approach to equality and supporting diversity is described in section 2.3, including the positive perceptions of 14 ADA staff that took part in the 2019 JISC Principal Investigators and Research Leaders Survey (PIRLS).

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

4.1 National and international research collaborations

We are very proud of our interdisciplinary approach (section 1.4) to addressing real-world problems through academically rigorous research. We collaborate extensively with colleagues from a range of disciplines, across the UK, regionally and internationally, and drawing upon our extensive networks of research partners developed through our membership and leadership of national and international initiatives. During the REF period, the Unit has led and/or been a very active member of 56 externally funded collaborative research projects and 2 KTPs, collectively with 163 partners (sections 1.3, 1.4). Since 2014, we have also hosted 26 events and 343 international visitors from 25 countries, which testifies to the Unit's status as an international research centre of excellence. The unit has 20 current projects with 95 partners in 24 countries. The success of these collaborations is demonstrated by the prestigious awards we have won (UALL Award - section 4.3.2) and that 46.3% of our Scopus publications since 2014 were co-authored with researchers in other countries. There are extensive support systems in place for making these collaborations effective, as detailed in section 3.

4.2 Links to research users

End user requirements have been strongly established and fed into research projects from their inception. Staff are duly supported (ILS section 4) to pursue these actions by means of time allocations for work with research users.

For example, in the UK, the Highways supply chain project (Koskela, Tzortzopoulos and Tezel) has addressed poor performance of construction through lean principles in close collaboration with design and construction managers. Wu's research on digital data capture for existing railway bridges has been developed directly with research users (KTP with Waldeck) and has enabled improvements in data collection and management for bridge maintenance.

Tzortzopoulos and Kagioglou's work in healthcare design involved Communities Health Partnerships, an organisation which is responsible for all primary healthcare facilities in the UK.

Internationally, the work of Gao and Pitts on the Sustainable and Creative Villages Research Network has led to contacts with professional practitioners and non-academic stakeholders, enabling a strong research base to be established and leading into live projects in the city and neighbouring areas in China.

Co-production of knowledge with our partners is a priority and has helped us to create direct impact from our research, shaping international agendas and helping to enrich the research environment. The direct involvement in research by the IOC-UNESCO Intergovernmental Coordination Group for the Indian Ocean Tsunami Warning and Mitigation System (ICG/IOTWMS) has helped Amaratunga and Haigh to have an influence on international policies for assessing tsunami preparedness. This work has informed priorities for the capacity

development of 28 countries, helping to protect many of the estimated 800 million people that live in coastal areas surrounding the Indian Ocean.

4.3 Contributions to the economy and society

4.3.1 Evidence of the wider activities and impact of research carried out in the unit that is not captured in the impact case studies

With significant research income generation and excellent partnerships with end users since 2014, the Unit has been well-placed to articulate its impact in addressing real world problems. There is a large volume of activity and research impact carried out by the Unit that is not captured in the impact case studies. For example:

- Koskela's lean construction research has supported waste reduction and increased profitability in HE projects.
- Pitts and Gao's work, including publication of a Design Manual, has prompted changes in policies from local government and design institutes in China that promote more sustainable design and construction practices in rural areas.
- Tzortzopoulos's development of a BIM protocol to support client's decision making in the retrofit of social housing has been implemented with Northern Ireland Housing Executive and is available for wider use by city councils and housing associations.
- Wu's work with Waldeck has had a direct impact on improving the safety and quality of data produced in the process of inspection of 50 Network Rail bridges, achieved by providing a complete new digital workflow from scan to offsite inspection.

4.3.2 Contribution to the discipline, nationally and internationally including indicators of wider influence, contributions to and recognition by the research base

Recognition by means of Prizes

The quality of our contribution to the discipline has been externally recognised by the receipt of a number of prestigious international prizes. Haigh and Amaratunga were the winners of the 2019 Newton Prize, which recognises the best research and innovation project in 2019 that created an impact socially and economically. In 2018, Amaratunga received the "President of Sri Lanka Award" from His Excellency, Maithreepala Sirisena, President of Sri Lanka, for her contribution to disaster resilience in Sri Lanka. Amaratunga, Haigh and Malalgoda were the winners of the 2018 UK UALL International Award which recognised innovative engagement, including partnerships that create change in an international context for the CADRE project. Amaratunga also won the Sri Lanka President's Award for Scientific Publication in September 2014. Temple was shortlisted in 2014 by the International Committee of Architecture Critics for the Bruno Zevi Book Award.

Journal editorships

3 high quality journals are edited by our staff: Disaster Resilience in the Built Environment (Haigh and Amaratunga), the Journal of Architecture (Delsante) and Routledge Research in Architectural History (Temple). There have also been 10 guest editorship roles. The Unit's staff sit in the Editorial Boards of 6 international journals. They have also edited 18 reports (e.g., UN Global Assessment Report 2015), and 17 international conference proceedings. Amaratunga was one of three international editors appointed by the Government of India for its Urban Resilience and Sustainability initiative.

Invited keynotes, lectures, conference lead and chair roles, networks and clusters

Contribution to the research base has been further maintained at the highest level through 98 invited public lectures and keynote addresses across five continents, including at key institutions and key stakeholders (e.g., UNDRR).

We convened or co-convened 26 international conferences and 67 international workshops, chaired 9 conferences and 26 conference panels, including the International Building Resilience conference series that was initiated by Unit staff and held in six countries since 2014.

Membership of research councils, national and international committees, associations and societies

Staff of the unit have representation on 28 national and international committees (5 as Chair) and 15 advisory / steering committees, for example:

- Kagioglou was the Vice President (2019 – 2020) and Tzortzopoulos is a Board member of CIB, leading redevelopment of their value proposition and global impact agenda.
- Koskela is a founding member of the International Group for Lean Construction, Director and Trustee of the UK Lean Construction Institute and Company Secretary.
- Ruddock is appointed as a member of the DfT Technical Challenge Panel.
- Amaratunga is a Steering Committee Member of the UK's Frontiers Programme, the joint programme of the UK four national Academies.
- Amaratunga is one of two UK members of the European Commission's Joint Research Center (JRC) and UNDRR, European Science & Technology Advisory Group (E-STAG).
- Amaratunga and Haigh were UNDRR Global Working group leaders of Words into Action Guidelines on Accountability and disaster risk governance, shaping guidelines in support of the Sendai Framework (2016 – 2019). They were also Steering committee members (2014 – 2020) of the UNDRR Making Cities Resilient campaign.
- Pitts is an Associate of PLEA (Passive and Low Energy Architecture), the longest running and most well-known organisation overseeing conferences in passive and low energy architecture.
- Temple was a member of the Bogliasco Foundation Fellowship Advisory Committee (2019), and a member of the steering committee of the Architectural Humanities Research Association (2016).
- Amaratunga and Haigh are expert members (2017 onwards) of the ICG/IOTWMS WG-1 on Tsunami Risk, Community Awareness & Preparedness of the IOC-UNESCO ICG/IOTWMS and provided input towards Indian Ocean wide policies of tsunami awareness.

Fellowships

All of the Unit's staff are members/fellows of one or more related professional institutions including RICS, CIOB and RIBA. 94% of the submitted staff FTE hold the Fellowship of the HEA and 30.1% are CMI Chartered Managers/Fellows. Temple received the Bogliasco Fellowship award in 2018 to research and write 'Architecture and the Language Debate: Artistic and Linguistic Debates in Early Modern Italy'. Wu's work on human behavior simulation for energy simulation was supported by his Royal Academy of Engineering Fellowship.

Participation on grants committees, refereeing academic publications and research proposals

Members of UoA13 have contributed to 37 assessment panels and peer review colleges, including EU Horizon 2020, Erasmus +, NERC, ESRC, EPSRC, AHRC, Royal Academy,

Newton, Carnegie Trust, Hong Kong SAR Research Grants Council, Volkswagen Foundation Momentum Initiative, Bogliasco Foundation Fellowship, Royal Society for the encouragement of Arts, Manufactures and Commerce and the Royal Historical Society. Staff have acted as external examiners to 72 PhD students over the REF period.

4.4. Contribution to the sustainability of the discipline - nationally and internationally

The Unit has made a significant contribution to the advancement of research and sustainability of the research area. We have delivered three Newton funded International post-doctoral researcher workshops (Amaratunga, Haigh and Tzortzopoulos), with 177 ECRs taking part on topics which were derived from the socio-economic needs of partner countries in Brazil, Indonesia and the Philippines. Amaratunga, as a member of the UNDRR Expert Review Group, has contributed to the development of a new global disaster risk reduction research agenda towards 2030 and beyond, linking science and policy. As highlighted in 3.3, several of our staff hold key roles at national and international committees, associations and societies (CIB, Lean Construction, UNDRR). We have organised 67 workshops and events and have further contributed to the discipline through the publication of 8 books, 37 book chapters, 122 journal articles, 155 conference papers, 20 reports, 8 editorials and 14 exhibitions during the census period.

4.4.1 Responsiveness to national and international priorities and initiatives

We are agile to respond to emerging challenges and agendas. For example, the CABARET project was launched to address priorities identified by ICG/IOTWMS, including a need to foster regional cooperation for more effective multi-hazard early warning. The Unit secured funding (Amaratunga and Haigh) to explore epidemic and pandemic preparedness, demonstrating our high-level support to address emerging priorities, and which led to further funding from the UKRI GCRF Agile Response call to address COVID-19. Also linked to the pandemic, Koskela delivered an international webinar on the impacts of Covid-19 to the future of construction management in June 2020. Our future research and impact strategy is very much aligned to such emerging needs (sections 1.3.2 and 1.5.3).

4.5 Engagement with diverse communities and public through its research

Our activities on informing/inspiring, consulting and collaborating have enriched our research. Interaction with the public has demonstrably improved the quality of work undertaken. For example:

- Temple, Delsante and Gao curated an architectural exhibition at Huddersfield Art Gallery (April 2016) to explore urban design in China through photographs, drawings, architectural models, maps and films. It provided a 'window' into the dramatic changes taking place in Chinese urban and rural life.
- Amaratunga, Haigh & Dias, in collaboration with government and NGOs, organised a Sri Lanka wide art competition that attracted entries from 3,500 school children and helped to improve their knowledge and understanding of disaster risk (March 2020).
- Dias engaged the public in a poster display about disaster risk and climate change as part of the University's European Researchers' Night (2016), which attracted 4,000 visitors.
- Amaratunga held a public dialog in the local language in the remote coastal regions of Sri Lanka, addressing the building of sustainable, disaster resilient communities (2016).