Ceramics in Architecture: Enabling the design, manufacturing and integration of decorative functional architectural ceramics through design and ceramic practices

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Abstract

This practice-based research on architectural ceramics is at the intersection of ceramic art, architecture and manufacturing.

Architectural ceramics have been an integral part of the built environment for seven thousand years. Combining functional and aesthetic qualities, decorative ceramics express site specificity and cultural identity in architecture through ornamentation, colours and motifs.

My research investigates the factors which inhibit the creation and integration of bespoke decorative functional architectural ceramics (DFACs) into buildings and urban spaces. These factors include: (i) a disjunction between architectural and ceramic art, craft and design practices; (ii) limitations in industrial manufacturing that could support the fabrication of bespoke ceramics; and (iii) misconceptions among architects and ceramic artists about the applications, manufacturing processes and cost of DFACs.

This study examines how to facilitate the design, ceramic craft making, industrial manufacture and structural integration of bespoke DFACs such as decorative building elements, surfaces and street furniture, aiming to contribute to buildings and urban spaces through ceramic aesthetic and material qualities.

The research is led by the combination of ceramic and architectural practices and by applying ceramic craft and digital techniques to industrial manufacturing processes. Existing precedents, case studies and semi-structured interviews with expert stakeholders are critically analysed through mixed-method research methodology and engagement with design and craft theories.

The ceramic practice outcomes evidence the creation of bespoke bricks produced in a factory setting to offer affordable solutions. The key findings of this research are set out to form recommendations and a facilitating framework to aid the practice of ceramic artists, architects and manufacturers engaged in the creation of bespoke DFACs.

This research addresses the practice-oriented gap in the design, ceramic craft making and industrial manufacturing of bespoke DFACs, setting out how to lead change in the production of architecture which contributes to diverse urban spaces.

Acknowledgements

I would like to thank my supervisors, Janet McDonnell, Kathryn Hearn, Melanie Dodd and Ruth Lang for their guidance and support during this research. I am very grateful for the endless encouragement and support and for them sharing their incredible knowledge.

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CONTENTS

List of publications

Exhibitions

- *NOVA X* (2021) [Exhibition]. Lethaby Gallery, Central Saint Martins, University of the Arts London, 18 September- 23 October 2021.
- *British Ceramics Biennial*, *Future Lights* (2019) [Exhibition]. China Hall, Spode, Stoke-on-Trent. 7 September-13 October 2019.
- *Future Lights* (2019) [Exhibition]. Munich Design Week. Munich. 10-17 March 2019.
- *Materials for Architecture* (2018) [Exhibition]. ILEC Centre, London. May 2018.
- *Ceramics and its Dimensions: Shaping the Future* (2018) [Exhibition]. Bröhan Museum, Berlin (January- April); National Museum of Slovenia, Ljubljana (May-July); Museum of Decorative Arts, Prague (September-November).

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- Gasparian, M. (2021) 'Bringing glazed bricks back into future', *Glazed Expressions*, Issue No.87 (TACS 40th anniversary edition, 2021), pp. 10-11.
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- Gasparian, M. (2020) 'Bridging the gap between the craft and industry', *EH Smith Architectural Solutions guest blog*, 1 June 2020. Available at: https://ehsmithclayproducts.co.uk/guest-blog-bridging-the-gap-between-craft-and-industry-by-maria-gasparian-ceramic-artist-and-architect/ (Accessed: 10 August 2021).
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- Gasparian, M. (2021) 'Bespoke bricks and architectural ceramics: craft and innovation' [Seminar]. Jacobs Engineering Group. London. 9 February.

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- Gasparian, M. (2019) ‘Bricks: Craft & industrial innovation’ [Lecture]. *Brick Development Association Brick Works series*. University of Cambridge. 16 October.
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- Gasparian, M. (2018) ‘Let’s talk about public space’ [Lecture]. *Dutch Design Week*. Eindhoven. 22 October.
- Gasparian, M. (2018) [Seminar]. ‘Applications of ceramics in cities’. PLP Architecture. London. 16 October.
- Gasparian, M. (2018) ‘More about Brick’ [Seminar]. Farrow Silverton Architects. London. 18 July.
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List of illustrations

N.B.: All image and diagram credits - Maria Gasparian, unless otherwise stated.

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Personal statement

My PhD enquiry was brought about by my aspiration to contribute to the built environment through the materiality of decorative architectural ceramics, aiming to contribute to humanistic architecture.

I originally trained as an architect in Armenia, then a republic of the Soviet Union. Historically located on the Silk Route, Armenia has been a transit point between East and West, influencing its architecture and decorative art. Stone is the prime building material in Armenia, which led to a rich tradition of master masons and architects employing bas-relief and high relief when carving into the structural elements of medieval religious and civic buildings, creating integrated decorations that have stood the test of time (Figures 0.1 and 0.2).

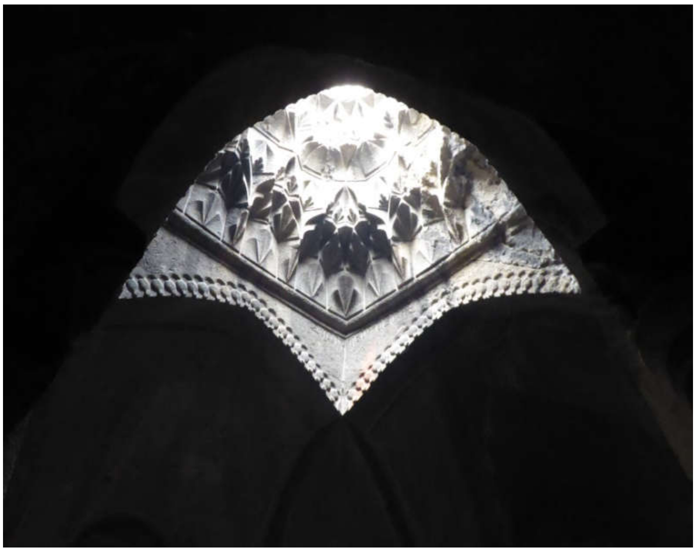


Fig. 0.1. *Detail of granite vaulted roof, Geghard Monastery, 13 c.* (2019)

Fig. 0.2. *Left: detail of a church portal, Geghard Monastery, 13 c. Right: Khachkar, cross-stone, Goshavank Monastery, 13 c.* (2019)

In the second half of the 20th century, Armenian cities, much like other Soviet cities, experienced large-scale urban migration, fuelling an urgent need for homes. This resulted in the rapid development of low-cost apartment blocks constructed from prefabricated concrete panels, with standardised plans developed by state architectural offices and applied throughout the country without much consideration of local conditions, materials or craftsmanship, resulting in a predominantly homogeneous, faceless urban environment (Figure 0.3).

Fig. 0.3. *View from a window, Yerevan, Armenia* (2019)

I moved to the UK in the early 1990s, attaining full accreditation as an architect before working at a large international architectural company in London. During this period I worked as a member of a design team, collaborating with a group of consultants and stakeholders, including local authorities, developers, structural engineers and artists. I led design and structural coordination on several major mixed-use developments and public spaces in the UK.

This experience gave me insights into the decision making processes connected with the choice of building materials and use of detailing. I came to realise that despite large project budgets, design objectives were often led by what was perceived by the client as providing ‘added value’, which was far divorced from aesthetics and considerations of the local context. Examples of these decisions included minimising the use of ‘solid’ materials between shop fronts so as to maximise the size of glass window displays, keeping the thickness of external walls to a minimum to maximise the lettable floor area, and the elimination of detailing that was not load bearing and utilitarian, while keeping the cost of exterior materials low.

My later experiences of working in a smaller architectural practice showed that while large projects funded by multi-million pound investments could allow for project-specific building detailing and building components being developed with a manufacturer, architectural projects with smaller overall budgets and a shorter time scale often used off-the-shelf products instead, narrowing the material and design opportunities for the architects.

My initial interest in architectural ceramics was brought about by my visit to the Alhambra palace in Granada in 1997. Here, the intricate tiled surfaces and geometrical patterns embodied the Arabic cultural narratives and aesthetics brought to Spain from North Africa during the Moorish conquest. The bright colours, achieved through the addition of metal oxides to glazes applied to masterly cut interweaving tiles, exhibited a longevity that is unmatched by any other man-made building material. By studying the use of ceramics in buildings and landscaping by Antoni Gaudi, Josep Maria Jujol, and Lluis Domenech i Montaner in Barcelona, I uncovered the diversity of ceramic applications and techniques which were inspired by historical examples and were then applied to modern architecture. These examples exhibited local and cultural identities, personal expression and spatial freedom that at the end of 19th century were enabled by the invention of new materials and techniques resulting in diverse architecture.

My material knowledge of ceramics was developed through attending pottery and sculpture classes in London. Working by hand and experimenting with traditional decorating techniques, I produced tableware, tiles and sculptural work. When exploring the material qualities of clay and the applications that fired ceramics can offer as a highly expressive and versatile building material, the following questions arose:

> ***How*** can decorative ceramics express cultural identity in architecture through colour, texture and patterns?
>
> ***How*** can colourful, textured ceramics be designed and produced to be integrated into buildings and urban spaces?
>
> ***Why*** *do architects in the UK not utilise decorative architectural ceramics in contemporary buildings and urban spaces?*

These questions, which were developed during the Masters in Ceramic Design course that I undertook at Central Saint Martins from 2014 - 2016, guided my research. They led me to investigate:

> ***Who produced*** *decorative architectural ceramics in the past* ***and who produces*** *them today?*
>
> ***What facilitates*** *their integration into buildings and urban spaces?*

These research questions formed the basis of my Winston Churchill Memorial Travelling Fellowship, which I undertook in 2016. The Fellowship enabled me to travel around Europe and the USA, investigating historical and contemporary precedents of DFACs used in public spaces, visiting factories and engaging with the stakeholders that facilitated their creation. Personally exploring the sites, observing and photographing ceramic interventions allowed me to analyse them in their context as well as examine their tactile and ceramic craft qualities. Several of the projects that I researched during my Fellowship were used in this study as historic and contemporary precedents.

My multidisciplinary practice led this research into the design, craft making and industrial manufacture of DFACs. Through designing, making and collaboration with the stakeholders of this research I explored the ways of creating DFACs in industrial settings. The outcomes of this research aim to facilitate the practices of architects, ceramic artists and industrial manufacturers, contributing to enriching the urban environment.

CHAPTER 1

INTRODUCTION: SUBJECT AND FOCUS

My practice-based research examines how to facilitate the design, ceramic craft making and industrial manufacture of DFACs and their structural integration into buildings and urban spaces.

My research bridges the realms of ceramic art, architecture and industrial manufacturing, is situated within buildings and urban spaces, and began from an initial interest in the material and aesthetic qualities of DFACs and their social impact. This enquiry is motivated by contemporary challenges in the urban environment such as a lack of individuality and sense of place and homogeneous developments in the UK created by the use of mass-produced standard bricks. An investigation into brick manufacturing formed a focus of my practice which led this research, aiming to contribute to the practice of ceramic artists, architects and industrial manufacturers in the creation of bespoke DFACs.

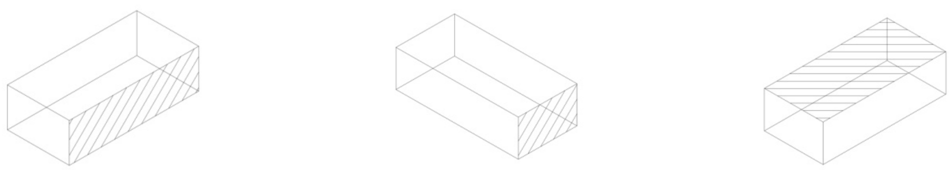
1.1 Definition of terms

1.1.1 Standard terminology

Brick bonds: A pattern in which bricks are laid (Brick Development Association, 2021a).

Brick surfaces (Fleming, 2006):

Stretcher (i): Side or wider surface of the brick
Header (ii): End or narrow surface of the brick
Bed (iii): Top and bottom surfaces of the brick



i) ii) iii)

Fig. 1.1. *Facing brick surfaces*

Capping brick: Brick laid on edge on the top of a wall flush with the vertical surface of the wall.

***Facing brick**:* Superior brick selected to be seen on the exposed face of a wall, in contrast to a cheaper 'common' brick that is used in situations where appearance or strength are not critical.

High-volume industrial manufacturing: Processes used to mass produce large quantities of goods in a short period of time. Products produced using high-volume manufacturing processes have little or no variation.

Research and development (R&D): Comprises those activities that are carried out by companies to develop innovative products and processes.

1.1.2 Terms specific to this study (my definitions)

***Architectural ceramics**:* Is a broad term covering ceramic products including roof tiles, wall tiles, floor tiles, chimney pots and decorative elements for facades. However, the term is frequently used with reference only to decorative interior and exterior finishes, thus excluding bricks (Van Lemmen, 2013). Coll Conesa et al. (2017, p.8) define architectural ceramics as "any kind of ceramic object made to be used in architecture".
In this study, the term '*architectural ceramics'* is applied to all fired clay products used in architecture, including bricks, paviours, roof tiles, sanitaryware, street furniture and unglazed and glazed elements for facades.

***Ceramic craft qualities*: ** Qualities that combine the intrinsic characteristics of ceramics which are achieved by the application of ceramic craft techniques resulting in diverse textures, colours and shapes.[1]

***Ceramic craft techniques**:* Hand, digital and hybrid forming and decorating methods used in ceramic art and craft studios. Craft forming and decorating techniques are described by Hooson and Quinn (2015).

[1] The discussion on ceramic craft qualities is included in Chapter 3, section 3.1.4.

***Ceramic material qualities*:** The physical properties and utilitarian characteristics of DFACs, required by the building standards and regulations for their integration into buildings and urban spaces.[2] Depending on the application of DFACs, these qualities can include load bearing capacity, fireproofing, waterproofing, frost resistance and anti-slip properties.

Decorative functional architectural ceramics (DFACs): Architectural ceramics that combine ceramic craft qualities with ceramic material qualities necessary for their integration into buildings and urban spaces.

Faience and architectural terracotta: The term '*faience'* in the UK and *'architectural terracotta'* in the USA refer to glazed architectural ceramics used as cladding for building facades. The term *'architectural terracotta'* is used in the UK relating to unglazed architectural ceramics made out of brown and orange earthenware clay. In this study the term *'faience'* is used to describe glazed architectural ceramics, whereas *'architectural terracotta'* is used to describe unglazed elements.

Flexible manufacturing: Manufacturing that incorporates varied processes and allows for the modification of these. Flexible manufacturing facilitates the creation of non-uniform material and aesthetic qualities in products which contrast with the uniform products fabricated in high-volume manufacturing.

Hybrid manufacturing: In this study, the term is applied to manufacturing that combines ceramic craft techniques, digital processes and industrial manufacture.

Traditional (ceramic) craft techniques*:* Pre-digital forming and decorating methods used to achieve ceramic craft qualities.

1.1.3 Typology of non-standard bricks

Standard specials*:* This term is commonly used for bricks that vary in shape from standard, rectilinear format bricks and are produced and stocked by manufacturers in the UK for forming corners, window sills, reveals, parapets, and copings.

[2] Architectural ceramics in the UK must comply with British Standards (BS) (BSI, 2021).

Standard specials are manufactured using either machine or hand-craft methods (Figure 1.2).

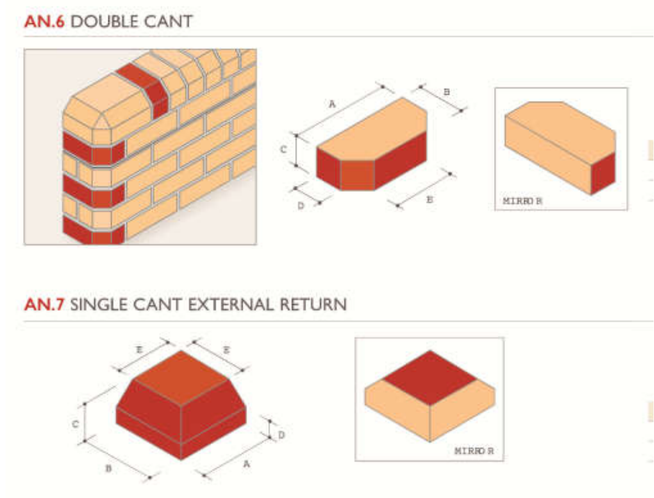


Fig. 1.2. *Ibstock Kevington standard special brick shapes* (2021)

Non-standard specials*:* Project-specific, custom-made, industrially produced bricks. Non-standard specials are manufactured using either machine or hand-craft methods (Figure 1.3, left).

Craft specials: Bespoke bricks produced by combining traditional ceramic craft techniques, digital and industrial manufacturing processes (Figure 1.3, right).

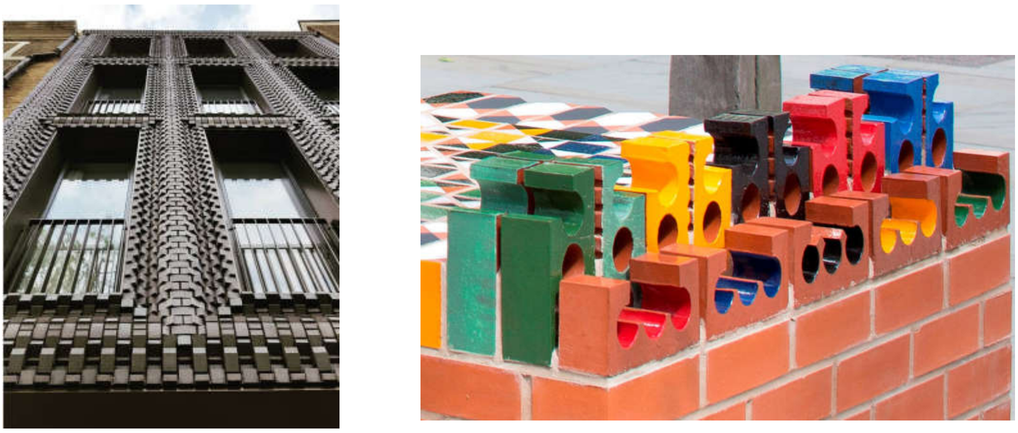


Fig. 1.3. *Left: non-standard special bricks, 'The Interlock', London, Bureau de Change Architects. Right: craft special bricks, 'Ceramic City Bench', architect and ceramic artist: Maria Gasparian* [3] (2018)

[3] The creation of 'Ceramic City Bench' is included in Chapter 4, section 4.5.

1.2 Overview

This research explores the processes of design, ceramic craft making and manufacturing of bespoke DFACs and investigates the factors that enable and inhibit their creation and structural integration into buildings and urban spaces. In Urban Studies (Gehl, 2011; White, 1980), Theory of the Production of the Architectural Space (Massey, 2005; Lefebvre, 1991), Phenomenology (Pallasmaa, 2005) and Dialogical art practices (Kester, 2004) there is discussion of both the physical and non-material aspects of peoples' engagement in urban settings. This research questions how bespoke DFACs can contribute through their material and ceramic craft qualities to the creation of site-specific, bespoke architectural designs, which can facilitate peoples' engagement. Whilst the qualities of DFACs are analysed in this study, the effects of ceramic interventions on the users of buildings and urban spaces are not investigated in this research.

Despite architects' growing interest in DFACs, as these provide sustainable, long-lasting solutions and aid individuality in buildings through their material and aesthetic qualities, there are barriers to their inclusion into buildings and urban spaces. My previous architectural experience identified the barriers encountered by architects, including assumptions about the cost and availability of bespoke DFACs. My ceramic artist's experience highlighted difficulties of scaling up hand-made ceramics for architectural applications. In communications with manufacturers during my earlier research, difficulties in the creation of ceramic craft qualities in high volume manufacturing were highlighted. Building on these insights, this research sets out to explore, in depth, the factors that inhibit the design, craft making, manufacture and structural integration of bespoke DFACs.

My training as an architect and ceramic artist allowed me to position my practice during this research at the intersection of three disciplines that facilitate the creation of bespoke DFACs: ceramic art, architecture and industrial manufacturing (Figure 1.4). This position enabled me to explore, in detail, the gaps within and between these practices.

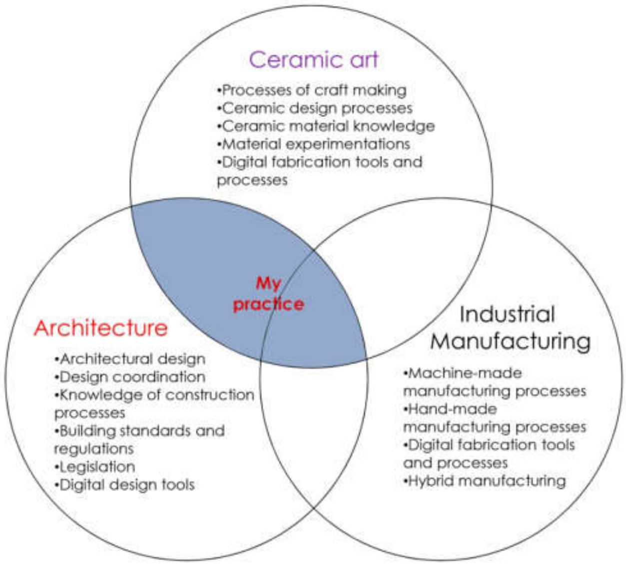


Fig.1.4. *Position of my practice at the intersection of architecture, ceramic art practices and industrial manufacturing*

During this research I engage with theories of architecture and production, craft and design thinking to explore critical perspectives on my own practice and the practices of ceramic artists, architects and industrial manufacturing which contribute to the creation of bespoke DFACs. Through the investigation of historical and contemporary discourse on craftsmanship and mass production, alongside digital design, craft and manufacturing processes used by contemporary specialist practices, I seek to address the economics of manufacture and the aesthetic considerations in the creation of bespoke DFACs.

This research is built out of three key components: i) contextual review and analyses of precedents, ii) my own practice investigations taking place at factories resulting in a body of ceramic work and built case studies, iii) semi-structured interviews with expert stakeholders.

The contextual analyses are built upon precedents of bespoke DFACs incorporated into architectural projects. These precedents identify key stakeholders, their collaborative relationships that facilitated the projects and determine the ceramic material qualities that enable the structural integration of DFACs. My practice investigations in the context of live projects seek to explore ceramic qualities and the design, craft making and manufacturing processes involved in the production and integration of DFACs. Semi-structured interviews with expert stakeholders, undertaken at the later stage of this research, contribute multiple perspectives into the practices and factors associated with the creation of bespoke DFACs.

My practice enquiry during this study focuses, in particular, on the design and manufacture of bespoke decorative bricks. While project-specific bespoke faience elements can be industrially produced to feature ceramic craft qualities, there are barriers to the manufacture of bespoke bricks in the UK. This is highlighted in the annual UK Brick Awards organised by the Brick Development Association (BDA). Whilst the Awards celebrate the best British and international architectural projects using clay bricks, I identified through a review of nominated and winning British projects between 2010 and 2018, that no bespoke bricks were used in these designs. Instead, to achieve varied aesthetics, architects utilised standard and standard special bricks laid in varied brick bonds to create ‘hit & miss’ and ‘textured brickwork’ as shown in Figure 1.5 (Brick Development Association, 2021b).

Fig. 1.5. *BDA Design Notes featuring ‘hit and miss’ and ‘textured’ brickwork* (2021)

Following my discussion with the BDA Technical Manager, Sean Wilkins (2019), on the possibility of manufacturing project-specific bespoke bricks and achieving ceramic craft qualities in industrial production, he noted:

> *“…we’ve nearly exhausted the design possibilities of textured hit & miss brickwork…we’re just at the first step towards a more ‘arts & craft’ approach to design. For me the big hurdle is strengthening that link between the*

manufacturers and designers, so we can achieve these types of design solutions in a practical and economic way".

Prompted by these insights, my practice focused on the relationships between the stakeholders involved in the design and manufacture of bespoke bricks, through undertaking factory visits and informal interviews with technical staff, management and makers. I conduct design experimentations and develop case studies in collaboration with manufacturers, exploring the combination of ceramic craft and digital processes, seeking new opportunities for the creation of bespoke bricks within volume production.

1.3 Research questions

The barriers that exist in the design, craft making and manufacture of bespoke DFACs together with the exclusion of bespoke decorative bricks from contemporary architectural projects brought about the following questions as a focus for my research:

RQ 1: What are the key enabling and inhibiting factors and relationships between the stakeholders associated with the design, ceramic craft making, industrial manufacturing and structural integration of bespoke DFACs?

RQ 2: How can ceramic craft qualities be combined with material qualities as required for the structural integration of bespoke DFACs?

1.4 Aim and objectives

The aim of this research is to establish how to facilitate the design, ceramic craft making and industrial manufacture of bespoke DFACs among ceramic artists, architects and industrial manufacturers.

Objectives

OB 1. Critically review and analyse historical and contemporary precedents of bespoke DFACs, within the context of architectural practices, ceramic art practices and industrial manufacturing which facilitated their production.

OB 2. Use factory visits and engagement with ceramic artists and manufacturers to establish the ceramic craft and industrial processes utilised for craft making and manufacture of bespoke DFACs.

OB 3. Use insights from OB1 to inform my architectural and ceramic practice, to develop innovative ceramic designs and carry out material experimentations in collaboration with industrial manufacturers.

OB 4. Use insights from OB 2 and OB 3 to create site-specific ceramic interventions including tactile and coloured surfaces and street furniture, in collaboration with manufacturers and other stakeholders.

OB 5. Critically analyse my experimental practice and case studies to establish how to achieve ceramic craft qualities of bespoke DFACs in industrial manufacturing settings.

OB 6. Use my interviews, personal communications and other forms of engagement with the specialist stakeholders to investigate the relationships between architectural, ceramic art and manufacturing practices.

OB 7. Use insights from the engagement with expert stakeholders to establish how ceramic craft and material qualities of bespoke DFACs can contribute to buildings and urban spaces.

OB 8. Use the insights from the context analysis, my architectural/ceramic practice and communication with expert stakeholders to draw out findings that will bridge the gap evident in practices of ceramic artists, architects, and industrial manufacturers engaged in the creation of bespoke DFACs.

1.5 Chapter summary and thesis structure

Chapter 2. Research approach
This chapter introduces the mixed-method methodology of this practice-based research. It lays out the methodology in relation to the design, making and manufacturing practices and highlights the position of my practice within this context. Methods for critically analysing the precedents as "representative collective cases" (Creswell, 2007), my own case studies and creative practice (Stake, 1995; Creswell, 2007; Yin, 2009) and methods for qualitative analysis of semi-structured interviews with expert stakeholders are described in this chapter.

Chapter 3. Contextual review: precedents and practices
Critical analyses of historic and contemporary precedents of DFACs included in this chapter aid the context analysis and provide insights into the enabling and inhibiting factors linked to the creation of DFACs and their integration into buildings and urban spaces. The practice of ceramic studio artists, contemporary architectural practice and industrial manufacturing of DFACs in the UK, Europe and the USA are critically analysed in this chapter. Models of specialist knowledge exchange and facilitation of the manufacture of bespoke DFACs are reviewed through analyses of symposia and multidisciplinary workshops contributing insights to the key findings.

Chapter 4. Practice investigation into design, craft making and industrial manufacturing
This chapter includes description and analysis of my architectural and ceramic practice which leads this research. Material research and design experimentations and two of my case studies are critically reviewed and analysed.

Chapter 5. Engagement with expert stakeholders: interviews
Semi-structured interviews with ten expert stakeholders representing architectural, ceramic art practices and industrial manufacturers contribute insights and aid a deeper understanding of the relationships within and between specialist practices and the values that bespoke DFACs add to architectural projects.

Chapter 6. Conclusions: facilitating practice
This chapter includes the key findings of this research. The research outcomes comprise recommendations for the stakeholders of this research, my ceramic

practice contributions and a description of the facilitating framework for the creation of bespoke DFACs. Future research which aims to continue the discourse beyond this study is highlighted in this chapter.

Figure 1.6 demonstrates how the components of this study interrelate and contribute to the key findings and outcomes of this research.

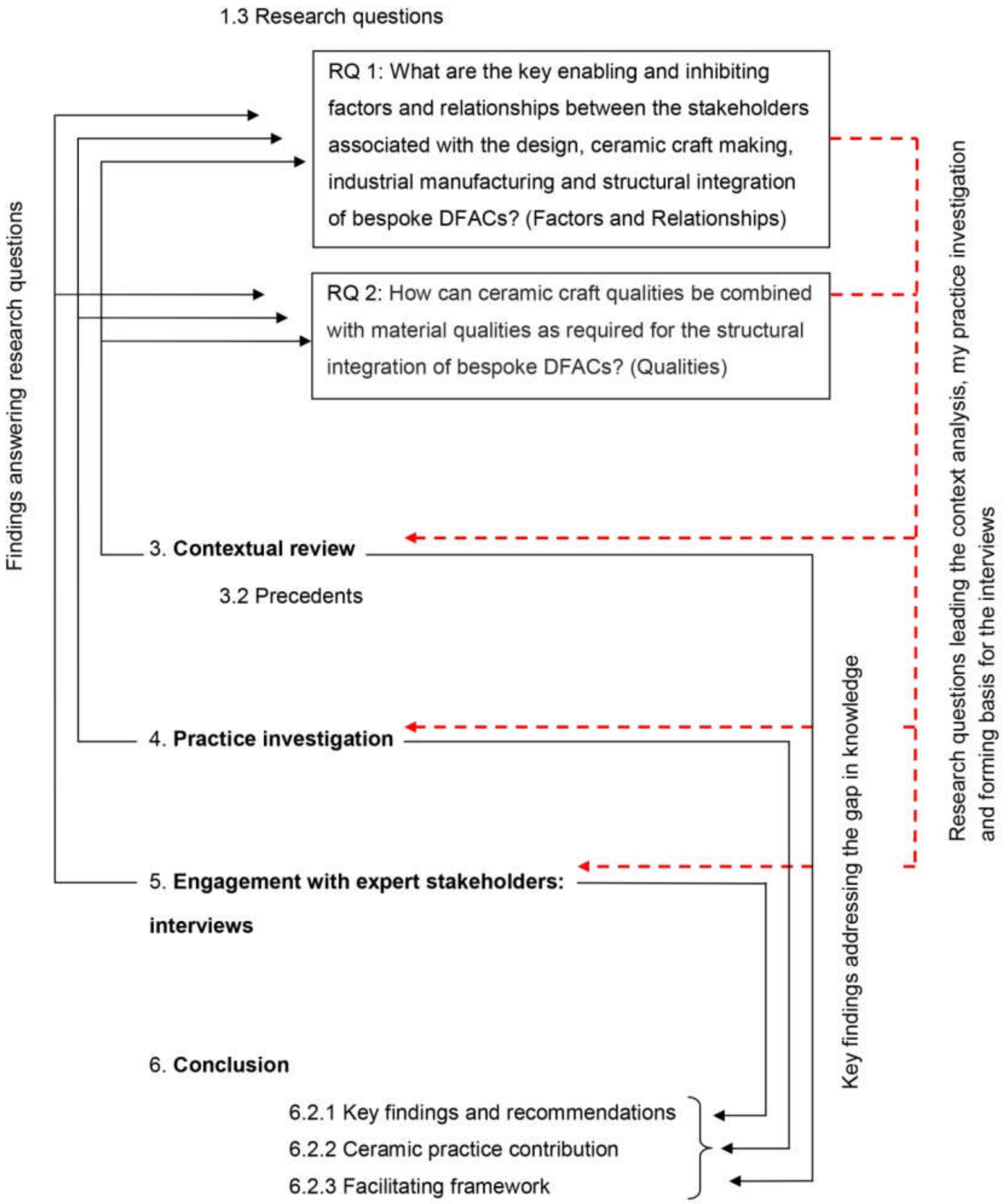


Fig. 1.6. *Thesis structure, identifying interrelations between the key chapters and sections*

1.6 Contribution to knowledge

The findings that are generated through analyses of each of the components of this research address the gaps in knowledge explored in the course of this study. Figure 1.7 demonstrates how the key findings were generated through the triangulation of data collected from the three sections of this research.

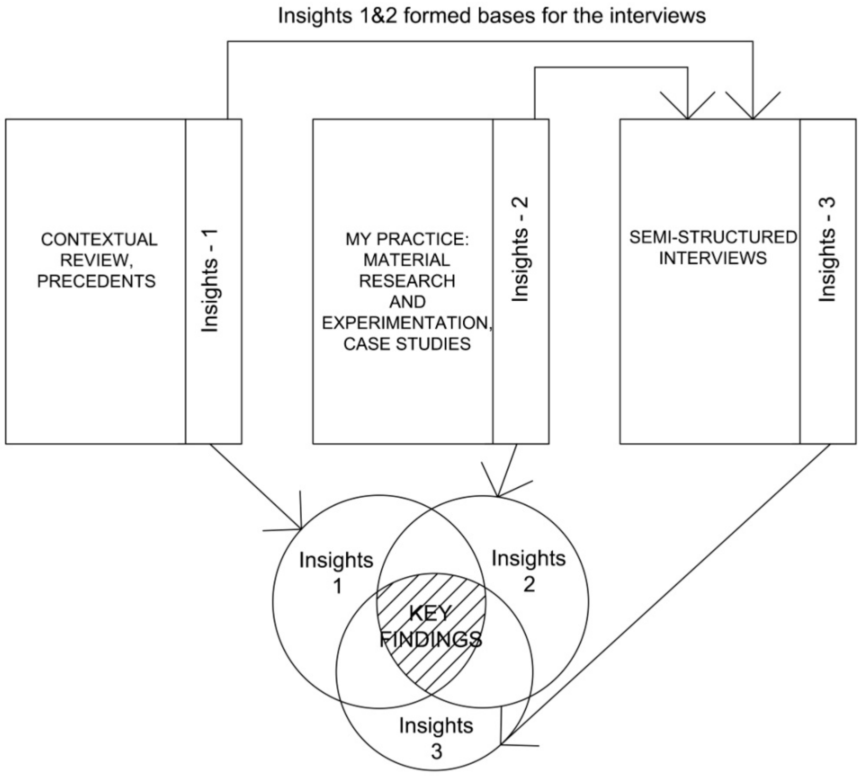


Figure 1.7. *Generation of key findings of this research*

The contributions of this research includes: i) the key findings which identify the factors that enable and inhibit the creation of bespoke DFACs and form the basis of recommendations for ceramic artists, architects, industrial manufacturers, planners and developers; ii) my ceramic practice comprising bespoke DFACs which evidence my findings. This includes a record of the manufacturing methods and processes of bespoke bricks together with a photographic record of two built case studies; iii) a facilitating framework that establishes collaborative links between the stakeholders of this research to enable the design, craft making and manufacture of bespoke DFACs.

1.7 Conclusion

My practice-based research at the intersection of ceramic art, architecture, and industrial manufacturing sets out to explore how to facilitate the creation and integration of bespoke DFACs, overcoming the barriers in design, ceramic craft making and industrial manufacture currently in evidence.

In addressing gaps in the knowledge of the specialist practices engaged in the creation of bespoke DFACs, my research investigates how the combination of ceramic craft, digital and industrial manufacturing methods can enable the creation of bespoke decorative bricks.

To undertake such research necessitated not only analytic reflection on the current context, but also active practice application to explore potential remedies. This methodology and the methods employed are discussed in the Chapter 2.

CHAPTER 2
RESEARCH APPROACH

2.1 Overview

My research practice adopts an interpretive mixed-method approach which combines case studies, reflective analyses of my professional practice and semi-structured interviews to investigate the issues which either inhibit or facilitate the creation of bespoke DFACs.

Multiple case study precedents are analysed alongside my ceramic and architectural practice. Added to this, my research employs semi-structured interviews with experts in the fields of ceramic art, architecture, and industrial manufacturing to add insights and construct multiple perspectives on the issues associated with the creation and structural integration of DFACs and the relationships between specialist practices. This chapter describes how each method was used to identify, collect and analyse data associated with the creation of bespoke DFACs, and highlights the interrelationship between the methods employed.

My combined professional practice as a ceramic artist and an architect is used as a research tool. The tasks that I perform as part of my architectural and ceramic artist's practices, during this research, are shown in Figure 2.1. In the diagram are outlined the processes that I engage in to enable the design, craft making and industrial manufacturing of bespoke DFACs.

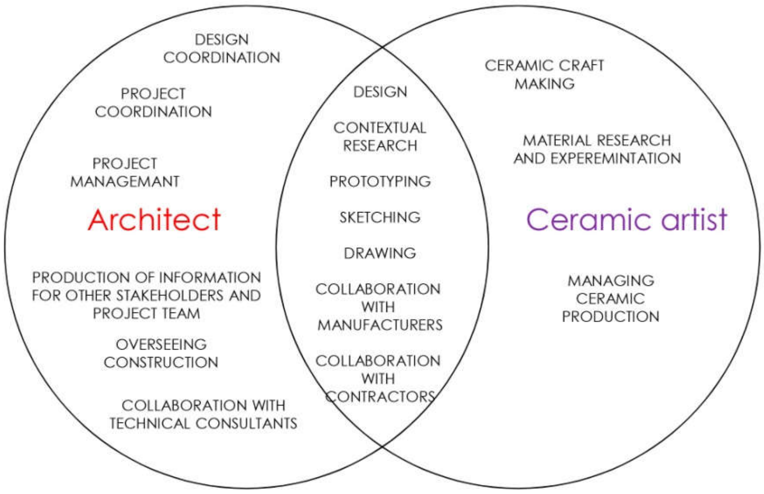


Fig. 2.1. *Tasks and specialist knowledge that are included in my combined practice*

As indicated in the diagram, collaborations with other stakeholders, engaged in the creation of DFACs, are part of an architect's and ceramic artist's practice. The diagram shows that certain activities are intrinsic to both professions, whilst others are practice-specific. The activities shown in the diagram aid this study by facilitating my practice explorations and my engagement with ceramic artists, architects, industrial manufacturers, clients, specialist consultants and contractors during this research. At the same time, the diagram highlights that the duality of my practice gives me insights which I would otherwise not have if I had represented only one profession. As an architect, without previous experience in ceramics, I would not have insights into ceramic material making. As a ceramic artist I would not have insights into construction, building regulations and the overall design process for the buildings necessary for the structural integration of DFACs.

The positioning of my practice at the intersection of ceramic art, architectural practices and industrial manufacturing, as shown in Figure 1.4 (Chapter 1), was instrumental to the investigation of the relationships and gaps in knowledge that exist between these practices, affecting the creation of bespoke DFACs.

2.2 Research strategy

My research follows three main approaches: i) precedent analyses that contribute to the contextual review; ii) the analysis of my creative practice and iii) the engagement with expert stakeholders through semi-structured interviews. Each of the components generate insights which address the research questions and contribute to the key findings, as shown in Figure 2.2. A critical review of historical (HP) and contemporary (CP) precedents allowed me to identify practitioners, companies and organisations involved in the creation of bespoke DFACs and gain insights into the ceramic craft qualities and methods used to achieve them. My two case studies constitute a major part of my practice investigations and are underpinned by my material research and design experimentations. Ten semi-structured interviews with expert stakeholders were undertaken to provide multiple perspectives and additional insights into the creation of bespoke DFACs. They were also used to collect feedback on my practice development and into emerging themes that arose in the course of this research.

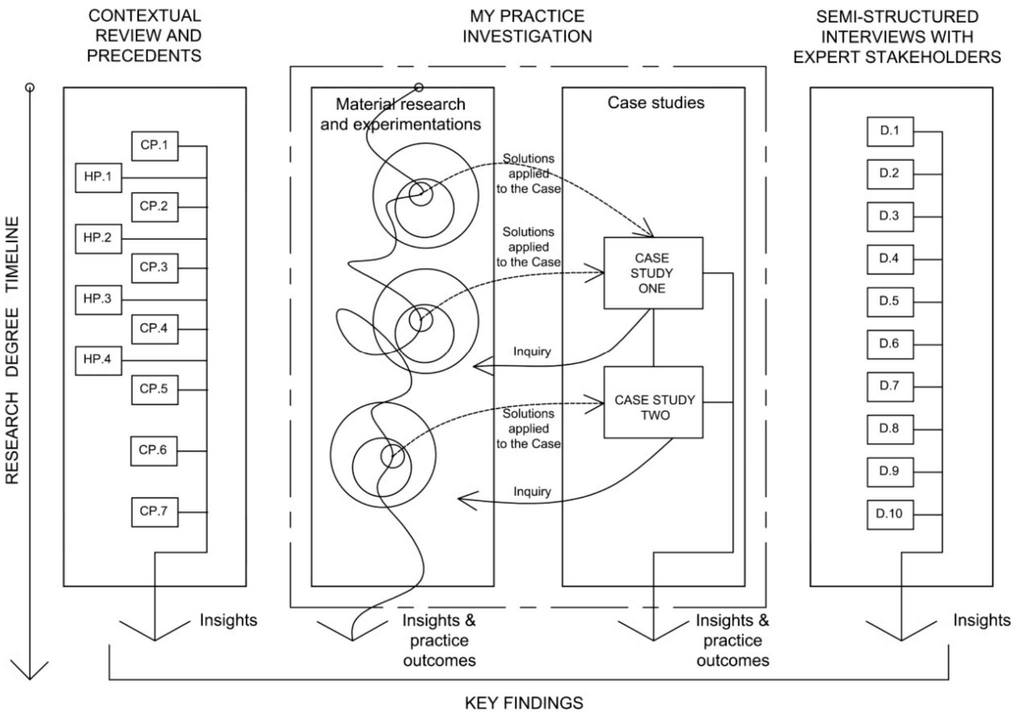


Fig. 2.2. *Main components of this study*

Figure 2.3 shows the interrelations between the main components of this research and the methods used within each component to generate the key findings, responding to the research questions. While the insights from the precedent analyses fed into my practice investigations, the interviews with expert stakeholders were aided by insights from both the contextual review and my practice investigations. The participants of the interviews were identified thorough my investigation into the context and development of my practice.

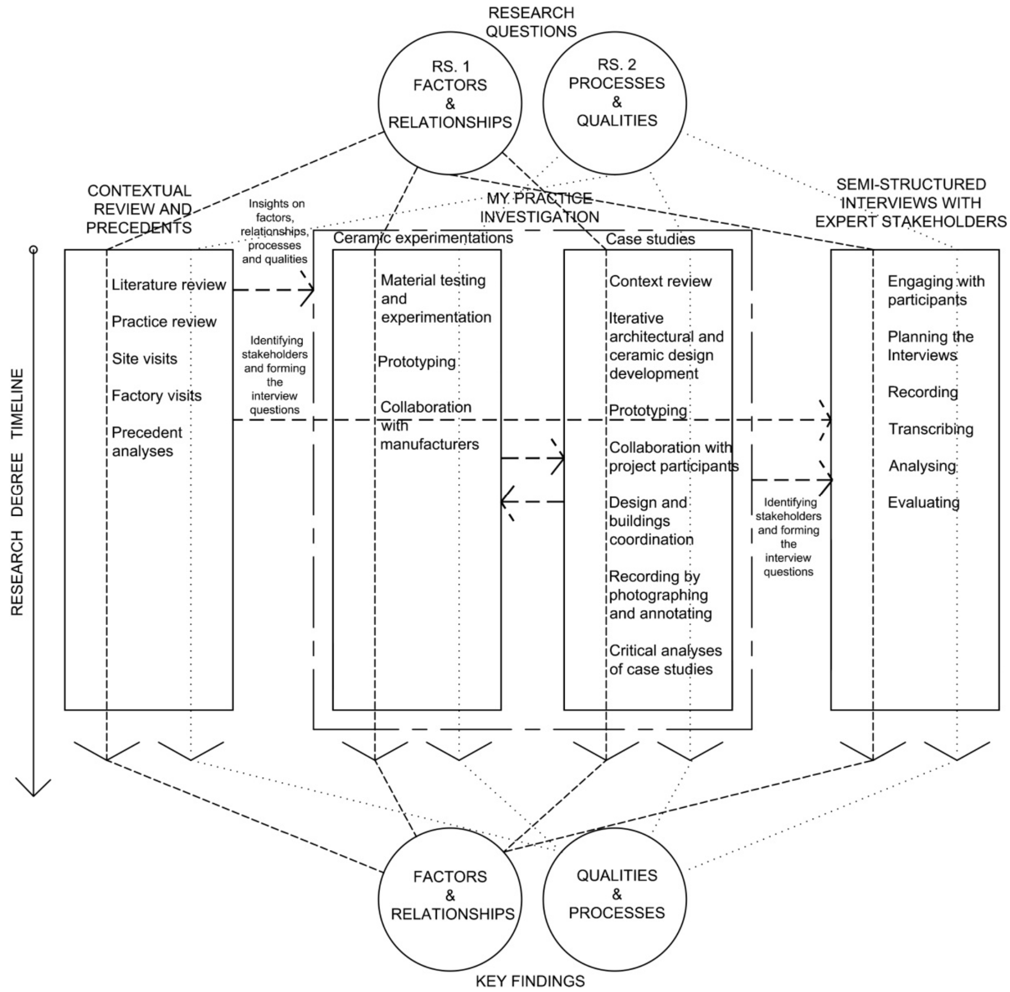


Fig. 2.3. *Research strategy for the generation of findings and interrelations between the components of this study*

2.3 Research methods

I employ different methodological approaches in each of the component parts of this study to identify, develop and analyse the insights and generate key findings.

2.3.1 Contextual review and precedents

Creswell (2007) describes case study methodology as “research that involves the study of an issue explored through one or more cases within a bounded system (i.e. a setting, a context)”. The investigation takes place through detailed data collection “involving multiple sources of information” (Creswell, 2007, p.73).

I use case study methodology for multiple historic and contemporary precedents of DFACs, and for my own case studies, to identify, describe, and analyse the barriers and enabling factors connected with the design, ceramic craft making, industrial manufacturing and integration of bespoke DFACs. The methods utilised for analyses of precedents include the collection of data through desktop studies, site visits and personal communications with project participants, which includes unstructured interviews.

In mapping out my subject area, I originally identified fifty historic and contemporary precedents of bespoke DFACs incorporated into buildings and urban spaces. My further investigation led to analysing ten of the precedents in depth. I visited all the locations of the selected precedents and communicated with the stakeholders involved in the projects in order to explore the material and aesthetic qualities of DFACs and the factors and relationships that facilitated their creation.[4] In the case of contemporary precedents, I engaged with the architects, ceramic artists and the manufacturers, while for two of the historic precedents I visited the manufacturers who were responsible for the restoration of the projects, to gain a deeper understanding of how the original DFACs were created and what processes and techniques facilitate the craft making and manufacture of similar designs today.[5] The historic precedents brought to light collaborative links that existed at the time which facilitated the creation and structural integration of DFACs, thus offering insights applicable to contemporary practices.

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[4] My site visits to the projects located in the Netherlands and the USA were enabled by the Winston Churchill Fellowship that I undertook in 2016 (Gasparian, 2017).

[5] Visits to the Ceramica Cumella and Boston Valley Terra Cotta factories and interviews with the specialists involved in the restoration of the mosaic bench in Park Güell and terracotta cladding of Guaranty Building in Buffalo gave valuable insights into the design and manufacturing processes that were originally used, and into innovative methods that were utilised in the restoration.

The research methods for historic precedents include desktop research, photographic survey and observations. In contrast to these, in the case of the contemporary precedents, I employ direct engagement with the project participants and their interviews available online, which would not be possible for historic precedents. My personal communications allowed for an in-depth analysis of the relationships between the stakeholders and a detailed understanding of the design, making and manufacturing processes, which are reflected in the analytical diagrams provided for each contemporary precedent.[6]

The research questions guided the choice of data to be gathered for each precedent, to identify the factors that facilitated the projects, ceramic material and ceramic craft qualities and relationships within the project team. This data is grouped into the following categories:

- **Key project information** includes construction dates, project participants, location, budget and materials used in the project.
- **Project context** identifies local, sociological and time-related aspects.
- **The design intent** highlights how the project was initiated by unpacking the roles of the key stakeholders. It also reveals the rationale behind the designs, material choices and detailing.
- **Design, craft and manufacturing processes** include a description of the architectural and ceramic design process, ceramic craft making, industrial manufacturing techniques and processes of construction.
- **Ceramic craft and material qualities** consider scale, colour, texture, shape and ornamentation as well as the physical properties of bespoke DFACs that enable their integration into the fabric of buildings and spaces.
- **Relationships and knowledge exchange** between the stakeholders involved in the projects, the distribution of power, decision making and collaboration are identified and examined through analytical diagrams.
- **Insights** addressing the aim of this research are extrapolated from the analyses.

The structure and data collection that was developed for the analysis of the precedents was applied to my own case studies. The insights from the precedents

[6] The detailed analyses of the precedents are included in section 3.2, Chapter 3 and Appendix B.

highlighted emerging themes, which were used to structure the interviews with the expert stakeholders in the later stages of my research.

2.3.2 My practice investigation

My combined architectural and ceramic artist's practice enables me to investigate the factors that enable or inhibit the creation of bespoke project-specific DFACs and the role of information exchange between the practices. It is used to reveal the barriers in the design, craft making and manufacturing of bespoke DFACs and the construction process through engaging in two case studies. My design experimentations focused on ceramic craft, manufacturing methods and the innovative digital techniques applied to bespoke designs and thereby investigating the potential methods of achieving ceramic craft qualities in industrial manufacture (RQ 1 and RQ 2). My practice investigations allowed me to test my assumptions and develop solutions that could be applied to the practice of others.

A reflective analysis of my combined ceramic and architect's practice, during my case studies, enabled me to analyse the role of each practice in the processes of design, craft making and manufacture and the specialist knowledge necessary to fulfil each task.

My practice, within the frame of this research, comprises two components: i) material research and experimentations that take place at the factories, ceramic studios and experimental facilities; ii) my case studies which constitute the design and construction of architectural projects containing structurally integrated bespoke DFACs. There is close articulation between the material research and experimentation component and my case studies, whereby ceramic experimentations run alongside my two case studies, providing material information and insights into the ceramic craft and industrial manufacturing processes (Figure 2.4). Whilst each of the two components brought about insights that contribute to the key findings of this research, the importance of preliminary research that supports the development of architectural projects, is made evident.

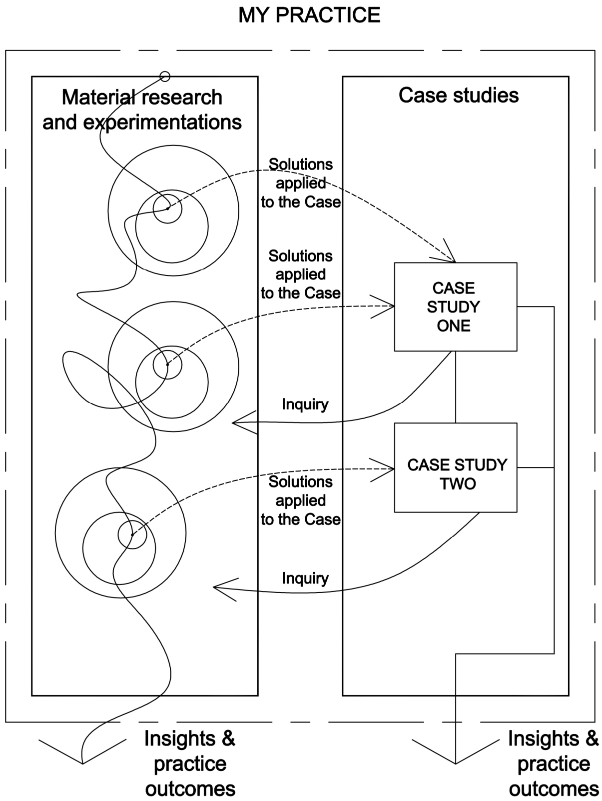

Fig. 2.4. *Interrelation between material research and experimentation and my case studies*

The DFACs for my case studies were developed by a two-step process, shown in Figure 2.5. First, my inspiration and motivation based on insights from the precedents and results of my experimentations. They were then developed by prototyping and material testing leading to ‘working solutions’ - designs for DFACs that can be structurally integrated into architectural projects, as shown in Figure 2.6.

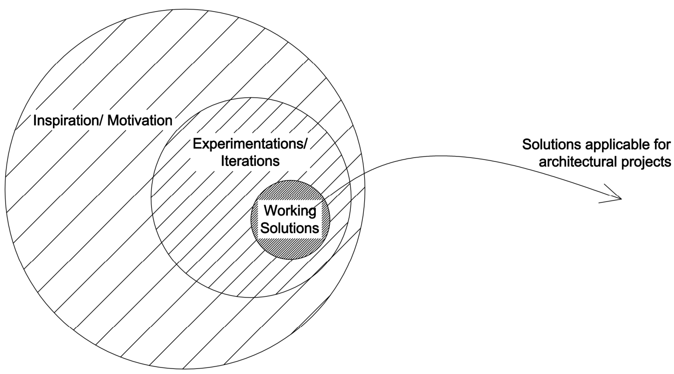

Fig. 2.5. *Development of design solutions through inspiration and material experimentation*

An example of design development is shown in Figure 2.6: My early experimentations carried out in 2017, as shown on images on the left, provided material knowledge that was applied to provide working solutions for case study 1 in 2018 (images on the right).

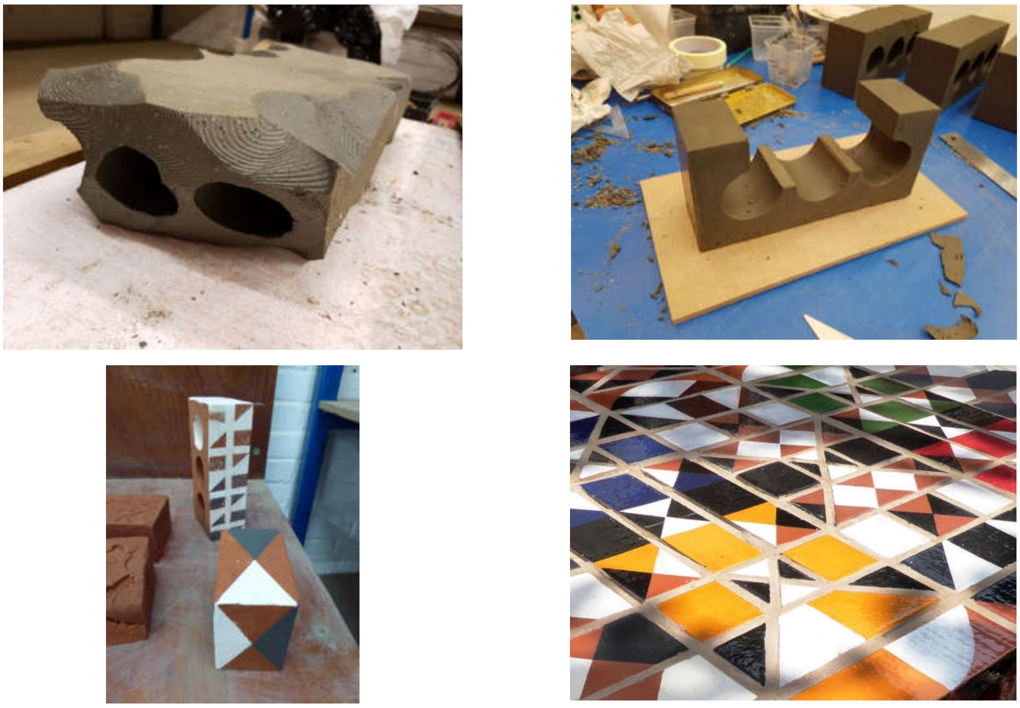

Fig. 2.6. *Clockwise: hand-carved extruded section of clay; hand-carved extruded brick forming Ceramic City Bench*; *decorated brick surface painted with multicoloured underglazes, Ceramic City Bench; extruded brick painted with diamond pattern using white and black underglazes* (2017, 2018)

2.3.3 Engagement with stakeholders

My engagement with the stakeholders of this research is an integral part of this study, comprising: i) personal communications with project participants through informal conversations and emails (Chapters 3 and 4); ii) collaboration and co-creation in factories and building sites (Chapter 4); iii) in-depth interviews with expert stakeholders (Chapter 5); iv) my participation in specialist symposia, multidisciplinary workshops, seminars and exhibitions (Chapters 3 and 6).

Locating my ceramic practice in brick factories aided communications with owners, brickmakers and roof-tile makers, glaze specialists, managing directors and directors of marketing. This gave me the opportunity to identify and analyse the enabling processes, inhibiting factors and relationships within manufacturing.

In-depth, semi-structured interviews with the expert stakeholders were undertaken to enrich my understanding of issues connected with the creation and structural integration of bespoke DFACs. The methods used for the selection of interviewees, planning, recording, transcribing and analysing the interviews are described below.

The semi-structured, in-depth interviews were designed to collect qualitative data from expert participants, so as to contribute to a richer understanding of the barriers to the design, manufacturing and integration of DFACs and the relationships between stakeholders. Purposeful sampling, as described by Creswell (2007, p.125), in which individuals are selected because they can "purposefully inform an understanding of the research problem", was utilised to recruit the participants for the interviews. The strategy for building the pool of participants is described in Chapter 5, section 5.2.1.

A combination of broad and specific questions were used in the semi-structured interviews. There were approximately ten questions put together for the interviews, which were then refined through a pilot test as recommended by Yin (2009). The questions were also subsequently revised through reflection after each of the interviews. The set of questions was customised for each stakeholder to reflect the nature and individuality of their practice. The questions were grouped into 3 segments, as suggested by Galletta (2013): i) an introduction - open ended questions setting the scene; ii) middle section - specific questions offering detailed insights on the project; iii) closing section – the lessons learned.[7]

The discussions with participants, on ceramic craft and material qualities of DFACs and craft and manufacturing methods used to achieve these, responding to RQ 2, was aided by the use of model decorative bricks and a Participants Information Document; which were introduced into the interview process.

Each interview is analysed through the following steps:

[7] An example of questions which were prepared prior to the interview are included in Chapter 5.

- The audio recording of the interview is transcribed and recorded as a text document.
- The transcription text is studied in detail, with themes relevant to this being highlighted in colour.
- The highlighted text is copied into a table which has three columns titled: quotes, insights and themes.[8]
- Emergent themes identified though my practice and context analyses are added to the table. New themes identified through the interview are highlighted.
- The insights are grouped into topics for each of the interviews.
- Condensing and comparing the data collected from all the interviews aids the writing up of key insights and contributes to the key findings of this research.

The details on interview planning, process and analysis are included in Chapter 5.

In order to position my practice in the field of the investigation from the start of this research, I have engaged with multiple stakeholders through presenting my work at symposia, seminars, exhibitions and by attending multidisciplinary workshops.[9]

2.4 Generation and presentation of key findings of this research

The key findings of this research are generated by extrapolating evidence from each of the components of this study, aided by the application of the methods described above. The key findings are produced through analyses of evidence from the interviews, precedents and my practice and by identifying common strands and overlapping insights (Figure 1.6, Chapter 1).

The key findings of this research aim to support the practices of ceramic artists, architects and industrial manufacturers; therefore, these are used to form design and practice recommendations for the stakeholders.

[8] For an example see Table 5.5, Chapter 5.
[9] Details of my public presentations and seminars for architects are included in Chapter 6, section 6.6. My participation in multidisciplinary workshops and symposia are included in Chapter 3, section 3.4.

My material research, experimentations and my case studies are documented through photographic record and include the description of design, ceramic craft, manufacturing methods and construction processes utilised in the creation of both practice components. Practice recommendations addressing ceramic artists, architects and industrial manufacturers, aiming to facilitate their practice, are based on the insights from my practice investigations.

The facilitating framework diagrams, based on the key findings, demonstrate both existing collaborative links and relationships between the stakeholders (RQ 1) and the proposed collaborative links between practices which could facilitate the creation of DFACs.

A summary of products and manufacturing processes used in brick factories in the UK, collected through my factory visits, is included in Appendix C.

2.5 Conclusion

The implementation of the research methods outlined in this chapter aims to identify and investigate the gaps in knowledge that exist within the ceramic art, architectural practices and industrial manufacturing connected to the creation and integration of bespoke DFACs. My creative practice, positioned on the intersection of ceramic art, architecture and industrial manufacturing, is applied as a methodology to investigate the barriers in design, craft making and manufacture.

The analyses of the design, ceramic craft and manufacturing processes facilitated by my research methods are conducted through precedent analyses, observation and photographic records during my factory visits, my primary experience of craft making and semi-structured interviews with expert stakeholders.

The case study methodology – as applied to the precedents and to my two case studies - explores the complex factors and relationships which enable and inhibit the creation of bespoke DFACs (Chapters 3 and 4). My reflection on direct design experimentations, material research and personal engagement in manufacturing processes seeks to reveal emergent themes regarding the design, craft making and industrial manufacturing of DFACs.

Chapters 3, 4 and 5 will demonstrate how this study is conducted through the application of the research methods described above, leading to the generation of key findings regarding the creation of bespoke DFACs relevant to the fields of architecture, ceramic art and craft practices, and industrial manufacturing.

CHAPTER 3
CONTEXTUAL REVIEW: PRECEDENTS AND PRACTICES

3.1 Overview

In this chapter I review and analyse the context of my research. My investigation into the context brought to light the specialist practices engaged in the creation of bespoke DFACs, identifying both the enabling and inhibiting factors associated with their design, craft making and manufacture. This review has enabled me to position my creative practice within the context of architecture, ceramic art and industrial manufacturing, thus allowing me to identify gaps in knowledge associated with the design, craft making and in particular, the industrial production of bespoke decorative bricks.

The analyses of historical and contemporary precedents, discussed in this chapter are used to contextualise the complex issues involved in the creation and integration of bespoke DFACs by unpacking the roles of the specialist practices involved in projects and the knowledge exchange between them. The material and ceramic craft qualities of precedents and the ceramic craft and industrial processes that facilitate their creation are investigated to provide insights for my research. The social and commercial values added to the architectural projects through the integration of bespoke DFACs are highlighted through precedent analysis.

My personal communications with key stakeholders included in Table 3.1, my factory visits and participation in multidisciplinary workshops, organised by industrial manufacturers (section 3.4), offer insights that enable a wider understanding of the context of this research.

The discourse on aesthetic variability, craft qualities and the use of ornament, which occupied architects and designers at the end of the 19th and the beginning of the 20th centuries, is explored in the context of contemporary design, craft making and manufacture of bespoke DFACs. Similar in scale to the changes driven by the Industrial Revolution in the 19th century, the increasing use of digital tools that enable direct fabrication and mass customisation in industrial manufacturing have brought about a major shift in the fabrication of building materials, crafting of detailing and the production of architecture. The use of digital tools and processes related to the creation of bespoke DFACs are investigated in this chapter.

3.1.1 Changes in practice

Harun Farocki's film *In Comparison* (2009) captures brick making and the construction of brick structures in different geographical and social contexts. It progressively shows more complex production methods, starting with the making of unfired bricks in Africa by hand, where clay is first dug out of the ground and mixed by foot, with water brought and poured into a ground hole by female workers. The wet clay is then slumped into open wooden moulds. The bricks dry in the open air and are laid in structures by the villagers. The walls are finished by the workers applying clay slurry (liquid clay) over the wall by hand. The film captures the making and construction as a lively social process.

The next section of the film takes us to India, where workers make bricks by scooping the soft clay from a small clay mound and slumping it into a metal mould. The film illustrates that the increasing complexity and precision of brick manufacturing processes leads to fewer and fewer people being involved.

The documentary culminates with a robotic arm constructing a wall of elaborate geometry in a vineyard in Switzerland. This scene demonstrates a digitally facilitated bespoke assembly made out of standard bricks. Glue is squeezed onto each brick and the robotic arm places it into a precisely programmed position. While there is not a person in sight throughout the process, what is not included in the film is all the people present behind the scenes of this automated process: a team of designers who operate the robot, who have written the digital code, designed the geometry of the wall, developed the adhesive, designed the metal support for the wall and manufactured the robot.

> ***Insight 3.1:*** *Automated and digital processes reduce human involvement and hand workmanship in brick manufacturing.*

My investigation into brick manufacturing and brick construction brought to light that while robotics is used for brick assemblies to create complex facades (ROB Technologies, 2021; Dakhli and Lafhaj, 2017), the application of digital tools has not been utilised in industrial brick manufacturing. At the same time, rapidly developing digital tools and processes utilised in experimental ceramic art practice and the industrial manufacturing of faience facades open up aesthetic and technical possibilities in the creation of bespoke DFACs.

3.1.2 Digital facilitation

Bechthold (2015) argues that while mass-produced repetitive elements are the most “cost effective” choice in manufacturing, there is real potential for parametric design in facilitating varied architecture. However, providing "individualised fabrication" requires redesigning industrial production processes. The discussion below highlights how digital tools for design, prototyping and fabrication can facilitate the creation of complex geometries in craft making and the industrial manufacturing of bespoke DFACs, as well as forming and decorating ceramics with precision.

Computer aided design (CAD) and computer aided manufacture (CAM) enable the creation of complex models and prototypes that can be translated into clay objects. 3D scanning and Computerised Numerical Control (CNC) milling processes are currently used in the creation of models and moulds for architectural ceramics on a large scale by major manufacturers of architectural ceramics for both restoration and new-build projects (Boston Valley Terra Cotta, 2021; Darwen Terracotta, 2021). Digitally programmed machines at Darwen Terracotta manufacturing use hot wire to cut polystyrene blocks which are then used as models in the creation of plaster moulds for linear cornices and mouldings for building facades.[10]

In addition to cutting and milling aided by digital tools, 3D printing with clay can provide direct fabrication by creating ceramic pieces while omitting interim processes, such as model and mould making. Despite this, 3D printing has limitations of speed and quality consistency, making it prohibitive for the present industrial fabrication of DFACs (Bechthold, 2017a).

3D printing in clay is explored by ceramic artists and designers such as Keep (2021), who uses digital coding to generate forms for sculptural stoneware vessels. Eden (2021) created sculptural vessels and decorative pieces before concentrating on 3D printing using polymer resins. Conti (2021) experiments with varied clay

[10] The manufacturing processes at Darwen Terracotta were investigated during my visit in January 2018.

bodies and applies stains and metal oxides to decorate his 3D printed intricate objects. Sintobin (2021) explores different clay bodies and varied firing temperatures to produce diverse aesthetics of her pieces printed in clay as well as experimenting with digital carving tools to alter unfired pieces.

When discussing 3D printed architectural ceramics, Bechthold (2016) claims that “the economics of 3D printing are still a difficult proposition when compared to the efficiency of industrial production methods”. Experimental ceramic facilities (Grymsdyke Farm, UK and EKWC, the Netherlands) and digital facilities at universities in the USA (University at Buffalo, New York; University of California, Berkeley; Harvard University, Massachusetts; University of Michigan) have investigated the aesthetic and functional possibilities of 3D printed architectural ceramics. The California-based experimental practice Rael San Fratello (2021) used 3D printed clay tiles for their ‘Cabin of 3D printed curiosities’. However, the experimental designs have not been yet applied into industrially-made architectural ceramics (Bechthold, 2017b).

The creation of ceramic floor tiles for the Victoria and Albert Museum shop (CP.4)[11] highlighted the issues connected with 3D printing with clay in the production of bespoke DFACs. The tiles that were 3D printed using liquid clay warped and delaminated in drying and firing and had to be remade by ceramic craft manufacturer Froyle Tiles, using a traditional hand press-mould technique, while retaining the 3D printed aesthetics.

My research has revealed that there are currently no precedents for the use of digital tools and processes in the industrial manufacture of bricks. However, innovative, digitally aided solutions for brick-making were investigated by The Material Processes and Systems (MaP+S) Group at Harvard University in 2013, led by Professor Bechthold (MaP+S Group, 2021), where brick prototypes were made in CNC milled moulds and complex 3D assemblies were erected by hand. While the project included hand-made experimental elements and assemblies (Imbern, 2014), the investigation into ceramic craft qualities and the future trialling of innovative solutions within industry were not a focus of the research group (Bechthold, 2018b).

[11] The precedent is included in Appendix B.

Insight 3.2: *Digital tools and processes are not currently (as of 2021) utilised in the industrial manufacture of clay bricks.*

3.1.3 Hybrid manufacturing[12]

In parallel with the increased use of digital tools in the production of buildings, there is an ongoing discourse about the importance of human input and craft aesthetics in architecture. As Bechthold (2016) notes, the "monotony and repetition of identical units that represent the logics of economies of scale more than those of design continue to dominate today". He also writes that mechanised processes ensure ceramic material qualities[13] through fabrication in a controlled environment. At the same time, it has been acknowledged that highly controlled manufacturing processes create aesthetically homogeneous products. The change in the aspirations of architects connected to the craft qualities of building materials in reaction to Bechthold's observation has been described by ceramic artist Loraine Rutt:

> "…the role (of arts and crafts in the built environment) is changing…. it is a wider subliminal desire, a backlash to our touch-screen, digital world, to touch a material reality… That's where architects have been having conversations about making architecture more tangible. It gives buildings more human character and scale, not just big, slick mass produced materials where there is very little variation in a material."
> (Rutt, 2021)

In response to architects' demand for aesthetic variation to provide project-specific solutions, the hybrid manufacturing methods, which include ceramic craft techniques and digital tools, are utilised to facilitate the "form customisation strategies" in an industrial setting described by Bechthold (2015, p.148). These strategies are applied into industrial "wet processes" such as extrusion, stamping and casting and at the post-firing stage, and can incorporate cutting, scoring, drilling, bending and adhering. Added to these methods, the use of glazes allows for the customisation of ceramic surfaces to respond to the project's "specific context" (Ibid. p.70).

[12] See Definition of terms, Chapter 1.
[13] See Definition of terms, Chapter 1

Hybrid methods of manufacture were explored as part of an international multidisciplinary Architectural Ceramics Assemblies Workshop (ACAW) [14], hosted annually by the ceramic manufacturer Boston Valley Terra Cotta (BVTC) in Buffalo, New York, USA, to facilitate the creation of innovative DFACs. The necessity of craft and ornament in buildings was the focus of the key note speech to the opening of the ACAW symposium preceding the workshop in 2020. James Von Klemperer of Kohn Pedersen Fox Associates stated that the intricacy of craft making needs to be incorporated into the making of buildings and become a major contributor to urban fabric.

In this context, I investigate the ceramic craft qualities[15] and the ways of achieving them in industrial manufacturing to identify how they can contribute to the creation of bespoke DFACs.[16]

3.1.4 Ceramic craft qualities

Ceramic craft qualities were defined in this study as qualities that combine the intrinsic characteristics of ceramics and are achieved by the application of ceramic craft techniques resulting in a diversity of textures, colours and shapes.

Explaining “what ceramic is” Greenhalgh (2021, p.18) notes that “ceramic is a process whereby sheets of pliant wet clay are made into two- and three-dimensional forms through bending, folding and constructing.” Clay is then fired, becoming stone-like, and “various minerals can be used to colour and pattern the surface.” A further description of the processes of firing and decorating highlighted the fact that ceramics demonstrate variable qualities that are site and culture specific.

Clay, the base component of all ceramics, comes in different colours which results from the way the clay been formed in the ground and through the inclusion of minerals such as iron oxide, and biological matter. The physical properties of clay dictate firing temperatures and define the aesthetic outcomes. Broadly classified into earthenware, stoneware and porcelain, clay from every clay pit and every batch

[14] The ACAW multidisciplinary workshop is discussed in section 3.4.1.
[15] See Definition of terms, Chapter 1
[16] My practice investigation included in Chapter 4 explore how ceramic craft qualities can be created to provide project-specific DFACs.

dug out of the ground looks different and has varied physical characteristics. The diversity of firing methods adds to varied aesthetic outcomes: the less controlled the firing process is, the more diverse the aesthetic and material properties are. Added to this, the presence of oxygen during firing and the position of ceramic pieces in the kiln affect ceramic characteristics.

Ceramic decorating techniques and materials have historically demonstrated locality and craft narratives. “The colour range in ceramic is dictated by materials that don’t burn away when the pot is fired” (Greenhalgh, 2021, p.19). Traditionally, this limited ceramic colours to the use of coloured clays (slips) and minerals for glazes that were available locally. However, not only local materials, but the trade that existed at a certain time, is reflected in the appearance and colours of ceramics, providing further variability (Rodler et al., 2019).

The way colour can be incorporated into architectural ceramics has changed with the growth of international trade and the development of chemical pigments that can be added to glazes and used in underglazes. ‘Craft glazes’ that use metal oxides, made in small batches and applied by hand produce colour and surface variation. The image on Figure 3.1 shows a translucent cobalt and copper oxide glaze applied by hand, thus creating colour variation created by the different thickness of the glaze.[17] The image on Figure 3.2 shows an industrially produced opaque glaze which is evenly applied by spraying, ensuring uniformity and an even surface coating.

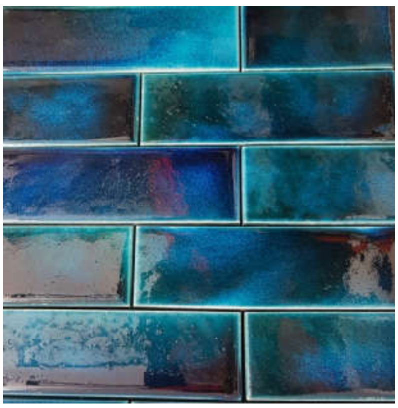

Fig. 3.1. *‘Craft glaze’ by H.G. Matthews brick manufacturer* (2019)

[17] Different thickness of the glaze including ‘pooling’ - glaze collecting in the indentations of ceramic piece - has been explored in my material experimentations in Chapter 4.

Fig. 3.2. *EH Smith Architectural Clay Products: glazed bricks with Olive Green glaze* (2021)

In addition to the colour variations that are enabled by the properties of clay, firing and decorating materials, the hand making processes are key contributors to the craft qualities of ceramics. The hand application and layering of glazes and underglazes using different craft techniques can change the appearance and surface qualities of DFACs. Describing the work of a studio potter, Greenhalgh notes: "…while they throw the wares in quantity,…each pot is in itself unique, because of the intervention of the hand" (Greenhalgh, 2021, p.52).

> ***Insight 3.3:*** *While contemporary industrial manufacturing methods incorporate controlled processes to achieve uniformity, craft interventions into the industrial processes contribute to the diverse qualities of DFACs.*

Ceramic craft qualities and the ways these are achieved to contribute to the creation of bespoke DFACs are investigated through the analysis of contemporary and historical precedents.

3.2 Critical analysis of historical and contemporary precedents

My initial desktop study highlighted the lack of literature relating to the creation of bespoke architectural ceramics and bricks beyond the restoration and historical projects. Following this, the contextual review for this study is structured around the historical and contemporary precedents, architectural projects incorporating bespoke DFACs. Ten of the precedents are selected for an in-depth analysis to identify the stakeholders involved in the creation of bespoke DFACs, to investigate the relationships between them and examine inhibiting and facilitating factors that exist in the creation of bespoke DFACs to address RQ 1. The material and ceramic craft qualities of the precedents are examined focusing on the ceramic craft making and industrial manufacturing processes addressing RQ 2.

Complete analyses of four selected historic (HP) and contemporary (CP) precedents are included in section 3.2.1, while others are incorporated in Appendix B. An overview and the summary of insights from these precedents are included in section 3.2.2.

The precedent analysis was aided by my personal communications with ceramic artists, architects and industrial manufacturers involved (Table 3.1). The table also includes interviews with project participants related to the precedents, which I used and which are available online.

Project	**Project Team**		
	Architects	**Ceramic artists**	**Manufacturers**
Ceramic mosaic bench, Park Güell, Barcelona (HP.3)	Antony Gaudi		Tony Cumella, Ceramica Cumella, Spain
Terracotta ornamental facade, Guaranty Building, Buffalo (HP.4)	Louis Sullivan		John Krouse, Boston Valley Terra Cotta, USA
Ceramic Kiosk, Seven Sisters underground station, London (CP.1)	Mathew Leung, Assemble	Matthew Raw	n/a
Bespoke glazed facade, 24 Savile Row, London	Stephen Pey, EPR Architects	Kate Malone	Richard Miller, Froyle Tiles

(CP.2)			
Polychromatic faience facade and ceramic artwork, One Eagle Place, London (CP.3)	Eric Perry	Richard Deacon	John Wilson, Darwen Terracotta
Ceramic floor tiles, V&A Museum shop, London (CP.4)	Guan Lee	n/a	Richard Miller, Froyle Tiles
Decorative brick cladding, Humtunnel, bicycle and pedestrian underpass, Delft (CP.5)		Marta Nagy	Small brick manufacturer in NL (currently not in business)
Civic Theatre, Haarlem (CP.6)	Erick van Egeraat	Babs Haenen	Jan Kok, Royal Tichelaar, Makkum

My personal communications during meetings and via emails Interviews with practitioners, available online

Table 3.1. Practitioners and organisations involved in historical and contemporary precedents

3.2.1 Analyses of selected precedents

3.2.1.1 Glazed ceramic detailing, social housing in Somers Town, London, UK (HP.2)

The social housing scheme designed by the architect Ian Hamilton along Drummond and Sidney streets in the Somers Town area of North West London, features glazed ceramic reliefs and sculptures incorporated into the buildings and communal spaces. The buildings of St. Michael’s Flats, Christopher’s House and St. Nicholas Flats include bespoke ceramic elements produced through collaboration between the sculptor Gilbert Bayes and Doulton & Co. ceramic manufacturer. These elements combine ceramic craft qualities with physical characteristics which enabled the integration of ceramic elements into the buildings and outdoor spaces.

The precedent was chosen to investigate its historical, social, material and manufacturing contexts to draw insights related to the enquiry of this research. The roles of ceramic artist, the ceramic manufacturer and their relationships were investigated through desktop studies.

Key project Information

Location	Camden, London, UK
Construction Dates	1920-1930
Project Participants:	
Client	St Pancras House Improvement Society
Architect	Ian Hamilton
Sculptor	Gilbert Bayes
Manufacturer of decorative ceramics	Doulton & Co.
Ceramic materials used	Doulton ware salt-glazed stoneware tiles and sculptural elements.

Project context

The housing shortage in the interwar period brought about an increase in the number of social housing schemes in England, thus presenting the challenge of creating architecture that improved living conditions within a limited budget (Tremayne, 2013). "Housing is not enough" was the slogan for this social housing development, which represented the beginning of the "war on slums" in London by Friar Basil Jellicoe, the founder of the St Pancras House Improvement Society, which is now known as the St Pancras & Humanist Housing Association (*Housing is not enough,* 2019).

Design intent

A new housing estate with ceramic art integrated into buildings and communal spaces, was designed to create an environment that would improve the quality of life for residents.

Colourful glazed ceramic decorative elements were conceived by the architect to decorate communal gardens and courtyards (Tremayne, 2013). These were created by the sculptor Gilbert Bayes who believed that "art should be part of everyone's daily life", not only through accessible locations but also through "subject matter" (*Housing is not enough,* 2019). He addressed this by creating tiles that depicted folk tales, stories from the lives of saints and popular contemporary motifs (Figure 3.3). Integrated into the brick facades, these brought individuality to the buildings.

Fig. 3.3. *Clockwise: Ceramic detailing in the window arches featuring Hans Christian Andersen's The Swineherd and The Wild Swans fairy tales; decorative clock with allegorical figures of the four seasons; 'sailing ships' ceramic finials at the tops of the concrete poles supporting washing lines* (2019)

Design, craft and manufacturing processes; ceramic craft and material qualities

Starting in 1863, Doulton & Co. produced decorative stoneware in association with Lambeth School of Art, which contributed to their commercial success (Eyles, 1975). The ceramic material known as 'Doulton ware' was frost-resistant, which made it usable outdoors.

The sculptor Gilbert Bayes (1872-1953) worked in a variety of media, which included ceramics (Irvine and Atterbury, 1998). From 1923 he was one of a group of sculptors and artists working with brightly coloured salt-fired glazed stoneware at the Doulton & Co. factory in Lambeth (Tremayne, 2013).

Glazed low relief stoneware "sectile" tiles were built into the arches over the windows and specially provided niches within the brick buildings and depicted fairy tales and allegorical motifs. Repeated reliefs were made and installed in different locations in the estates, evidencing the fact that these were made in a mould. The tiles were cut into irregular pieces, following the contours of the figures. The tiles are set centrally and follow closely the contours of the semi-circular and rectangular brick niches of the building, suggesting that information exchange took place between the architect and the sculptor, allowing the precise integration of the ceramic artwork into allocated spaces within the facades (Figure 3.2).

Ceramic finials for the tops of the concrete washing lines created by Bayes depicted popular Arts and Crafts motifs of sailing ships, birds and symbols of saints. Unfortunately, at the time of writing (2021), most of the free standing finials are no longer in situ or have been substituted by replicas. At the same time, the structurally integrated relief tiles are fully intact.

Relationships and knowledge exchange

The roles and relationships between the stakeholders involved in the creation of DFACs for the Somers Town social housing estates was based on desktop investigations, which revealed that the manufacturing facilities of Doulton & Co. facilitated the creation of ceramics through collaboration with the sculptor. The information exchange between the sculptor and the architects was also made evident. The project highlighted the role of the client, who initiated the commissioning of the artwork aiming to improve the environment for the residents of the estate.

Insights from HP.2

- Client's initiative and vision to improve the environment for residents facilitated the creation of bespoke DFACs.

- Doulton & Co. industrial manufacturer facilitated manufacturing of bespoke DFACs by operating facilities that produced salt-glazed, high-fired, frost-resistant stoneware ceramics for architectural applications.
- Collaboration between the ceramic manufacturer and a school of art facilitated development of ceramic craft qualities within the industrial manufacturing.
- Sculptor's ceramic material knowledge enabled the creation of bespoke DFACs.
- The sculptor working at the industrial manufacturer's facilities, set up for artists and designers facilitated the creation of bespoke DFACs.
- Longevity of ceramic elements was ensured by their structural integration into the buildings.

3.2.1.2 Ceramic kiosk, Seven Sisters underground station, London, UK (CP.1)

This precedent explores the creation of hand-made glazed tiles for external cladding of the kiosk located at the entrance to Seven Sisters underground station in North London. The project was facilitated by the collaboration between the ceramic artist Matthew Raw and the Assemble architects, whose architectural practice is characterised by their involvement in experimental and self-built projects. The overall design and processes utilised in craft making of tiles highlight the material and aesthetic outcomes affected by the methods employed.

The precedent was selected to critically analyse the craft production methods and ceramic craft and material outcomes that were achieved without the involvement of an industrial manufacturer.

Key project Information

Location	Seven Sisters underground station, London
Construction dates	Completed December 2017
Project participants	
Client	Transport For London (TfL), Art on the Underground programme, funded by Arts Council England
Architect	Assemble

Ceramic artist	Matthew Raw
Makers	Matthew Raw, members of Assemble, two trainees
Tiling contractors	unknown
Ceramic materials used	Glazed stoneware handmade tiles. Clay body coloured by yellow, blue and green pigments

Project context

The project was commissioned by the Art on the Underground programme and was funded by the Arts Council England. The architectural practice Assemble was commissioned to revitalise an abandoned kiosk at the entrance to Seven Sisters underground station in London. The architect's proposal was to clad the existing structure of the kiosk with ceramic hand-made tiles (Figure 3.4).

Fig. 3.4. *Left: Kiosk before renovation* (photo: courtesy of Assemble, 2015). *Right: Opening ceremony of renovated kiosk* (2017)

Design intent

The brief was developed by the architects in collaboration with TfL and responded to the tradition of use of ceramics at London underground stations (Art on the Underground, 2017). The project architect Mathew Leung explained that the kiosk aimed to create a sense of "pride and ownership" at one of the entrances of the station by involving TfL staff in making of the tiles for cladding the kiosk. It also aspired to create jobs by reopening the kiosk for trade. However, the engagement with TfL staff did not take place due to a lack of facilities suitable for tile making at the TfL premises (Leung, 2018).

Assemble architects and the ceramic artist Matthew Raw created tiles that featured ceramic craft qualities which were achieved by making all the elements by hand (Raw, 2018; Leung, 2018). Leung noted:

> "The fun with these tiles was to try and introduce that element of chance and... [the] trace of the maker... [to] give this kiosk a sense of it being something that is made. ... [to make] it feel as though it was loved and…as though this little bit of Seven Sisters was special enough for someone to put the time and care into it." (Art on the Underground (2017))

Design, craft and manufacturing processes; ceramic craft and material qualities

The architects, who had no preliminary knowledge of making ceramic tiles or working with clay collaborated with Matthew Raw, a ceramic artist, who previously produced hand-made tiles for an architectural interior installation (Raw, 2021). All the tiles for the project were hand-rolled by the artist, members of Assemble and two trainees who were recruited through Create Jobs, an employability programme for young people in London.
Raw explains that the aesthetic language for the tiles was developed during the process of co-production:

> "Assemble got me involved in this project to help them to produce the cladding for the …project... I've got involved in a technical capacity. After a few sessions we came up with an idea of colouring the clay...The technique that we developed is by rolling it (the clay) flat...and introducing something that we call 'slugs'. The idea was that we could get into the clay body and make each slab bespoke" (Art on the Underground (2017)). (Figure 3.5).

Fig. 3.5. *Left: production in the studio by members of Assemble and Matthew Raw. Right: through-body coloured clay* (photos: courtesy of Assemble, 2017)

Raw introduced the traditional ceramic technique of mixing coloured pigments into clay to give the tiles a "through-body" colour. Smaller elements of clay of contrasting colours were placed on the tile and rolled over to embed the inclusions. Various marbled effects were created by combining and rolling white and blue, grey and white and yellow and blue inclusions (Figures 3.5 and 3.6).

Fig. 3.6. *Left: coloured 'slugs' imbedded in the body of the tile. Right: tiles in situ* (photos: courtesy of Assemble, 2017)

The hand-craft making of tiles created ceramic craft qualities and an irregular, non-uniform appearance, which was intended by the architects and the artist.

The traditional terracotta, faience and brick corner details and window sills in buildings are created by hand-pressed or by machine-extruded solid or hollow elements with thicknesses to provide robust detailing. However, the process for the creation of the cornices and bullnose corners of the seats for the kiosk was devised by the architects and included slumping thin hand-rolled tiles into plaster moulds. Raw noted that the high cost of the pigments resulted in the production of very thin coloured-clay tiles. The thickness of the fine stoneware clay tiles caused some of these to warp and crack during drying and firing. The hand-made tiles were fired and glazed by the ceramic artist at Assemble's Sugarhouse studios in London and installed by the tilers. The irregularities of the tiles affected the detailing of the kiosk resulting in uneven cornices and corners (Figure 3.7).

Fig. 3.7. *Left: cornice formed by irregular hand-made tiles. Right: a cracked hand-made tile made by being slumped in the plaster mould* (2017)

Fig. 3.8. *Left: Matthew Raw filling up the kiln at the studio. Right: tiling contractors on site* (photos: courtesy of Assemble, 2017)

Fig. 3.9. *Kiosk two years after completion* (2019)

Relationships and knowledge exchange

Figure 3.10 demonstrates the role and relationships between the stakeholders of this project, highlighting the collaborative enabling links that were formed between them through information and knowledge exchange.

Crucial collaboration between the ceramic artist and architects took place from the start of the project and enabled the design development of craft aesthetics through material experimentation. At the same time, the role of the ceramic artist, sharing his knowledge of ceramic material and techniques with the architects and two trainees enabled the co-creation and physical making of bespoke DFACs.

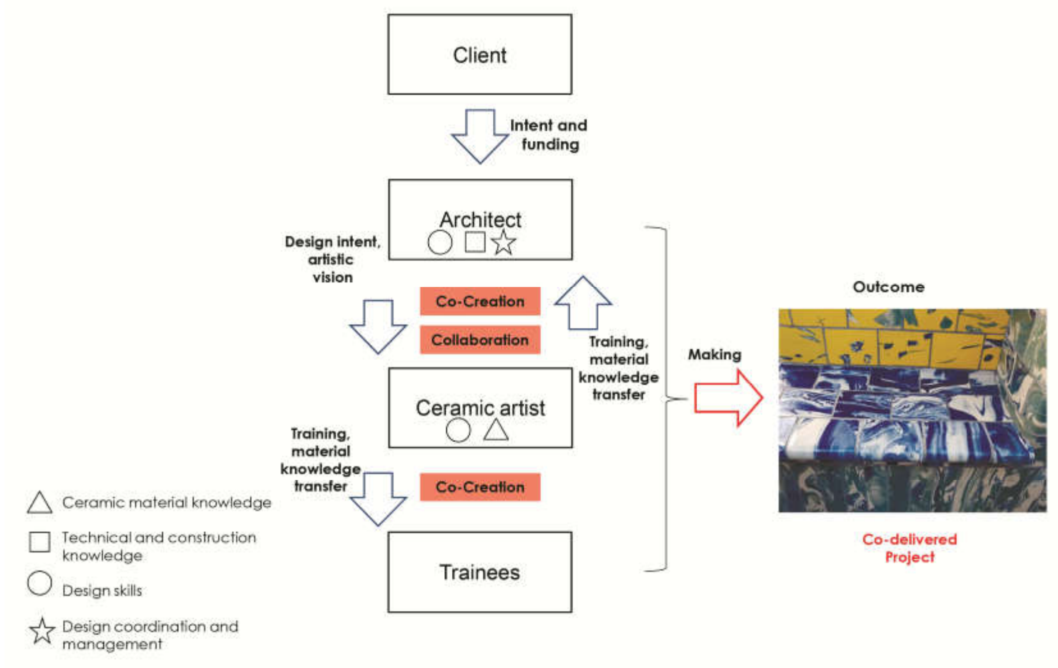

Fig. 3.10. *Relationships between project participants, information and knowledge exchange*

Insights from CP.1

- Knowledge exchange between the ceramic artist and the architects enabled material development and experimentations that led to the creation of ceramic craft qualities of DFACs.
- Skill and ceramic knowledge transfer from the ceramic artist to the architects and trainees enabled co-creation.
- Early involvement of the ceramic artist and collaboration with the architects enabled the creation of bespoke DFACs.
- Ceramic craft qualities and heterogeneous aesthetics were achieved by the makers' personal input.
- Limited project budget and lack of knowledge of manufacturing processes on the part of the architects and ceramic artist affected the material quality of the tiles.
- While the hand-craft, non-specialist making of tiles created ceramic craft qualities, it resulted in inconsistent material qualities and poor detailing.

3.2.1.3 Bespoke glazed facade, 24 Savile Row, London, UK (CP.2)

The scheme consists of a ceramic facade glazed by crystalline glazes developed by the ceramic artist Kate Malone and produced in collaboration with Froyle Tiles small-scale craft manufacturer.

This precedent was selected to examine the factors that enabled the creation of bespoke crystalline blue and ivory coloured glazed tiles and their structural integration into the facade of the building. The collaborations that facilitated this project as well as the processes that aided the creation of ceramic craft and material qualities of the glazed tiles were subject of investigation, addressing my research questions. In response to OB 1.2 the relationships between the ceramic artist, the architect, manufacturer and planners were identified and analysed. RQ 2 led an enquiry into how ceramic craft qualities were achieved through craft and manufacturing processes to express the site-specificity required by the architects' brief. Information was gathered through a site visit, photographic survey, the informal conversations with the project participants and their interviews which were available online.

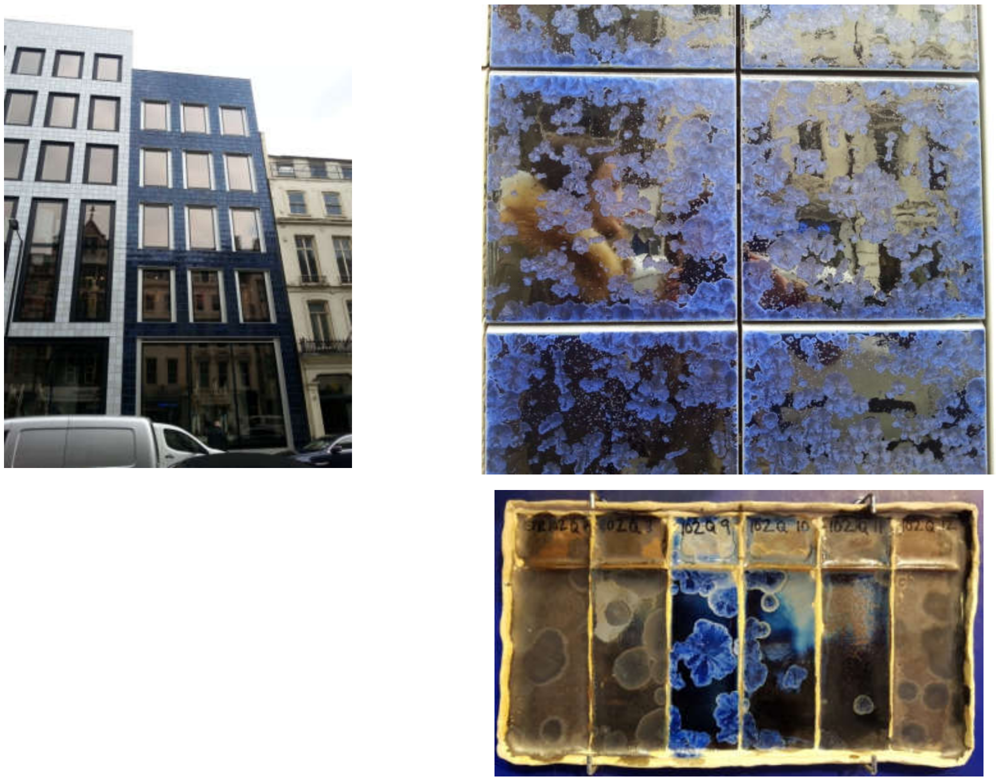

Fig. 3.11. *24 Savile Row: Clockwise starting from top left: blue and white elevation street view; detail of the blue crystalline glazed tiles; glazing tests produced in Kate Malone's ceramic studio* (2019)

Key project information

Location	24 Savile Row, Mayfair, London
Construction dates	Completed 2014
Project participants	
Client	Aerium and Terrace Hill Group plc
Architect	EPR Architects
Ceramic artist	Kate Malone
Ceramic manufacturer	Froyle Tiles and Kate Malone Studio
Ceramic materials used	'Agrob Buchtal' Factory-made square stoneware facade tiles. Dark blue and ivory crystalline glazes

Project context

The client's brief for the office development in Mayfair in the West End of London aimed to express individuality of the building through creating a visually rich fabric for the facade. Savile Row, the street where the building is located, is known for menswear shops and tailors who craft bespoke tailored suits. Stephen Pey of EPR Architects noted that "simple cuts and luxury fabrics" were the inspiration for the building and became part of the narrative for the glazed facade (Cfile, 2021a).

EPR architects who have previously collaborated with Kate Malone in the creation of artwork for a building facade in Brighton, involved her in the creation of bespoke glazes for the facade. Samples of crystalline glazes provided by the artist at the early stage of the project facilitated the planners' support. Enforcement by the planners at the later stage of the project ensured that the glazed elements were not excluded from the building in the event of a cost-cutting exercise (Stephenson&PRO, 2014).

Design intent

The "simple cut and fine materials" were reflected in the design of the scheme that features two buildings which contrast in colour. The simple geometry of the facade is contrasted by the rich surface qualities (Figure 3.11). The reflective qualities of glazed surfaces were utilised to animate the facade during the day with the changing light conditions.

Design, craft and manufacturing processes; ceramic craft and material qualities

Textured ivory and dark-blue crystalline glazes were developed over three years of research by the artist Kate Malone in collaboration with the architect and the manufacturer. The time and budget for the glaze research was included in the program of the project. Three types of frost-resistant, high-fired glazes were developed by the ceramic artist at her studio through systematic testing and cataloguing of results. Crystals covering the entire surface of the tiles were achieved by oversaturation of metals and the process of cooling in the kiln. (Figure 3.12).

While all the glazes were produced in the artist's studio, the firing of 10,000 hand-glazed tiles was made possible by the craft tile manufacturer Froyle Tiles, who accommodated the handmade process and customised firing cycles into their production. Each tile was hand glazed, carefully placed and levelled in the kiln and fired at 1300° C, which provided frost resistance and durability. Referring to other manufacturers who were approached to provide firing of highly volatile glazes, Malone noted that nobody was prepared to take the risk (Stephenson & PRO, 2014).

The tiles used for the facade were standard rain-screen tiles fabricated by Agrob Buchtal, a German manufacturer of tiles and terracotta facades. The tiles use a proprietary fixing system that ensured the structural integration of the tiles into the building facade.

Relationships and knowledge exchange

Collaboration between the ceramic artist and the architects facilitated the development of coloured glazes through a series of iterations. Collaboration between the ceramic artist and Froyle tiles craft manufacturer ensured the craft application and consistent results across the large number of tiles, which at the same time provided the uniqueness of each tile through the variation of crystals in the glaze (Figure 3.12).

Communication between the ceramic artist, craft manufacturer and high-volume manufacturer, who provided the tiles for the facade, resulted in iteration of the tile detailing improving the glazing results.

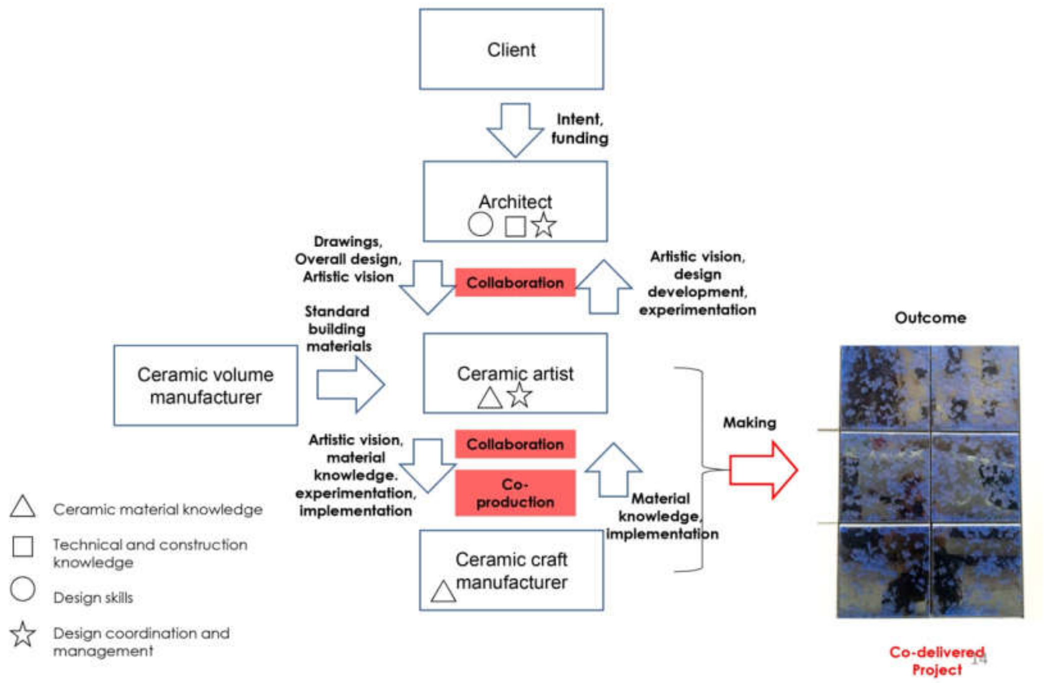

Fig. 3.12. *Relationships between project participants, information and knowledge exchange*

Insights from CP.2

- The budget and time allocated for the material research and experimentation enabled the development of bespoke glazes.
- Architect's previous experience of design and integration of DFACs facilitated the project.
- Early involvement of the ceramic artist allowed glaze research and development to take place.
- Early involvement of the ceramic artist secured the planners support, which protected the bespoke DFACs from being excluded from the project at a later stage.
- Flexibility of the ceramic craft manufacturer facilitated the manufacturing and firing of bespoke glazes.
- Collaboration between architects, ceramic artist and the manufacturer from the start of the project enabled the design development and the creation of ceramic craft qualities.
- Use of standard tested tiles and proprietary fixing system facilitated the structural integration of glazed elements.

3.2.1.4 Ceramic facade , 1 Eagle Place, London, UK (CP.3)

The scheme features a ceramic glazed facade designed by Eric Parry Architects and a polychromatic sculptural ceramic cornice designed by Turner Prize winning artist and sculptor Richard Deacon. The project involved the collaboration of a large team of specialists, who had the challenge of producing a ceramic facade that had the aesthetic qualities of a traditional 19th century faience building, while utilising contemporary building techniques and satisfying current building regulations and statutory requirements, such as heat transfer and structural stability.

The investigation into the complex communications between the architects, sculptor, large ceramic manufacturer, specialist facade engineer and a specialist contractor, which facilitated the detailing and creation of the facade was the focus of this precedent analysis (RQ 1). The processes of creation of ceramic craft qualities by the ceramic manufacturer without the involvement of a ceramic artist were explored responding to RQ 2.

Key project Information

Location	One Eagle place, Piccadilly, London
Construction dates	Completed 2013
Project participants	
Client	The Crown Estate
Architect	Eric Parry Architects
Artist	Richard Deacon
Facade engineer	Arup Group Limited
Specialist contractor	Szerelmey Ltd
Ceramic manufacturer	Darwen Terracotta
Ceramic transfers manufacturer	Tadema Designs Ltd
Ceramic materials used	Press mould stoneware ceramic panels, White glaze, colour ceramic decals

Fig. 3.13. *Sculptural cornice and white faience cladding with "rouge blush" window reveals* (2019)

Project context

A multipurpose development for the Crown Estate in Central London was designed to create a site-responsive building matching the streetscape and the materials of its historic location.

Design intent

The architect Eric Parry, who had previously designed buildings involving architectural ceramics, intended to link the new building to the historical context by utilising glazed ceramics that were used extensively in 19th century buildings on Regent Street and Piccadilly, and by responding to the streetscape through the alignment of the floors and cornices with surrounding buildings (Eric Parry Architects, 2021) (Figure 3.14).

Fig. 3.14. *Left: architect’s sketch showing the new building in the context of the street* (2021). *Right: detail of Richard Deacon's polychromatic ceramic cornice next to the neighbouring building* (2017)

Design, craft and manufacturing processes; ceramic craft and material qualities

The main facade of the building is fully clad with white ceramic panels, featuring coloured detailing around the windows, and a polychromatic sculptural ceramic.

The combination of digital and traditional manufacturing techniques enabled precision and speed in the fabrication of the facade panels and the sculptural cornice, which were created by the traditional forming technique of pressing the clay into plaster moulds. The moulds were cast from polystyrene models, which were wire-cut utilising digital 3D software at Darwen Terracotta factory (Wilson, 2017). The structural design and assembly of the ceramic facade panels and cornice were enabled by specialist input from ARUP facade engineers, and Szerelmey Ltd, a contractor specialising in the construction of ceramic and masonry facades. Early structural tests highlighted the problem of the facade "swaying" against the structure. Innovative design and rigorous testing were carried out by the facade engineers to overcome this issue, thus facilitating the successful structural integration of DFACs. Full-size mock-ups were produced by the manufacturer and tested with the involvement of the facade engineers (Harrison, 2017).

The design development of ceramic elements for the facade and the cornice was supported by Szerelmey Ltd, the specialist contractor, who was involved from the early stages of the project and who prepared the drawings necessary for assembly of the elements, thus influencing the manufacturing of the pieces. The position of joints and sizes of composite ceramic elements were developed in collaboration between the contractor, engineer, architect and manufacturer.

The articulated profiles of the cornice were inspired by the cornices on surrounding buildings and were decorated with colourful artwork by Richard Deacon (Figure 3.13 and 3.14). Initial tests were produced by Deacon by painting the elements with ceramic underglazes and firing these at the ceramic studio. However, transferring this technique into industrial manufacturing, using standard firing at Darwen Terracotta led to a change of the original colours. To overcome this problem, ceramic decals - a ceramic craft technique which is widely used in tableware production but not utilised on building facades - were produced by Tadema Designs Ltd, by digitally scanning the hand paintings, which allowed the reproduction of the colours and painterly qualities of the original artwork (Figure 3.15). A similar issue was encountered in the creation of the bright red spray effect for the window reveals, which had been specified by the architect. This could not be achieved with the application of traditional glazes with high temperature industrial firing, so the decals were also used as an innovative method for decorating DFACs.

Fig. 3.15. *Left: original glazed transfer sample produced by Darwen terracotta; a studio painted sample by Richard Deacon. Right: red "spray" of window reveals achieved by ceramic transfers produced by Tadema Design Ltd* (2019)

The relationships and knowledge exchange

The relationships between the project participants involved in the creation of the ceramic elevation and ceramic sculptural cornice are described in Figure 3.16 and Figure 3.17.

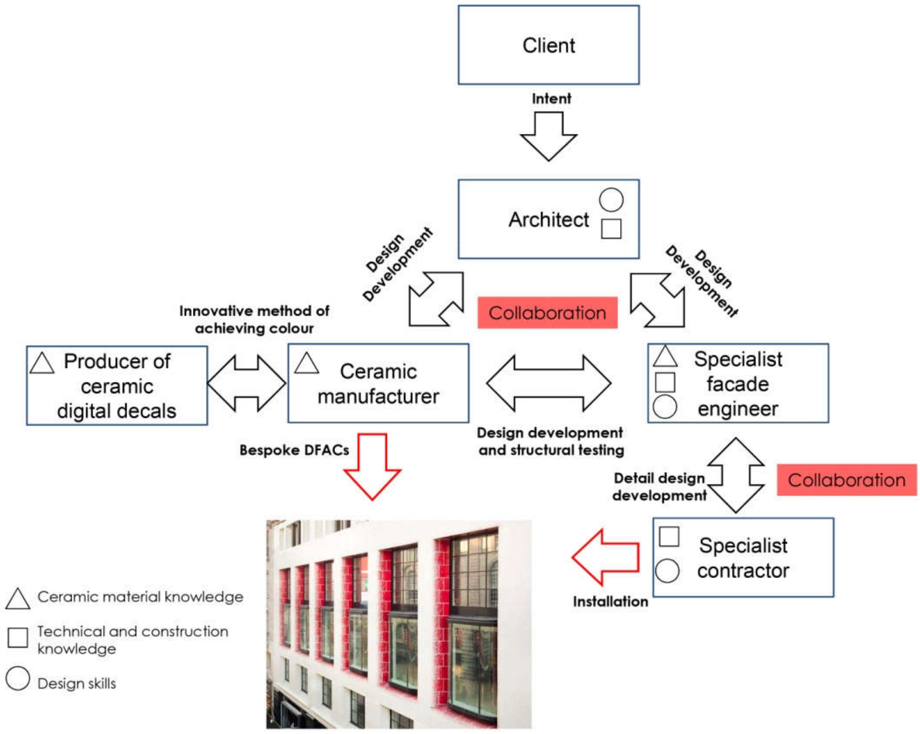

Fig. 3.16. *Faience facade: relationships of project participants, information and knowledge exchange*

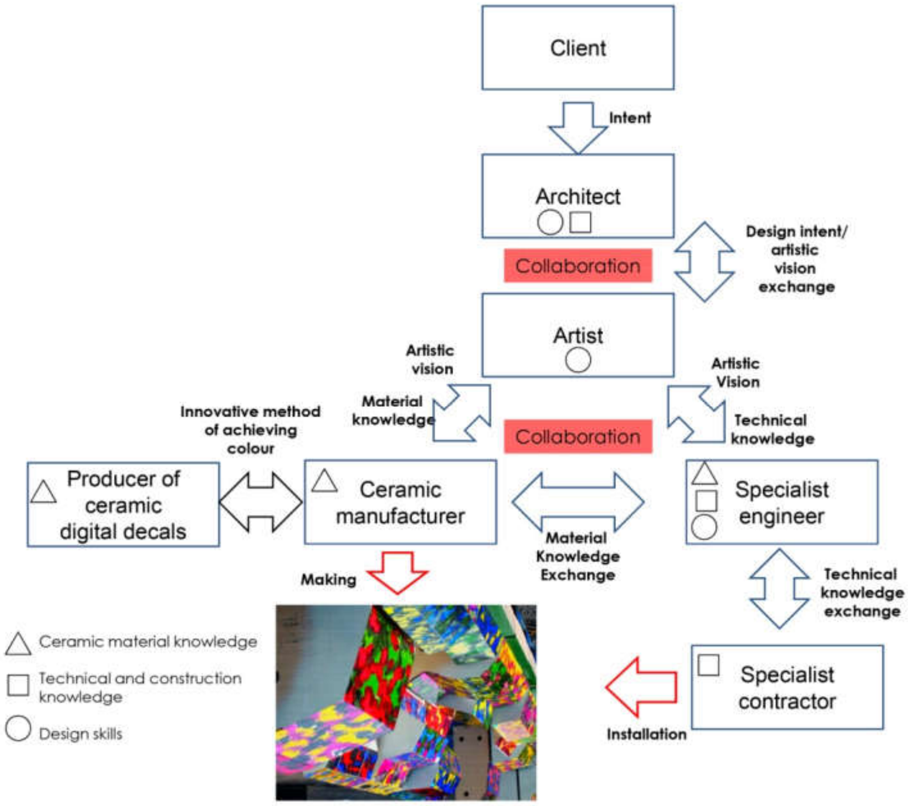

Fig. 3.17. *Ceramic cornice: relationships of project participants, information and knowledge exchange*

Insights from CP.3

- Knowledge exchange and collaboration between all the design team members including the manufacturer and the specialist facade contractor from the early stages of the project enabled the creation and integration of the bespoke facade and sculptural cornice.
- Architects' previous experience of design and integration of DFACs in buildings facilitated the project.
- Combination of hand, digital and industrial manufacturing processes enabled the creation of ceramic artwork that was structurally integrated into the building and featured ceramic craft qualities.
- Bespoke DFACs were used to link the new building to its historic context.
- Material testing and experimentation undertaken by the ceramic manufacturer supported the design development.
- Structural testing was carried out in collaboration between the cladding subcontractor, ceramic manufacturer, structural engineers and facade engineers which enabled the structural integration of DFACs.
- Involvement of the specialist facade contractor supported the design development from the early stages of the project.

3.2.2 Overview of additional historic and contemporary precedents[18]

Brick artwork, Het Schip social housing complex, Amsterdam, Netherlands (HP.1)

This precedent examines the creation of brick artwork incorporated into the walls of a social housing complex in Amsterdam, which was built between the two World Wars in response to a housing shortage. The leading architect of the Amsterdam School,[19] Michele de Klerk collaborated with Amsterdam's chief municipal sculptor Hildo Krop to create sculptural accents for the Het Schip housing complex. While the project had a limited budget, the expressive brick detailing and sculptural

[18] Additional precedents are included in Appendix C.
[19] Amsterdam School was the leading aesthetic and social movement in the Netherlands between 1910-1930. The slogan of the Amsterdam School *was: 'Beauty should not be restricted to the elites of society, but instead should be used to improve all of society'*. (Casiato and van Os-Thompson, 2003)

elements were strategically placed on the corners of buildings, creating site-specific narratives and adding to the character of the buildings.

The precedent offered insights into enabling factors in the creation of brick sculptures and their structural integration into the fabric of the buildings. This included the involvement of the sculptor who worked in a variety of media, including clay, and his collaboration with the architect who produced the sketches for the sculptures and designed the locations of the artwork. The government loans and housing reform that supported the development and the aesthetic and social principles of the Amsterdam School architects were the facilitating factors in the integration of brick artwork which was created with the view to improve the environment for the housing residents.

Ceramic mosaic bench, Park Güell, Barcelona, Spain (HP.3)

The investigation into the creation of the ceramic bench located in the public park, created through collaboration between architects Antoni Gaudi and Josep Maria Jujol, craftsmen and sculptors in 1900-1914, is the focus of this precedent. Ceramic craft qualities and the ways these were originally achieved through the use of brightly coloured fragments of low-fired tableware and ceramic tiles and the later restoration of the bench were explored to identify craft and manufacturing processes.

Insights from this precedent highlighted the enabling factors which included client commitment to the project, artistic freedom and involvement of several sculptors and craftsmen during the execution of the mosaic bench which provided a variability of aesthetic language. Information and knowledge exchange through prototyping and three-dimensional modelling by the architects, on-site collaboration and co-creation enabled the construction of the complex geometry of the bench and the creation of bespoke mosaics. The original use of local ceramic products created site-specific aesthetics and expressed the local cultural context. My factory visit to Ceramica Cumella, responsible for the restoration of the bench, highlighted the issues connected with the original use of low-fired terracotta pieces, which were substituted by high-fired stoneware to add to the longevity of the bench.

Terracotta ornamental facade, Guaranty Building, Buffalo, USA (HP.4)

This precedent investigates the creation of the ornamental terracotta facade of an early skyscraper designed by the architects Louis Sullivan and Dankmar Adler, completed in 1896. The ceramic craft qualities and the methods of design and manufacture of the ornamental cladding were the focus of my investigation.

My analysis brought to light that information exchange through sketches, prototyping and modelling by the architects enabled the design and construction of elaborate ornamental elements, which were subsequently manufactured in industrial settings. The terracotta modular elements featuring intricate ornamentation were used as fireproof cladding to protect the steel structure of the building.

The original hand-made processes used in the manufacture of a high-relief facade, were reproduced by the latest digital and manufacturing processes used in restoration of the cladding by Boston Valley Terra Cotta manufacturer. The renovation used hybrid methods of manufacturing which combine digital technology, industrial ceramic manufacturing processes and hand-made processes. The comparison of these methods with the original craft making techniques demonstrates how elaborate ceramic elements can be reproduced with precision, while reducing the time and hand labour involved in industrial manufacturing.

Ceramic floor tiles, Victoria & Albert Museum shop. London, UK (CP.4)

The creation of the ceramic floor tiles was investigated in this precedent, highlighting the importance of early involvement of a ceramic material specialist to achieve the material qualities required for their structural integration.

Originally 3D printed clay tiles, produced at Grymsdyke Farm experimental facilities (Grymsdyke Farm, 2021) by architect Guan Lee, were inconsistent in their appearance and many of them warped and delaminated in drying and firing. This had resulted from the material properties of the clay. The tiles were then re-made by Froyle Tiles craft manufacturer, using a traditional press-mould technique, while preserving the “digital” aesthetics. This precedent brought to light that a lack of ceramic material knowledge on the part of the architect can cause material failures. It was demonstrated that the involvement of a small-scale craft manufacturer facilitated the manufacture of floor tiles that combined material and ceramic craft qualities. It also demonstrated that while 3D printing in clay presents opportunities and provides distinct aesthetics, it has limitations in the production of DFACs.

Decorative brick cladding, Humtunnel, bicycle and pedestrian underpass, Delft, the Netherlands (CP.5)

The decorative brick cladding for the underpass was designed and its production facilitated by the ceramic artist Marta Nagy in response to the brief by the Delft City Council aiming to improve the environment of this city-centre location. The processes of design and manufacture of the bricks by the artist in collaboration with a small-scale brick manufacturer were investigated in this precedent.

The insights highlighted the facilitating factors such as commissioning of bespoke DFACs by the local authority, which resulted in an improved environment of the underpass aided by the application of undulating bricks. Ceramic material knowledge, design and management skills performed by the ceramic artist facilitated the design, craft making and manufacture of bespoke decorative bricks through collaboration and making at the factory.

Civic Theatre, Haarlem, the Netherlands (CP.6)

The creation of porcelain cladding for the facade of the new extension to the Civic Theatre was investigated in this precedent. The involvement of a ceramic artist and her contribution to the aesthetics of the building, the collaborative relationships between the architect, the ceramic artist and Royal Tichelaar industrial manufacturer, were investigated to gain insights into the factors that facilitated the manufacture and integration of bespoke ceramic elements.

The insights included the contribution of a ceramic artist to the aesthetics of the building through her collaboration with Royal Tichelaar industrial manufacturer which facilitated iterative design and making processes of cladding elements, ensuring material properties necessary for their structural integration. It was also revealed how material experimentations at the factory facilitated the creation of a colour scheme which was developed to link the building with its historic surroundings and the original theatre building.

3.2.3 Discussion of the insights from the precedent analyses

Emergent themes that came out of the precedent analyses address my research questions on the factors and relationships that facilitate and inhibit the creation of bespoke DFACs and allow their structural integration.

Material knowledge of ceramic artists and their personal aesthetics facilitate the creation of ceramic craft qualities in ceramics for architectural applications, while their early engagement is a key facilitating factor. The collaboration of ceramic artist Matthew Raw with Assemble architects from the early stages of their project during the creation of hand-made tiles for the Ceramic Kiosk (CP.1) led to development of distinct aesthetics through the use of coloured clay.

Established studio ceramic artists Kate Malone and Babs Haenen (CP.2 and CP.6), were engaged by architects to utilise ceramic craft techniques and the artists' personal ceramic language and techniques in the creation of DFACs designed for the buildings. While Malone was approached by EPR Architects to develop bespoke crystalline glazes for the facade in Savile Row, London, Haenen was invited by the architect Erick van Egeraat to create "porcelain theatre" and use her techniques developed through their sculptural pieces to create prototypes for the cladding elements (Haenen, 2020) [20]. Both artists collaborated with the industrial manufacturers to ensure the creation of ceramic craft qualities that are intrinsic to their studio work. The material qualities necessary for the structural integration of bespoke pieces were provided by the industrial manufacturers who produced these in collaboration with the artists.

It has been identified through the precedents (CP.2 and CP.3) that architects' prior experience of working with DFACs facilitated the design and manufacture, ensuring the ceramic craft qualities of bespoke DFACs.

In the Humtunnel project by Marta Nagy (CP.5) there was no involvement from the architect, instead the ceramic artist's background knowledge of architectural ceramics and technical requirements enabled her to carry the project through. The project was facilitated by the flexibility of a small-scale Hungarian brick manufacturer who undertook the production of special shaped bricks. Both the

[20] My communications with Babs Haenen are included in Appendix D.

flexibility of manufacturing and the artist's personal involvement in the making process facilitated the creation of bespoke brickwork for the pedestrian tunnel. The enabling flexibility of manufacturing was demonstrated by Froyle Tiles in the creation of the bespoke glazed facade at 24 Savile Row (CP.2).

The collaboration between the project participants involved in the contemporary precedents, identified as a key enabling factor in the creation of bespoke DFACs, is demonstrated in Figures 3.18, 3.19 and 3.20.

Figure 3.18 highlights the relationships of ceramic artists, architects and industrial manufacturers involved in the precedents.[21] It has been demonstrated that collaboration between ceramic artists Kate Malone and Babs Haenen, with both industrial manufacturers and architects, led to a successful integration of bespoke ceramic elements into the facades of buildings. The collaboration of Matt Raw with the Assemble architects without the involvement of an industrial manufacturer, highlighted the technical challenges connected with ceramic hand-making and a lack of knowledge of manufacturing processes on behalf of the architects and the ceramic artist (CP.1). On the other hand, the ceramic artist Marta Nagy designed and co-produced bespoke bricks aided by a small-scale flexible manufacturer without any input from an architect, facilitated by her background knowledge of architectural projects; she previously collaborated with architects and an industrial manufacturer on the project of integrated artwork in the library in Pecs, Hungary (Gasparian, 2017).

[21] A short description of the artists' practices, architects and industrial manufacturers in this research is included in Appendix A

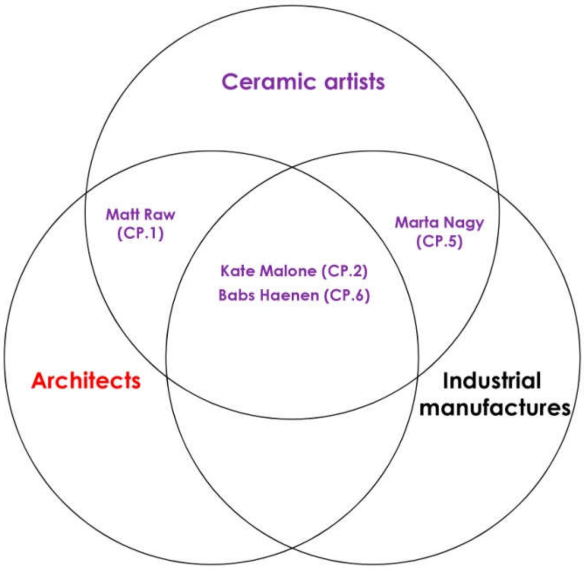

Fig. 3.18. *Ceramic artists involved in the creation of contemporary precedents*

The position of architectural practices on the diagram in Figure 3.19 reflects their collaboration with ceramic artists and industrial manufacturers during the creation of the precedents. Both EPR Architects and Erick van Egeraat Architects successfully collaborated with the ceramic artists, who facilitated the creation of bespoke ceramic facades. 1 Eagle Place project was supported by the Darwen Terracotta manufacturer who provided material research and craft making of the sculptural cornice. On the other hand, it was demonstrated that the creation of 3D printed ceramic floor tiles for the Victoria and Albert Museum shop by the architect Guan Lee, without the involvement of a ceramic specialist, led to technical problems such as warping and de-lamination of tiles, which resulted in the tiles being remade by Froyle Tiles manufacturer, using traditional ceramic craft methods (CP.4).

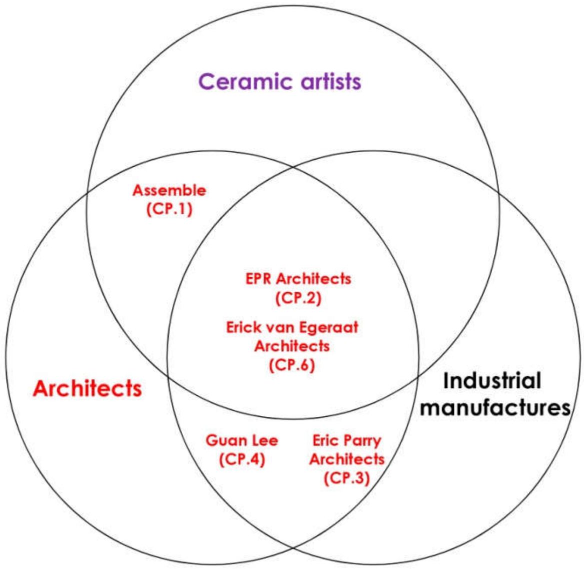

Fig. 3.19. *Architectural practices involved in the creation of contemporary precedents*

The position of manufacturers in Figure 3.20 reflects their engagement with the ceramic artists and architects in the projects.

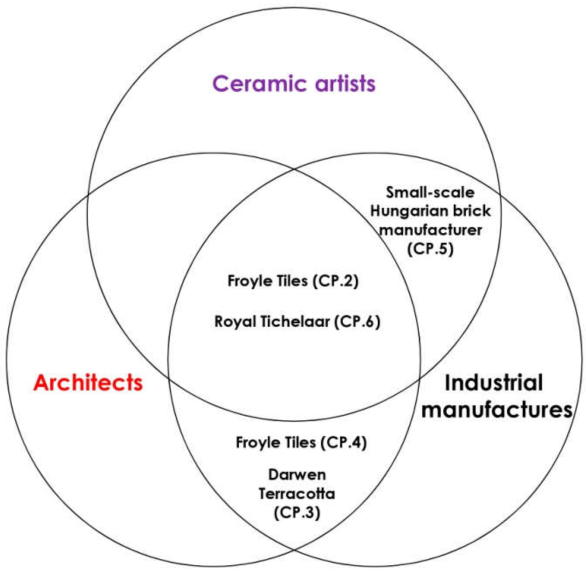

Fig. 3.20. *Industrial manufacturers involved in the creation of contemporary precedents*

The diagrams 3.18, 3.19 and 3.20 demonstrate that collaboration between all three sectors engaged in the precedents, facilitated the creation of bespoke DFACs, which combine the ceramic craft and material qualities required for their integration.

Figure 3.21 shows the links that provided knowledge exchange and collaboration between project participants in contemporary precedents facilitating the creation of bespoke DFACs.

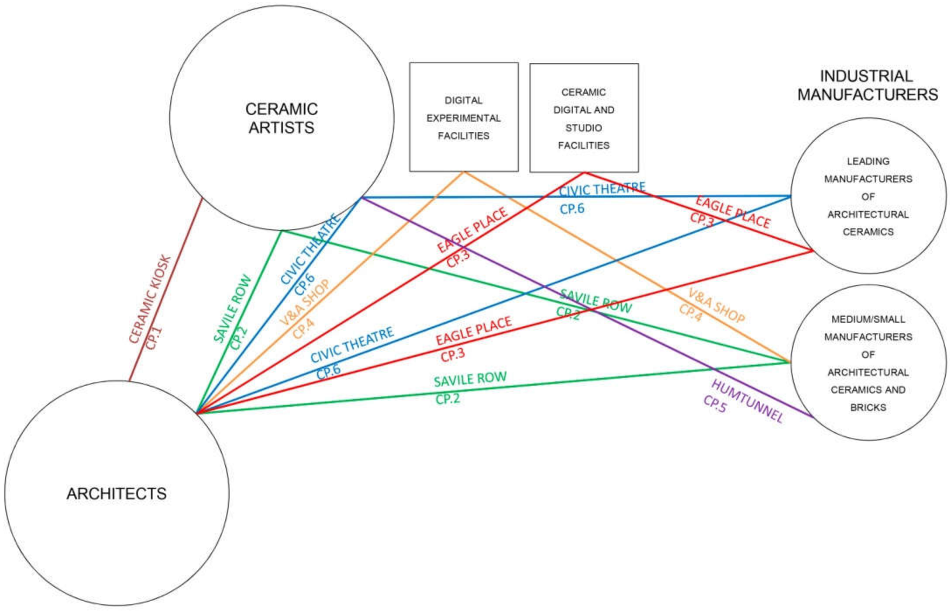

Fig. 3.21. *Collaborative links between project participants in contemporary precedents*

3.3 Specialist practices in focus

The practices of the key stakeholders of this research: ceramic artists, architects and industrial manufacturers, who were collaboratively involved in the creation of the precedents discussed earlier in this chapter, are reviewed in this section. Section 3.3.1 includes a review of contemporary ceramic studio practitioners and discusses the barriers that inhibit craft making of DFACs and their structural integration into the fabric of buildings. It also identifies model ceramic practices that enable the creation of DFACs. Section 3.3.2 discusses the contemporary architectural practice and aspects associated with the design and specification of bespoke DFACs. Section 3.3.3 examines industrial manufacturing and investigates issues connected with volume production, workmanship, industrial and craft processes and flexibility of fabrication linked to the size of the manufacturing.

The roles and relationships with and between the clients, planners, facade engineers and specialist contractors who also play an integral part in facilitating the creation of DFACs and make crucial decisions on the integration of these into buildings and urban spaces are highlighted in the precedents but are not investigated in depth in this research.

3.3.1 Ceramic art practice

My investigation into the practice of studio ceramicists in the UK identified ceramic artwork, for architectural applications that was produced by the artists without the engagement with industrial manufacturers and comprised wall tiles for interiors and exteriors (Chowdhary, 2021), mosaics (Brandis, 2021) and ceramic pieces that were installed in the interiors of buildings (Marques, 2021; Twomey, 2021). This artwork demonstrates ceramic craft qualities created by the artists working in ceramic studio settings, without consideration for the technical necessity of structural integration. On the other hand, ceramics that are structurally integrated in the fabric of buildings and urban spaces, becoming a part of the load bearing elements have to comply with the rules and regulations of building construction.[22] Since building standards and regulations that architects deal with as a part of their everyday practice are rarely considered in ceramic studio art and craft practices, combining ceramic craft qualities with ceramic material qualities required for architectural projects presents challenges in the craft making of bespoke DFACs.

> The necessity of knowledge of technical requirements and material qualities of DFACs was made evident during my involvement in a project undertaken by ceramic studio artists Anna Barlow and Miray Mehmet Fontanelly, in which I had an advisory role. At the start of the project, which involved the creation and integration of ceramic glazed paviours for the public pathway between Battersea Park and Queenstown Road train stations in London, the artists were not aware of the technical requirements that had to be addressed for the paviours in the public realm such as slip resistance, frost resistance and load bearing capacity to withstand vehicle impact. The artists

[22] Discussion on ceramic material qualities and material testing necessary for the structural integration of DFACs is included in section 3.3.3.

acknowledged that these qualities would be difficult to achieve in a studio setting.

It become apparent, through conversations with the ceramic artists, that the project architects did not have knowledge of craft processes, manufacturing processes and the time needed for the industrial manufacturing of clay paviours. Consequently, there was no time allocated in the project program for design development, experimentation of bespoke clay paviours and the manufacturing of these.

A collaboration with an industrial manufacturer to facilitate the production of paviours was considered at this stage. However, involvement of a small-scale British craft manufacturer would incur testing by an independent company, resulting in additional expense. The alternative - involving a Dutch brick manufacturer for fabrication of glazed paviours would require the artists to travel to the Netherlands and be involved in glaze development and production. These options were shown to be non-viable as there was no sufficient time or budget allocated for either testing or travel. In this project the timing and cost for testing proved to be prohibitive, and resulted in the artists sourcing the paviours in a resin composite material rather than ceramics.

Insight 3.4: *Ceramic artists' lack of knowledge of technical requirements inhibits the creation and integration of bespoke DFACs.*

Insight 3.5: *Architects' lack of knowledge of ceramic craft and manufacturing processes inhibits the creation and integration of bespoke DFACs.*

While the precedent analyses demonstrated the facilitating relationships formed between practices during specific architectural projects, there are other models of collaboration which enable the development of bespoke DFACs and the creation of ceramic craft qualities in industrial settings. Examples of which are to be found in the practices of Dutch ceramic artist and glaze expert Christine Jetten and Kansas-based ceramic artist Andy Brayman.

Jetten's engagement in architectural projects takes place at an early stage through appointment by the architects. Her ceramic expertise facilitates the development of bespoke glazes at her studio in the Netherlands following the architect's brief. However, added to this, she often assists large industrial manufacturers at a later stage of the project to translate the ceramic craft qualities produced at her studio into standard industrial processes. Jetten works at factory facilities alongside in-house glaze specialists to recreate her craft glazes utilising materials and firing processes used by the high-volume manufacturers. Her collaborations often lead to the creation of innovative bespoke glazes that are used by the manufacturers in future projects. At the same time, there are challenges in Jetten's practice, which include time constraints that are imposed by the project program, the limited manufacturing flexibility of large industrial manufacturers and issues of intellectual property over the bespoke glazes (Jetten, 2017).

Ongoing collaboration between ceramic artist Andy Brayman and Boston Valley Terra Cotta (BVTC) manufacturer in New York includes research and development (R&D) of innovative solutions for the manufacturer. Brayman supports architects through the design process during the Architectural Ceramics Assemblies Workshop (ACAW) (Architectural Ceramic Assemblies Workshop, 2021b).[23]

> ***Insight 3.6:*** *Collaboration between ceramic artists and industrial manufacturers facilitates innovation and development of ceramic craft qualities in industrial manufacturing of DFACs.*

It is common for the manufacturers of ceramic tableware, sanitaryware and interior ceramic tiles to employ a team of in-house designers, to collaborate with ceramic artists and designers enabling the development of bespoke products. Such manufacturers include Wedgwood, Vista Alegre, Villeroy & Boch and Ideal Standard. The example of ceramic craft qualities being developed in industrial manufacturing was demonstrated through collaboration between the ceramic artist Kathryn Hearn and manufacturer Wedgwood in 2001, where Hearn developed three collections of bespoke vessels (Hearn, 2001).

An example of a designer-manufacturer collaboration that facilitated the creation of ceramic craft qualities in production of ceramic tableware through hand craftsmanship while reducing the cost of production was demonstrated in the engagement of Italian designer Enzo Mari with the Königliche Porzellan-Manufaktur (KPM) Berlin from 1993 to 1996. The aim of this four-year project was to sustain the factory's traditional craft skills and knowledge in the competitive porcelain market by using craft makers' and artists' skills in an innovative way.

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[23] The collaborative relationships between the artist and manufacturer and the ACAW workshop are discussed in sections 3.2.3.

Building on the makers' craft and artistic skills, Mari proposed a series of interventions that led to the creation of bespoke individual pieces through the use of diverse decorating techniques and modifying slip-cast vases and existing tableware designs in an unexpected way (Lohmann, 2020).

> ***Insight 3.7:*** *Utilising craft makers' skills at the factory in an innovative way can lead to the creation of cost-effective solutions while sustaining ceramic craft qualities.*

In contrast to these examples, the industrial manufacturers of clay bricks, roof tiles and producers of architectural terracotta and faience in the UK, Europe and the USA do not currently employ ceramic artists or designers to develop bespoke products.

3.3.2 Architectural practice

The aspects of contemporary architectural practice that enable and inhibit the design and integration of bespoke DFACs into buildings and urban spaces were initially investigated through contemporary precedents. Precedent analyses highlighted that bespoke DFACs were designed and manufactured for specific architectural projects, with designs developed by the architects in collaboration with the ceramic artists. In the contemporary precedents which involved ceramic artists, their appointments were initiated by the architects who aimed to achieve ceramic craft qualities in their buildings (CP.1, CP.2, CP.6).

> ***Insight 3.8:*** *Architects facilitate the engagement of ceramic artists in the projects.*

While I investigated the architects' role in the knowledge exchange between stakeholders, decision making and the distribution of power within the projects, a wider perspective on architectural practice and building procurement processes in the UK brought to light inhibiting factors connected with the design, specification of materials and detailing in buildings.

The detailed requirements for 'knowledge', 'understanding' and 'skills' of architects in the UK are set by the Architects Registration Board (ARB) that has held the responsibility for the prescription of architectural qualifications since 1997 (ARB, 2010). These requirements include design skills, knowledge of construction and management skills. Discussing architectural practice, Thomas (2007, p.2) suggests that “the privileging of form is deeply imbedded in our working practices and material is rarely examined ...to act as a servant to form.” She suggests that an architect envisages a shape of the building and the material used for building is chosen as an afterthought to “fill up the space between the lines”. At the same time, Thomas notes that there is increasing interest in questions of materiality in architecture brought by technological, environmental and current philosophical debates. Connected to this change, there has been an increase in awareness in architectural ceramics, on the part of architects and designers. However, there are aspects that inhibit the specification, design and integration of bespoke DFACs by architects.

The RIBA Plan of Work document has been used by architects in the UK since 1963 as a design and process management framework that sets out the stages of design and construction processes from inception to completion. The latest revision of the document aimed to improve on the previous 2013 Plan of Work in relation to sustainability issues, the planning process, procurement and information requirements, to become a tool that can be used by the UK construction industry. The sustainability and ethics of building production were set as core objectives for the latest revision of the RIBA Plan of Work 2020 document (RIBA, 2021, p.5, p.73). Listed architectural “project drivers” include awareness of circular economy considerations, compliance with regulations and new forms of procurement. Added to this it was noted in the document that: “Digital innovation continues to transform many aspects of project workflow, arguably moving towards a paradigm shift…” (Ibid, p.5).

While there is considerable attention in the 146 page document given to Building Information Modelling (BIM), digital technologies and changing relationships between stakeholders, there is no mention of materials in the architectural process beyond an ‘Outline Specification’.[24] Moreover, it was stated in the document that: “The construction industry is starting to use programme approaches drawn from the manufacturing industries geared towards repetition… This way of working is starting

[24] The purpose of an Outline Specification is: “First, it conveys to the client team the quality of the proposed finishes, presented via sample boards at a client’s Design Review. Second, it allows the cost consultant to align the Cost Plan with the level of specification appropriate to the design team’s Quality Aspirations for each Building System” (RIBA 2020, p.117).

to be used for manufacturing whole 'Building Systems', not just individual construction products, leading to increased standardisation and repetition in large parts of buildings…" (Ibid. p.116). It can be argued that the use of repeated Building Systems and standardisation of buildings will facilitate the creation of a homogeneous built environment, while restricting the use of bespoke elements in buildings.

This is compounded by the assumptions of architects related to the high cost, availability and manufacture of DFACs, prohibiting their use. Identifying these assumptions revealed the lack of information and knowledge among architects of manufacturing processes and the potential for customisation and availability of bespoke DFACs.[25] Samuels (2018) brings forth the possible result of architects' misconceptions: "affordability is a design problem which architects are ruled out of ... because of erroneous assumptions about expense and risk, the result being the unloved, short-lived and soulless buildings that act as the scenery for most of our lives." (Samuels, 2018. p.1),

At the same time, the traditional role of architects - producing overall and detail designs, specifying materials and controlling project outcomes - is changing, thus affecting the design and specification of bespoke DFACs. Throughout the RIBA document it is evident that complex relationships between the Client Team, Design Team and Construction Team are shifting, particularly affecting the responsibilities and control over design, management processes and deliverables. It has been noted that "the aspects of building design are increasingly being carried out by specialist subcontractors", and a shift towards a contractor-led procurement route (Design and Build (D&B) contracts) and sub-contractor led production information processes is described in the RIBA document. Greenwood et al. (2008) discuss in detail the loss of control over the design and quality of the building process as architects are directly employed by the contractor under a D&B contract. The RIBA Plan of Work 2020 also acknowledges the problematic nature of the D&B procurement route addressing the creation of bespoke materials. "Many architects are looking to use new materials on their projects to deliver better performance or a new design language. However, under a Design and Build contract, the construction team may be unwilling to take responsibility for a new and untested material.

[25] Gaps in knowledge and misconceptions of architects connected to the creation of bespoke DFACs were brought to light during my presentations of seminars and lectures. The list of my presentations is included in the List of publications, pp.9-10.

Research and Development (R&D) must be undertaken to develop a new generation of materials…" (RIBA, 2021, p.116)

The enabling role of material research, experimentations and design development in the creation of bespoke DFACs was made evident through the analyses of the 24 Savile Row and 1 Eagle Place projects (CP.2, CP.3). However, there is no provision for R&D and material research in the framework of the RIBA document (Figure 3.22).

> ***Insight 3.9:*** *Contractor-led project procurement routes (such as Design and Build contracts) are an inhibiting factor in the creation of bespoke DFACs.*

> ***Insight 3.10:*** *Lack of provision for R&D in the RIBA Plan of Work (2020) is an inhibiting factor for the manufacture of bespoke DFACs.*

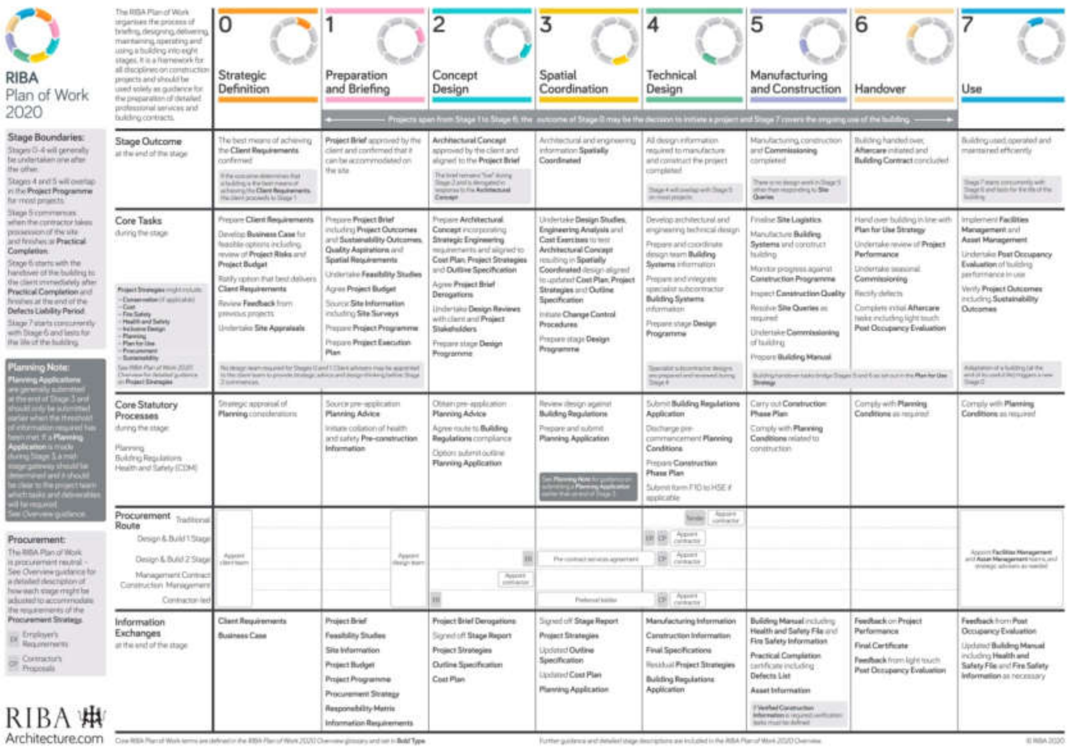

Fig. 3.22. *Stages of RIBA Plan of Work 2020*

Pressman (2014) describes the role of the architect as the design team coordinator and notes various models of collaboration between the design team members on architectural projects. While it has been acknowledged that engineering consultants should be involved in the inception of an architectural project and be "participants in a reciprocal dialogue at strategic points in the process to innovate, integrate, inform and iterate" (Pressman, 2014, p.19), material specialists are not often involved in the design process, particularly at the early stages of projects. The RIBA Plan of Work 2020 document does not acknowledge the need for appointment of material specialists to projects. In the developments that involve the integration of bespoke DFACs into buildings this constitutes a major barrier.

3.3.3 Industrial manufacturing

The complexity of factors that affect the production of building materials is noted by Thomas (2007, p.8); she writes: "building materials are constituted by a whole complex of practices. They are social and cultural constructs, produced through the complexities of legislation and regulations, through techniques of production and fabrications…" The factors that inhibit and facilitate manufacturing of bespoke DFACs are discussed in this section.

Industrial manufacturing of DFACs has been undergoing major changes over the last decade, linked to the increasing demand from architects and the latest technical innovations (Bechthold et al., 2015). Architect Zaera-Polo noted the architects' interest in three-dimensionally complex designs influences the manufacturers of DFACs who predominantly produce flat extruded elements (Pell et al., 2010). At the same time, Bechthold (2016) observes that: "design, production and construction expertise for…complex systems remains underdeveloped".

While my own practice explorations during this study took place within brick factories in the UK, European and North American manufacturers were investigated alongside British manufacturers of DFACs to gain a broader understanding of issues associated with industrial processes and relationships between the stakeholders involved in fabrication of bespoke DFACs.

3.3.3.1 Facilitating capacity and testing

Precedent analyses demonstrated that the large industrial manufacturers of architectural ceramics can facilitate the production of bespoke DFACs by providing factory facilities, machinery, tooling, material knowledge and craft skills of the makers at the factories.

Addressing the requirement by the Building Regulations and British and European standards for material testing and certification, large industrial manufacturers (Wienerberger, Ibstock Brick, Boston Valley Terra Cotta) have their own material testing labs which allow tests for mass-produced products to be carried out in-house. Extensive material research, trialling and testing is undertaken for all new products, and as a result, factories producing glazed DFACs have libraries of tested glazes and clay bodies which facilitate the colour choice for bespoke shapes developed for particular architectural projects.

> ***Insight 3.11:*** *Large manufacturers of DFACs can facilitate development, manufacturing and testing of bespoke DFACs.*

However, while large architectural projects that have a budget allocated for the development of bespoke solutions can benefit from large manufacturers' support through their early engagement, as seen in the examples of 1 Eagle Place in London (CP.3) and the Civic Theatre in Haarlem (CP.6), there are barriers to small and medium-size projects as noted by the architects during my conversations at the *Materials for Architecture* exhibition (2018) and seminars that I presented for architectural companies[26]. These barriers include a lack of information regarding the sourcing of materials, manufacturing processes and costs associated with these.

> ***Insight 3.12:*** *There is a lack of information for architects on bespoke DFACs, manufacturing processes and costs associated with these.*

3.3.3.2 Flexibility of manufacturing

It has been acknowledged that bespoke products and ceramic craft qualities are difficult to achieve in high-volume manufacturing. The reason for this is an increased cost of production resulting from additional "timing and tooling", the time that it takes to reset a standard manufacturing process and the cost of production of customised tools (Pottle, 2017; Wimbush, 2020). In contrast, medium and small-scale manufacturers have flexibility that allows them to integrate varied manufacturing processes, enabling the creation of bespoke DFACs.

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[26] List of my public presentations is included in the list of publications, pp.10-11

The connection between the scale of the factories and flexibility of the manufacturing[27] was highlighted in the 24 Savile Row in London (CP.2) and Humtunnel in Delft (CP.5) precedents where the production of ceramic craft glazes and bespoke shapes of bricks were facilitated by the small-scale flexible manufacturers, while large manufacturers found it difficult to accommodate customised processes.

> ***Insight 3.13:*** *Small-scale manufacturers can facilitate the production of bespoke DFACs for medium and small-scale architectural projects through their flexible manufacturing processes.*

An example of a small-size manufacturer able to combine flexibility, technical innovation and craft making is Ceramica Cumella, located in Spain (Ceramica Cumella, 2021).[28] This family run company represented by three generations of ceramicists, collaborated with artists and architects, and created innovative bespoke DFACs for a number of large-scale architectural projects across Europe. Outsourcing the making of large quantities of DFACs to local factories provides the manufacturing capacity required for large architectural projects. This allows the company to remain flexible to carry out material research, experimentation and to develop innovative designs. However the challenges of outsourcing the manufacturing entails the risks associated with quality control and responsibility over the final products (Cumella, 2016).

> ***Insight 3.14:*** *Outsourcing the production of bespoke DFACs for large projects allows manufacturers to keep the size of manufacturing small and maintain flexibility.*

3.3.3.3 Collaboration with universities

Ceramica Cumella engaged with universities to help develop their products, having collaborated with the Institute for Advanced Architecture of Catalonia (IAAC) in Barcelona, and organising summer schools at the factory, involving students from the London Architectural Association (AA), and Bartlett School of Architecture, University College London (UCL). An example of an input from IAAC students was demonstrated in the creation of ceramic facade cladding for the Ohla Hotel in

[27] See Definition of terms in Chapter 1
[28] I have visited the company in 2016.

Barcelona. The ceramic facade featured music carved into extruded clay elements by a robotic arm programmed by the students. Engagement with the AA resulted in an exhibition at the AA in London, which featured bespoke DFACs manufactured by the company.

Boston Valley Terra Cotta (BVTC), a manufacturer of architectural ceramics in the USA, has an ongoing collaboration with the University at Buffalo, New York and runs an apprenticeship programme for students from the university. This collaboration led to the digitalisation of many processes within the factory, and to the creation of innovative tools and machines which facilitated digital customisation of standard products (Gasparian, 2017).

Similarly, the Spanish Ceramic Tile Manufacturer's Association (ASCER) have sponsored research projects during a seven-year programme at Harvard University, Cambridge, Massachusetts, USA, the Institute for Advanced Architecture of Catalonia (IAAC) in Barcelona, Spain, and the University of Liverpool, UK. The outcomes of these collaborations include academic articles, publications featuring architectural projects of bespoke DFACs and innovative ceramic designs shown at the annual *Chevisama* ceramic tile show in Valencia (Bechthold, 2016).[29] Such collaborative relationships between industrial manufacturers and university departments of architecture at universities facilitate innovation in manufacturing processes and the creation of bespoke products. It was also demonstrated through the collaboration between the BVTC and Alfred University, New York, that collaborative links with a university ceramic department can facilitate the creation of ceramic craft qualities in DFACs.[30]

> ***Insight 3.15:*** *Links between universities and manufacturers facilitate technical innovation and the creation of bespoke DFACs.*

3.3.3.4 Brick manufacturing context

While the industrial manufacturers of architectural terracotta and faience have for the last decade been exploring ways of creating ceramic craft qualities for architectural projects, brick manufacturers in the UK, by contrast, have not done so

[29] Details of ASCER’s programme are included in section 3.4.
[30] This collaboration took place during the ACAW multidisciplinary workshop discussed in section 3.4.1.

and have predominantly continued to produce standard products. Figure 3.23 shows the percentage of brick sales by a major UK brick manufacturer, Ibstock Plc in 2019 (Batterham, 2020). The pie chart shows that two of the sectors – 'volume housing' constructed by large house builders and 'refurbishment, maintenance and improvement' (RMI) each constitute 47% of total sales of bricks. The bricks sold within these sectors are predominantly standard products. Standard products utilised by the large house builders in standardised house designs result in homogeneous developments (Barratt Homes, 2021; Taylor Wimpey, 2021; Bovis, 2021).

Only 6% of bricks manufactured by Ibstock Plc are utilised in projects specified by architects. However, these are standard and standard-special bricks which can be used in various brick bonds. A similar percentage breakdown in the UK sales of bricks by Wienerberger, the world's largest brick manufacturer was brought out in my personal communication with the Director of Marketing at Wienerberger UK.

The Brick Development Association (BDA) technical notes and Brick Bulletin (BDA, 2021) demonstrate the prevalence of standard bricks in architectural projects in the UK, while only a small proportion of the projects utilise glazed bricks (Brick Development Association, 2021c).

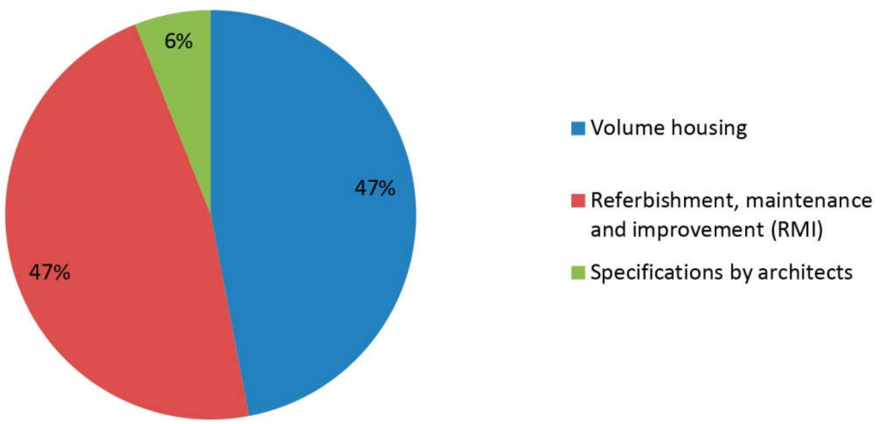


Fig. 3.23. *UK sales by sector for 2019, Ibstock Plc*

> ***Insight 3.16:*** *There is a lack of bespoke bricks produced by brick manufacturers and specified by architects in the UK.*

3.4 Multidisciplinary events facilitating knowledge exchange

To further explore the relationships between the professional communities engaged in design, craft making and manufacture of bespoke DFACs addressing RQ1, I took part in multidisciplinary workshops and symposia that were initiated and supported by industrial manufacturers and which brought together multiple stakeholders of this research.[31]

My participation in the Architectural Ceramics Assemblies Workshops (ACAW) in Buffalo in 2016 and 2018, and in two symposia on architectural ceramics in Liverpool – 'Moulding Futures' in 2017 and 'Constructive Dialogues' in 2018 - brought to light that collaborative relationships between ceramic artists, architects, academia and manufacturers facilitate the creation of bespoke DFACs (ECALAB, 2021a). The Brick Project that took place in 2005-2007 at the European Ceramics Work Centre (EKWC) in the Netherlands (EKWC, 2021), initiated by Wienerberger AG brick manufacturer demonstrates the models of collaboration between ceramic artists and architects that facilitate the creation of innovative brick designs.[32]

3.4.1 Architectural Ceramics Assemblies Workshops (ACAW), Boston Valley Terra Cotta (BVTC), Buffalo, New York, USA[33]

BVTC, a leading manufacturer of architectural ceramic facades, launched an annual multidisciplinary workshop in collaboration with the University at Buffalo (UB) in 2016. The workshops were intended to open up a discourse on architectural ceramics between architects, facade engineers, ceramic artists and educators, aiming to facilitate research and innovation while exploring potential architectural projects. During the annual workshops participants are supported by groups of students from the architectural department of UB. Ceramics students from Alfred University provide digital support, CAD drawings, quick prototyping and ceramic making.

[31] The full list of my professional engagements is included on pp. 9-10 of this thesis.
[32] Whilst I did not take part in this workshop I collected the data on the workshop during my visit to EKWC in 2016 (Gasparian, 2017), through my personal communications with three of the participants of the workshop and through the project publication (Erven and Zwinkels, 2007).
[33] I have participated in the ACAW in 2016 as a part of my Winston Churchill Fellowship and during this research in 2018.

The workshops bring together “representatives of industry” from the USA, Europe and Britain, “offering participants the opportunity to explore innovative building solutions and further their understanding of architectural terracotta for large-scale assemblies” (Architectural Ceramic Assemblies Workshop, 2021a). However, the investigation of “variable materiality” of ceramics taking place during the hands-on workshops is done primarily to address the sustainability and physical performance of facades.

In order to introduce the material properties of architectural terracotta earlier in the architect’s design process and to “develop research and design models between manufacturing and architectural industries”, several teams consisting of 5-6 specialists representing different professions come together several months prior to the workshops which are held in August of each year. Participants who are based in different countries meet online through video conferencing sessions and via emails; with designs being developed through their information exchange. The design development is supported throughout the year by the technical experts from BVTC and by Kansas City-based Matter Factory ceramic and digital facilities, who provide R&D for BVTC. Following the design developments, computer generated models are transferred to The Matter Factory where the prototypes are made. Subsequently the full-size ceramic components of experimental designs are made at the BVTC factory and glazed. The programme culminates in a week-long workshop at the University at Buffalo Sustainable Manufacturing and Advanced Robotic Technologies (SMART) facilities and BVTC, where the teams get together, construct the assemblies from their prototypes, and present their exploration and outcomes to the fellow participants.

> ***Insight 3.17:*** *Early involvement of specialists in a project facilitates the development of new designs.*

> ***Insight 3.18:*** *Technical support from the manufacturer during design development enables the creation of innovative designs.*

Knowledge exchange between the participants takes place at all stages of the workshop: during the lectures by the participants and invited experts, hands-on workshops, making, quick prototyping and physical assemblies of the prototypes manufactured by BVTC prior to the workshops. Factory visits, which familiarise the participants with the manufacturing processes, are an integral part of the workshops. Those participants who have attended workshops benefit from the knowledge of manufacturing processes when developing new designs.

> ***Insight 3.19:*** *Familiarising architects, engineers and ceramic artists with existing manufacturing processes through factory visits enables future designs.*

> ***Insight 3.20:*** *The knowledge exchange between participants of multidisciplinary workshops facilitates research, design, manufacture and innovation in the field of bespoke DFACs.*

Whilst the constraints of high-volume manufacturing inhibit the allocation of time and facilities for in-depth material research and development (R&D) necessary for the development of bespoke solutions, this was overcome in the collaboration between ceramic artist Andy Brayman and BVTC. By investing in The Matter Factory experimental facility in Kansas City led by Brayman, BVTC are able to develop innovative products for the manufacturer and to support the annual ACAW workshop. The equipment at the experimental facilities replicates the firing and manufacturing processes at the main factory but on a smaller scale, which facilitates the production of innovative designs and ceramic craft qualities at BVTC (Architectural Ceramic Assemblies Workshop, 2021b).

> ***Insight 3.21:*** *Large manufacturer outsourcing R&D to a flexible experimental facility enables the creation of bespoke DFACs.*

The other insights from this workshop demonstrated that:

> ***Insight 3.22:*** *Involvement of ceramic artists facilitates the creation of ceramic craft qualities.*

> ***Insight 3.23:*** *Participation of educators and academics in multidisciplinary workshops facilitates further research.* [34]

[34] The outcomes of annual workshops are available online (BVTC, 2021) and through publications (Garofalo and Khan, 2017).

3.4.2 Moulding Futures and Constructive Dialogues symposia

The Spanish Ceramic Tile Manufacturers' Association (ASCER) has supported research and innovation at a number of Spanish and international universities, sponsoring a six-year research project at the University of Liverpool. This research project resulted in two symposia and an accompanying exhibition. The 'Moulding Futures' and 'Constructive Dialogues' symposia on architectural ceramics were organised by ECALAB, a research unit based at the University of Liverpool, in collaboration with Leeds Beckett University (ECALAB, 2021a). The symposia were used as a platform to engage with multidisciplinary participants and leading experts in the field - manufacturers, researchers, architects and ceramic artists. Specialist speakers including Antoni Cumella of Ceramica Cumella, Spain; Martin Bechthold of Harvard University, USA; Alexis Harrison, of ARUP consulting engineers, UK and Eric Parry of Eric Parry Architects, UK held a discussion on the role of ceramics in architecture, and their contribution to the built environment.

My communication with the expert speakers, participating manufacturers and ceramic artists who contributed to the exhibition contributed insights to my research. The presentations and conversations at the symposia and the exhibition highlighted the facilitating roles of the industrial manufacturers that support research and innovation and the role of academia, leading technical innovation and research. Whilst the barriers to wider application and manufacture were discussed by the participants, it was acknowledged that collaboration and knowledge exchange between disciplines is a key enabling factor for the creation of bespoke DFACs and innovation in the field.

The theme of the *Ceramica* exhibition (ECALAB, 2021b) was to explore "how traditional ceramic techniques and digital engineering can be used to produce…sustainable architectural elements." For the exhibition, the organisers commissioned eleven national and international ceramic artists, asking them to "reinterpret a digitally produced object," aiming to explore its "transformation through the hand of the craftsman". Plaster moulds were made from digitally produced prototypes and were given to the artists to experiment with various ceramic materials and techniques. The final ceramic pieces demonstrated the varied aesthetics produced by the artists (Figure 3.24).

Fig. 3.24. *Clockwise from top left: Szabo, E. (2017) 'Silver Lining', porcelain and fibreglass; Keogh, J. (2017) 'Reconstructions', white porcelain with gold lustre; Binns, D. (2017) Fragments of Time', unglazed porcelain, terracotta with ground ceramics; Taylor, J. (2017) 'Corona Cones', unglazed porcelain* (2017)

> ***Insight 3.24:*** *Individual input and personal expression of ceramic artists can create diverse aesthetics through the combination of traditional craft and digital techniques.*

3.4.3 The Brick Project

An example of facilitating knowledge exchange during a multidisciplinary workshop that led to the creation of bespoke DFACs, was the Brick Project that took place in 2005-2006 at the European Ceramics Work Centre (EKWC) in the Netherlands. It was organised and sponsored by the Wienerberger AG brick manufacturer (Erven and Zwinkels, 2007).

EKWC, where the workshop took place, was founded in 1991 for ceramicists' residencies, involved designers and from 2005 invited architects aiming to revive the relationships between ceramics and architecture. The international workplace offers residencies for artists, designers and architects to experiment with ceramics. The residencies provide access to facilities that include studio spaces, workshops, ceramic equipment, kilns, digital tools and critically offer support from specialist staff (EKWC, 2021).

> ***Insight 3.25:*** *Experimental ceramic facilities can support ceramic artists, designers and architects in developing experimental ceramic designs and artwork and facilitate links between disciplines.*

For the Brick Project, Dutch and foreign architects, ceramic artists and designers were invited to form groups with representatives of another discipline. This multidisciplinary approach led to knowledge exchange and “cross fertilisation" (Erven and Zwinkels, 2007, p.11). It had been envisaged by the organisers that all the participants are "intensively involved from the start" (Ibid.), with artists and designers working in the studio in collaboration with the architects to ensure that the results could be utilised after the project.

The groups were asked to put forward a proposal under a broad theme of ceramics in architecture aiming to develop conceptual prototypes that will “give an idea of the direction in which brick could develop in the future” (Ibid.). Sixteen participants took part in the project and produced experimental designs exploring the aesthetics of bricks, including colours, textures and shapes, and investigating various functional applications.

Insights from analysis of the Brick Project highlighted how multidisciplinary collaborations allowed the development of bespoke bricks which included ceramic craft qualities through the participation of ceramic artists. The involvement of architects in the workshops aimed to facilitate the structural integration of these designs into buildings (Jetten, 2016; Molenaar, 2016). At the same time, architects gained ceramic material knowledge by working alongside ceramic artists and through working with clay. Studio facilities and material specialists supporting the project facilitated the research, design development and material experimentation that resulted in the creation of innovative conceptual brick designs.

> ***Insight 3.26:*** *Combined residencies, which include ceramic artists and architects facilitate knowledge exchange and development of innovative*

solutions leading to the creation of bespoke DFACs and their integration into buildings and urban spaces.

The outcomes of the project were widely disseminated by the publication of the 'Brick: the book' (Erven and Zwinkels, 2007).

> ***Insight 3.27:*** *Multidisciplinary workshops and symposia facilitate knowledge exchange between specialist practitioners and academia, leading to innovative DFAC designs, further research and wider dissemination in the field of architectural ceramics.*

3.5 Conclusion

By exploring the models of collaboration between the stakeholders that lead to innovation, this research has revealed the facilitating roles of the key practices in the creation of bespoke DFACs. Unpacking the aspects of ceramic art, architectural practice and industrial manufacturing has allowed me to identify the disjunction between these sectors, and the barriers associated with the creation of bespoke DFACs. Investigation into precedents to identify the ceramic craft qualities and material properties of bespoke DFACs required for their structural integration brought to light the manufacturing and ceramic craft processes used.

As Schön (1983, p.3) notes: "We conduct society's principal business through professionals specially trained to carry out that business." In this context the knowledge exchange between the practices is critical to facilitate the design, craft making and manufacture of bespoke DFACs. The analyses of precedents included in this chapter demonstrate that the combined specialist knowledge and skills of architects, ceramic artists and industrial manufacturers facilitate the creation and integration of bespoke DFACs. The knowledge and skills include i) design skills performed by the architects, ceramic designers, artists and engineers; ii) ceramic material knowledge provided by ceramic artists and industrial manufacturers; and, iii) knowledge of construction and technical expertise of architects, structural engineers and specialist subcontractors. The precedent analyses demonstrate the facilitating role of the information and knowledge exchange between the project participants (Insights from all the precedents, Insight 3.6). At the same time my investigation into the practices of ceramic artists, architects and industrial manufacturers highlights the gaps in knowledge and the disjunction between the practices that inhibit the creation of bespoke DFACs (Insights 3.4, 3.5, 3.10, 3.12).

The facilitating role of ceramic artists in the creation of bespoke DFACs was discussed in this chapter. Ceramic artists facilitate the design development of bespoke DFACs by sharing their material knowledge with architects and can aid the creation of ceramics craft qualities in industrial settings by collaborating with industrial manufacturers (CP.1, CP.2, CP.6, Insights 3.6, 3.22, 3.24).

Ceramic artists can provide ceramic samples and material tests at the early stages of architectural projects, which facilitate planning approval and ensure support by the planners at the later stages of the project (CP.2). It has been shown that ceramic artists can provide R&D for industrial manufacturers (Insight 3.6, 3.21). On the other hand, ceramic artists' lack of knowledge of technical requirements and building regulations inhibits the creation and structural integration of bespoke DFACs (Insight 3.4). Large industrial manufacturers can facilitate testing of bespoke DFACs (Insight 3.11), while the cost of testing and certification of bespoke DFACs makes craft making prohibitive for studio ceramic artists and small craft manufacturers.

Examination of architectural practice shows that architects are instrumental in appointing ceramic artists into architectural projects (Insight 3.8), while architects' prior knowledge of ceramics plays a facilitating role (Insight 3.19). Key aspects of architectural practice that include project coordination, enabling information exchange between the project participants and setting out the project programme highlight the importance of knowledge of manufacturing processes and production timing of DFACs. Inhibiting factors that affect architects' practice in the creation of bespoke DFACs include contractor-led project procurement routes (such as design and build contracts) (Insight 3.9) and the lack of provision for material research and experimentation/Research and Development (R&D) in the RIBA Plan of Work 2020 (Insight 3.10).

My review of industrial manufacturing demonstrates manufacturers' facilitating role in the provision of material qualities required for the structural integration of bespoke DFACs (HP.2, CP.2, CP.4, CP.5, CP.6, Insights 3.11). The precedent analyses demonstrate that the creation of ceramics craft qualities can be facilitated by flexible manufacturing utilising the material knowledge and makers' skills at the factories and through collaborations between manufacturers and ceramic artists (CP.2, CP.4, CP.5, CP.6, Insights 3.7, 3.13). Industrial manufacturers can provide material research and experimentation/ R&D to support architects and ceramic artists in the creation of bespoke DFACs (CP.2, CP.3, CP.4, CP.6, Insights 3.11, 3.18). I have identified that off-site experimental facilities can support high-volume manufacturers, ceramic artists and architects enabling the development of bespoke solutions (Insight 3.21, 3.25).

My involvement in multidisciplinary workshops and symposia shows that knowledge exchange between specialist practitioners and manufacturers leads to the creation of innovative designs and processes, further academic research and wider dissemination of information among the specialist communities (Insights 3.20, 3.23, 3.26, 3.27). The workshops demonstrated how the early engagement of stakeholders in architectural projects can facilitate design development, material research and experimentation leading to the manufacture of innovative bespoke DFACs (Insight 3.17).

Collaborative relationships between the manufacturers and universities facilitate innovative solutions that lead to bespoke designs and innovation of manufacturing processes (Insight 3.15).

The insights that emerged from the context analyses have provided the basis for the development of my own practice, which aims to bridge the gap that I have identified in the practices that engage in design, craft making, and industrial manufacture of bespoke DFACs.

CHAPTER 4
PRACTICE INVESTIGATION INTO DESIGN, CRAFT MAKING AND INDUSTRIAL MANUFACTURING

‘We need to organize our processes of fabrication in a manner that allows the materials to talk back. To make patterns integrate material issues… we must test and prototype and find solutions presented by both our ornate pattern and the qualities of the material.’
Spuybroek (2016)

4.1 Overview

This chapter discusses the role of my design and ceramic practice in establishing how to facilitate the design, making and industrial manufacturing of bespoke DFACs, and to integrate these within urban spaces. To examine the diversity of industrial processes, products and ceramic craft qualities I collaborated with two brick manufacturers during my practice development: i) Wienerberger, a global mass-producing brick manufacturer; and ii) H.G. Matthews, a small family-run brick manufacturer and the only one in the UK that produces glazed bricks. My material experimentations and design development were aided by the use of the facilities at two ceramic studios in London: Central Saint Martins ceramic workshop for mould-making and glazing, and Regent College London, Kingsbury where I carried out glazing for my craft specials and case study 1. The Digital Fabrication Bureau at Central Saint Martins was instrumental in producing laser cut and CNC milled elements, which aided my prototyping and experimental designs.

By positioning my interdisciplinary practice in an industrial setting and engaging in architectural projects, I have been able to analyse the ceramic craft and material qualities of DFACs and the design, craft and manufacturing processes associated with their creation. My ceramic practice as demonstrated through two case studies developed in response to the aim and objectives of this research. The research reveals the challenges and opportunities associated with design, craft making and industrial manufacturing, while demonstrating how bespoke DFACs can be produced through collaboration and knowledge exchange between stakeholders.

My practice in the frame of this research consists of two elements, material research and experimentation, and my case studies; these run in parallel and support each other (Figure 2.5, Chapter 2). The two case studies carried out at brick factories (OB 2 - OB 5) are underpinned by experimental ceramic practice consisting of material testing, design experimentations and prototyping. The bespoke DFACs produced as a result of my practice, combine ceramic craft qualities with material qualities required for their structural integration. The findings from my experimental practice have aided design decisions in these case studies: the choice of ceramic materials and products, digital and ceramic craft techniques, and of suitable manufacturing processes. At the same time, my design experimentations and a collection of ‘craft special’ bricks were developed in response to the briefs of my case studies. My previous knowledge of ceramic craft techniques and knowledge of manufacturing processes, gained through my work at the factories (OB 2) were critical in achieving ceramic craft qualities within the project constraints for each of the case studies.

The practice outcomes of this research include: i) a record of material experimentations (section 4.2); ii) a collection of 'craft special' bricks (section 4.3, Appendix B4); iii) records of two case studies (sections 4.4 and 4.5, Appendices B.1 and B.2), iv) a collection of model bricks used to facilitate engagement with expert stakeholders and with makers at the factories (included in Chapter 5, Appendix B.3).

Scaled model bricks, that were originally produced to facilitate the interviews with expert stakeholders, demonstrate various textures, surface qualities, and colours. The model bricks were also used to facilitate conversations and knowledge exchange between myself and the staff at H.G. Matthews brick factory (section 4.2.4). [35]

My guiding aesthetics, the guiding principles that I have set for myself and the constraints that exist in the industrial manufacturing of DFACs determined my practice development.

4.1.1 My guiding aesthetics

The development of my practice was influenced by my architectural and ceramic training and was also influenced by the cultural context of my native country, Armenia. By engaging in craft making and exploration of ceramic craft qualities, my focus was to contribute to the individuality of buildings and urban spaces through the integration of bespoke DFACs.

The decorative motifs, colours and ornamental reliefs used in Armenian architecture and applied arts reflect the locality and cultural narratives. Wornum (1851, cited in Greenhalgh, 1993, p.2) notes: "As every individual has some peculiarity in his mode of writing, so every age or nation has been distinguished in its ornamental expression by a certain individuality of taste, either original or borrowed." The geometric, floral and zoomorphic patterns used in Armenian rugs and floor, wall and bed coverings were specific to the country's regions (Figure 4.1). An example of a

[35] Details of making and the use of model bricks are included in section 5.3, Chapter 5.

local material affecting the aesthetics of the artefacts is a crimson dye made out of the Ararat cochineal insect, specific to the Ararat valley, which was used in rugs giving them distinct characteristics. The dye was also used in painting, illuminated medieval manuscripts and stone detailing in buildings.

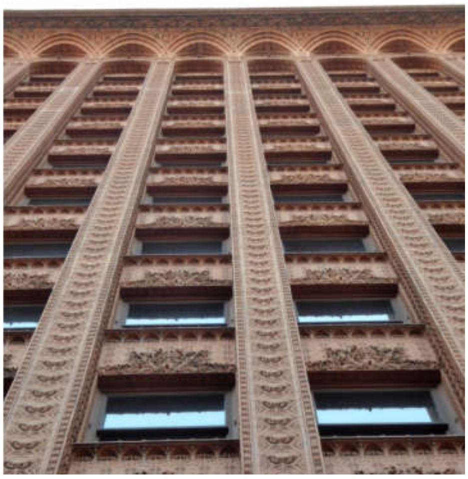
Fig. 4.1 *Ornamental surface coverings: 19th century Armenian rugs. Museum of Applied Art, Yerevan, Armenia* (2019)

The craftsmanship and skills developed in relation to the local material can be seen in the elaborate stone carvings that formed ornamentation. Medieval churches in Armenia include decorative motifs intricately carved in stone by local master-masons (Figure 4.2). These being structurally incorporated into the load-bearing elements of buildings ensured the survival of ornamentation throughout the centuries. At the same time, these motifs can be seen in the Islamic architecture of the same period, executed in plaster and coloured ceramics.

Insight 4.1: *Structural integration of ornamentation in a building ensures its longevity.*

Fig. 4.2 *Structural ornament in Armenian churches. Clockwise from top left: decorative lintel forming the niche of the facade,* Geghard Monastery, 13 c.*; capitel with abstract floral ornament, interior of a chapel; fragment of two altars*. *Noravank Monastery 13 c.* (2019)

Highlighting the importance of ornament being integral to the body of a building, architect Louis Sullivan (1892, cited in Greenhalgh, 1993, p.10) believed that "…it must be manifest that an ornamental design will be more beautiful if it seems a part of the surface or substance that receives it than if it looks 'stuck on' so to speak" (Figure 4.3).



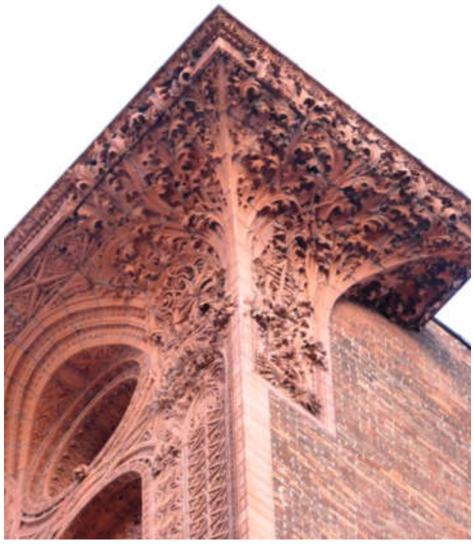


Fig. 4.3 *Functional integrated ornament: fireproof terracotta cladding. Louis Sullivan (1896), The Guaranty building, Buffalo, New York. Fragment of the elevation and the floral cornice* (2018)

My practice, explored in this research, was developed through engaging in the ceramic making process during the Masters in Ceramic Design course. Directly working with clay allowed for the immediacy of personal expression, which for me, was missing in architecture, particularly on large-scale projects. My sculptural ceramic pieces, created during the MA course, translated gestural expression into clay, both through direct forming methods and by hand-making plaster moulds containing complex curves. “Conversations” with the materials, an intrinsic part of making, took place at every stage of the making process while the clay transformed in drying and firing, manifesting ceramic craft qualities (Figure 4.4).

Fig. 4.4. *Gasparian, M. (2016) 'Folium', 45 x 50 cm, stoneware clay, stoneware slip, red shiny glaze. Formed as a part of a larger panel, the piece transformed in drying and firing adding to the dynamics of the piece* (Photos: Barrett, J. 2017)

The importance of integrated ornaments in my work was explored at this stage, starting from surface decoration, progressing to low and high relief and finally developing an ornament that formed the body of my pieces, while creating an abstract surface (Figure 4.5).

Fig. 4.5. *Gasparian, M. (2016) 'Capitel' 30 x 30 x 15 cm. Stoneware clay, stoneware clay slip, blue-green earthenware glaze* (2016)

While I was exploring the modularity and scaling-up of ceramic pieces, the need to engage with industrial manufacturing became evident, as hand-making processes, equipment and the handling of pieces were challenging in the ceramic studio setting. I did not utilise the opportunities that digital manufacturing tools offer in forming ceramic pieces.

Reflecting on my previous design and ceramic practice, my design and material explorations which form the basis of this dissertation sought to i) use patterns, colours and relief to respond to the cultural contexts of ceramic interventions; ii) utilise ceramic craft qualities in the creation of DFACs and iii) develop DFACs that could be structurally integrated into buildings and urban spaces. These aspects then fed into the development of ornamentation achieved by relief, texture and colour incorporated into load bearing elements - bricks.

4.1.2 Guiding principles

Lawson (1994, p.137) suggests that designers bring their own intellectual programme into each project, which is a result of a "lifetime of study and development." He notes that this intellectual programme, combined with designers' professional concerns, provides a series of guiding principles which inform each project.

My extensive involvement, as an architect, in large commercial developments in the UK confronted the challenges connected with the detailing and materials being used in building facades, which often become subject to a money-saving exercise and are eliminated from the project or substituted with cheaper alternatives. The importance of the use of tactile materials in urban spaces was made apparent through my previous architectural projects. Added to this, my review of mass housing developments in the UK highlighted how standard building products create a homogeneous built environment. Resulting from these insights, the guiding principles that drove the design process for my case studies and material experimentations were to:

- Provide individuality in buildings and urban spaces through site-responsive ceramic interventions, utilising three-dimensional forms, patterns and ceramic craft qualities, while using cost-effective solutions.

- Engage with people through the introduction of elements of surprise and positive distraction by using colourful and tactile elements, and by interrupting repetitive patterns.

- Provide human scale[36] through breaking up large surfaces into elements related to the scale of the human body and by setting ceramic interventions within arm's reach.

4.1.3 Constraints in industrial manufacturing of DFACs

My previous research, factory visits, precedents and context analysis as explored in Chapter 3, highlighted the constraints associated with the manufacture of bespoke DFACs. These constraints influenced the methods that I have used in my material experimentations and designs, which aim to mitigate these constraints.

My personal communications with manufacturers in the USA and in the UK confirmed that tooling and energy consumption for customised solutions contribute

[36] Human scale in architecture is used to describe structures and streetscapes that correspond to the human body and human senses. Human scale is seen as an important factor in the creation of quality urban spaces (Burke, 2016; Project for Public spaces, 2021) while Gehl (2010) linked it with "the experience of comfort and wellbeing".

to the high cost of bespoke DFACs. Workmanship has been noted to be another factor that increases the cost of production of bespoke solutions. On the other hand, it has been made evident in my conversations at the factories that repetitive mass-produced ceramic elements and bricks are the most economical to manufacture.

Historical discourse on the economy of manufacturing that originated from the effects of the Industrial Revolution is still current in today's manufacturing context. Charles Babbage (1832, cited in Adamson, 2009, p. 49) noted that the accuracy of the work executed by machines and time saving are the most important advantages "derived from machinery and manufacturers". He also noted that "At each increase of knowledge, as well of contrivance of every new tool, human labour becomes abridged" (Ibid.). The effects of automated processes and facilitation by digital tools in reducing human involvement and hand workmanship have been shown in the discussion of changes in the production of bricks.[37]

Through my investigation, I became aware that there is limited material research and product development taking place at brick factories in the UK. At the same time standard clay products are tested and certified at the high-volume producing factories. Reflecting on this, I investigated how to facilitate the manufacture of bespoke DFACs by utilising digital tools and ceramic craft techniques and combining these with existing industrial processes to achieve cost-effective solutions.

4.2 Preliminary material research and experimentation

I carried out the material research and experimentations to identify and examine how ceramic craft qualities could be achieved in factory settings (RQ.2, OB.2, OB.5). This process was instrumental in identifying the enabling and inhibiting factors that affect the manufacture of bespoke DFACs and for investigating the relationships between staff at the factories and with other stakeholders (RQ 1).

[37] Section 3.1.1, Chapter 3.

4.2.1 Review of existing manufacturing processes

My visits to the factories that manufacture architectural ceramics and bricks in the UK during this research, were aimed to identify existing manufacturing processes and customisation techniques in order to determine the potential for the creation of bespoke DFACs and ceramic craft qualities (RQ 2, OB 2, OB 5). Working with Wienerberger brick manufacturer to gain an in-depth understanding of manufacturing processes, I was able to personally explore possibilities for the creation of bespoke bricks.

The Ewhurst Wienerberger factory was chosen for my material experimentations and design developments because it has two departments, one that manufactures mass-produced extruded bricks and a second, the Keymer facility, that produces hand-made bricks and roof tiles (Keymer, 2021). The traditional hand-making skills and medium-size manually filled kilns in use at Keymer allow for the making of hand-made roof tiles, small quantities of hand-made solid bricks and 'standard special' bricks (Figure 4.6). The Keymer facility was key in enabling my design and material experimentations as it allowed the making and handling of small quantities of bespoke bricks.

> ***Insight 4.2:*** *A small-scale facility that utilises hand-made processes and small-scale equipment can facilitate material research and experimentations.*

Fig. 4.6. *Existing manufacturing processes and products at the Keymer facility. Clockwise from top left: wooden brick moulds; hand-made 'standard specials' bricks*; *back stamped with the hand of the maker; hand-pressed roof tiles* (2017)

In contrast, the majority of bricks at the Ewhurst factory are standard products formed by the extrusion method. Large tunnel kilns and automated processes including robotic operations are used for moving, stacking and firing bricks within the factory. Human involvement is limited to quality control and overseeing the machines and equipment. This makes any human intervention in these processes difficult. Figure 4.7 shows extruded and wire-cut bricks produced at Ewhurst.

Fig. 4.7. *Extruded and wire-cut bricks at the Ewhurst factory* (2017)

Establishing the difference in time for the manufacturing of hand-made and extruded bricks at Ewhurst factory was critical for the design development of my case studies. This knowledge affected both the design process and the aesthetic outcomes of the projects.

> ***Insight 4.3:*** *Knowledge of manufacturing processes and production timing of bespoke DFACs facilitates design development and aesthetic outcomes of architectural projects.*

4.2.2 Review of existing customisation processes

Identifying methods at the factories, that can change the aesthetic qualities of standard products without affecting their material qualities was one of the aims of my investigation addressing RQ 2. Figure 4.8 shows the existing customisation techniques that are utilised at the Ewhurst factory to produce standard and 'standard special' bricks. Textured rolls and the application of sand to the surface of extruded bricks aim to mimic the aesthetics that characterise more expensive hand-made bricks. Cutting and bonding standard bricks with epoxy glue presents a more economical method of making 'standard special' bricks compared to making special shaped solid bricks by hand in a mould. The techniques shown are utilised by most mass-producing brick factories in the UK. Colour variation in the bricks and roof tiles at Ewhurst is achieved by the application of sands with various percentages of manganese oxide.

> ***Insight 4.4:*** *Customisation of bricks at factories in the UK is limited to the change of surface qualities to mimic hand-made aesthetics.*

Fig. 4.8. *Customisation processes used at the factory. Clockwise from top left: applying textures by rolling and spreading sand on the extruded clay, cutting fired bricks and binding them using epoxy glue, using sand coloured by manganese oxide applied to the surface of extruded bricks to achieve colour variation* (2017)

> ***Insight 4.5:*** *at the time of this research no digital tools are used in the customisation of products at brick factories in the UK.*

In discussing strategies of digital customisation of architectural ceramics, Bechthold (2016) notes: "despite advances, we continue to struggle with high production and construction costs when customizing building components." He also notes that "in the pre-industrial age craftspeople could readily create individualized elements based on their intimate knowledge of tools and materials". I therefore worked alongside the tile and brickmakers at the factories to investigate their craft processes. This was done in parallel with the use of digital tools and techniques aiming to bring forward cost-effective bespoke designs that can be achieved in industrial manufacturing.

> ***Insight 4.6:*** *The combination of hand-craft and digital techniques presents opportunities for the creation of cost effective products.*

4.2.3 Innovative customisation and experimental designs

The importance of hands-on material experimentation became apparent during my practice investigations at the factory. Groth (2016) suggests that "learning by doing and acting…affect our future actions with similar or new materials". Figure 4.9 illustrates how my initial material experimentations provided knowledge of material properties and then aided the development of my future designs through a reflective process. Images on the top of Figure 4.9 show early experiments - soft brick made in the mould manipulated by hand and a section of extruded leather-hard clay carved with a metal wire. The later designs shown below include leaf motifs hand-pressed into mould-made bricks and geometrical patterns incised into leather-hard extruded bricks by a metal tool.

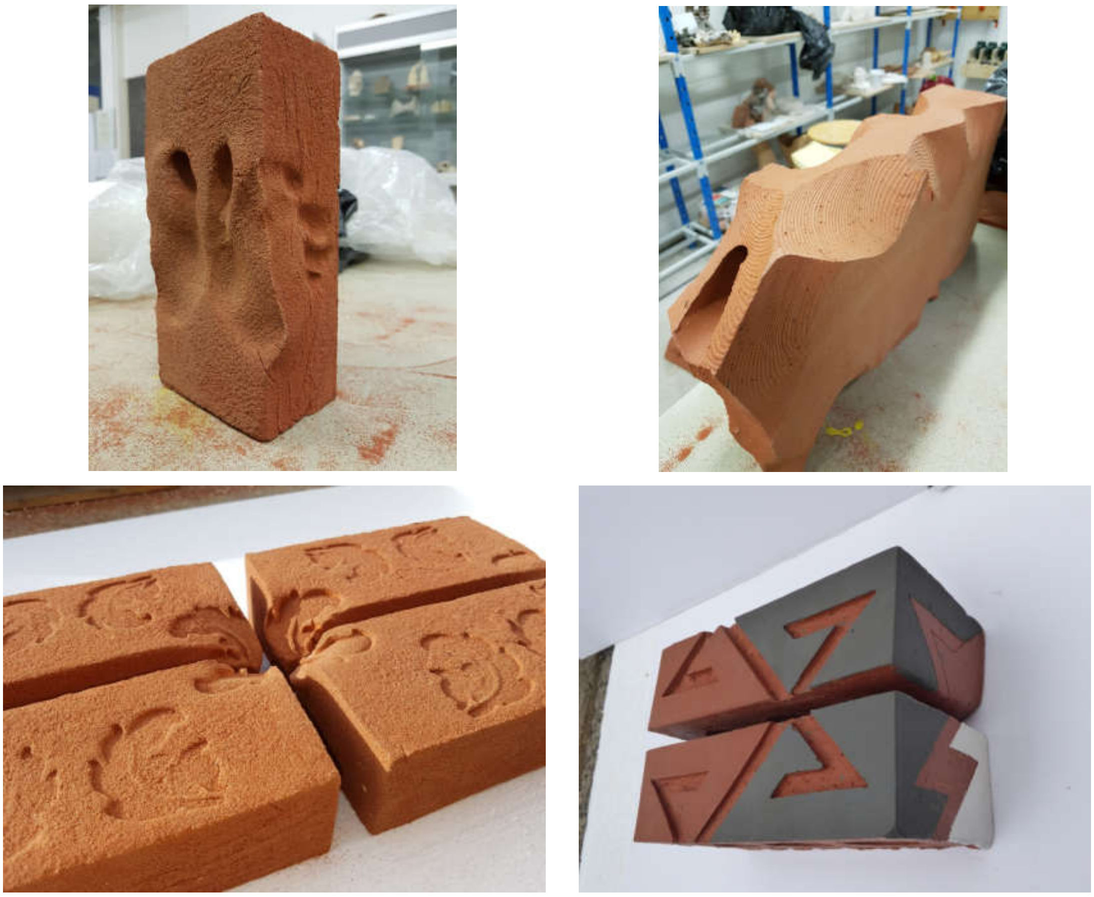


Fig. 4.9. *"Learning by doing and acting*" (2017)

> ***Insight 4.7:*** *Hands-on working with materials facilitates the generation of innovative designs.*

The ceramic and wood workshops and the Digital Fabrication Bureau at Central Saint Martins college were critical in supporting my experimentation and design development at the factories. Wooden and plaster moulds, laser cut decorative patterns and CNC milled three-dimensional components were made at these facilities and were used for the brick moulds to achieve low and high relief, aiding the creation of bespoke pieces.

> ***Insight 4.8:*** *Digital fabrication facilities and ceramic studios facilitate the design, making and manufacture of bespoke DFACs.*

4.2.3.1 Customising existing products

My experimentations at the factories progressed from modifying existing standard clay products to intervening into hand-made and machine processes, whilst achieving ceramic craft qualities through experimentation with textures and colours.

As a starting point of my experiments, I applied ceramic craft techniques to the hand and machine-made bricks and roof tiles and used materials readily available at the factory. Engobes, metal oxides and coloured sands were used to achieve a polychromatic surface that could be produced in the firing at the factory without disrupting existing industrial processes. Stamped hand-made solid bricks, hand carved extruded bricks decorated with coloured clay slips and hand-made roof tiles decorated with white and black decorating slips, cobalt and copper oxides using stencils and wax resist were produced at this stage (Figure 4.10).

Fig. 4.10. *Experimentations with colour and low relief applied to the standard clay products at the Ewhurst factory* (2017)

Figure 4.11 summarises the ceramic craft techniques that I have applied to existing products to achieve ceramic craft qualities without affecting material qualities of standard products.

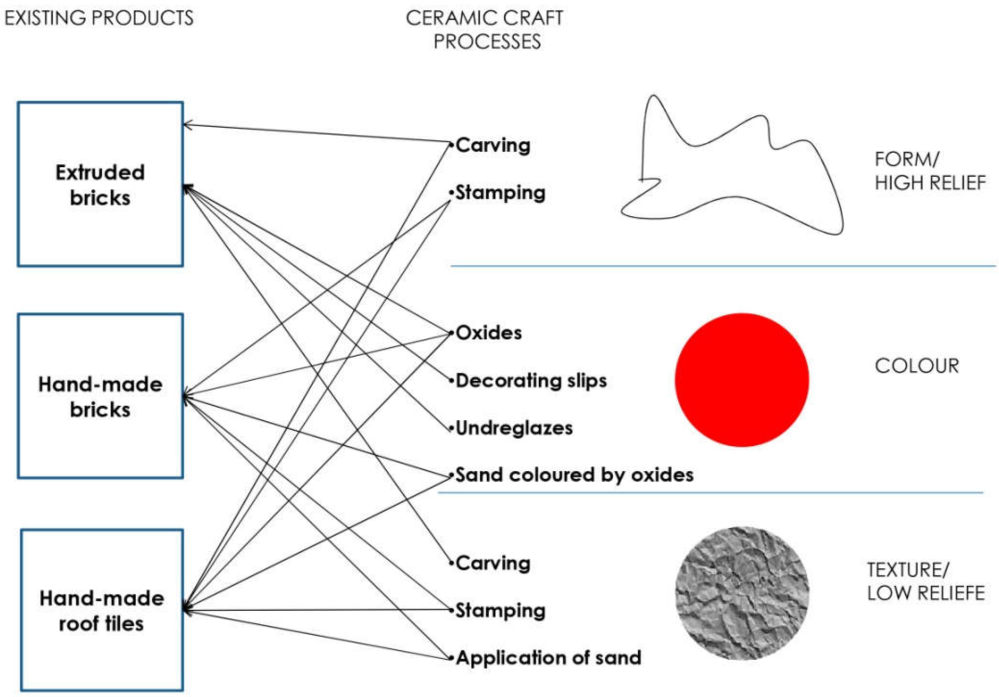


Fig. 4.11. *Customising existing products at the Ewhurst factory in 2017-2018*

The lack of glazing facilities at Ewhurst factory limited my experimentation on surface qualities and bespoke colours. My initial experiments with glazing and firing of the glazed bricks were carried out in ceramic studios. The capacity of small-scale facilities and transportation between the manufacturing sites were identified as major inhibiting factors to this process. My collaboration with H.G. Matthews, a small craft brick manufacturer at the later stages of this research, enabled me to use a diverse range of glazes and decorating techniques to achieve various colours and surface qualities.[38]

> ***Insight 4.9:*** *Lack of glazing facilities at brick factories limits the creation of bespoke colours and ceramic craft qualities in brick manufacturing.*

[38] See section 4.2.5

4.2.3.2 Customising existing hand-made processes

Initial experimentations demonstrate that textures cut into the extruded bricks and stamped into mould-made bricks can be successfully achieved by hand (Figure 4.10). However, this is a labour-intensive process which adds significantly to the manufacturing time, which would affect the cost.

By observing the hand-making processes of bricks and roof tiles and engaging in conversations with the tile and brickmakers, I developed methods of achieving bespoke designs and ceramic craft qualities, which avoid adding to the material, workmanship and production time used in the making of standard bricks, hence providing economically feasible solutions. Ornamental bricks shown on the left image of Figure 4.12 demonstrate the relief surface that was created by laser-cut inserts in a standard brick mould. The colour variation demonstrated on the image on the right is achieved by the use of sands with the addition of manganese oxide utilised at the factory.

> ***Insight 4.10:*** *Knowledge of manufacturing processes and engagement with the makers facilitates the development of cost-effective bespoke designs*

Fig. 4.12. *Unfired and fired ornamental bricks made in a customised mould* (2017)

To support the design development for my case study 2,[39] I ran a series of experiments at the Ewhurst factory aiming to achieve high relief in bricks. The high relief and complex curves that were part of my design, were achieved in custom-made wooden moulds by using CNC milled inserts produced at the Digital

[39] See section 4.5.

Fabrication Bureau at Central Saint Martins college. Through collaboration with the makers at the factory, I identified the most efficient ways that the bricks can be made using custom-made moulds, as shown in Figures 4.13 and 4.14.

The standard brick-making process involves a shallow wooden mould in which the bottom of the mould makes the 'bed' of the brick[40]. To create high relief on the 'stretcher' side of the brick the CNC milled profile was first inserted into the side of the existing brick mould. Figure 4.13 shows the stages of the making, demonstrating how the relief that included an undercut[41] had to be taken out of the mould with every brick to release it. This made the making process slower than that of a standard brick.

Fig. 4.13. *Creating a high-relief on the stretcher side of a brick in a standard brick mould* (2019)

Following the discussions with the brick makers, a deeper mould was made to create the stretcher side at the bottom of the mould (Figure 4.14). In this mould the relief piece did not have to be removed with each brick, thus keeping the production time the same as for standard bricks. It was this method that was used for the manufacture of the capping bricks for my case study 2.

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[40] For brick terms see the Definition of terms, Chapter 1.

[41] In ceramics and sculpture an undercut is created by the overhanging portion of the form or relief.

Insight 4.11: Collaboration and knowledge exchange at the factory between the designer and maker can lead to optimisation of the manufacturing process.

Fig. 4.14. *Creating high-relief to the stretcher side of bricks in a custom-made mould* (2019)

4.2.3.3 Customising existing machine-made processes

My experimentations at the H.G. Matthews factory in 2019 were undertaken initially to investigate colour through glazing. Reviewing manufacturing processes at the factory, I identified an automated brick-making process which uses small-scale machinery to manufacture bricks by slumping clay into brick moulds. The scale of the machinery allows for the production of bricks in small batches, which facilitated my intervention and led to the creation of the decorative bricks. The relief of these bricks was achieved by modifying standard machine moulds ensuring that the production time matched that for standard machine-made bricks. (Figure 4.15).

Insight 4.12: Small-scale machinery facilitates manufacture of small quantities of bespoke pieces.

Fig. 4.15. *Machine-made ornamental bricks* (2021)

This process presents a significant contribution to the manufacturing of decorative bricks. While custom-made, hand-made moulds have been traditionally used for making bespoke detailing and architectural ornamentation, the customisation of machine moulds to produce ornamental bricks has not been done before in the UK. My research into brick manufacturing abroad also shows that this method has not been utilised in Europe or the USA (Gasparian, 2017).

> ***Insight 4.13:*** *Customisation of machine brick press-moulds facilitates the creation of cost-effective bespoke bricks.*

4.2.4 Glazing in ceramic studios

The lack of glazing facilities at brick factories in the UK was highlighted through my practice.
My glazing experiments at the early stages of this research were facilitated by the use of Central Saint Martins college ceramic studio and also the ceramic studio at Kingsbury Institute in London, which was used for pottery classes. Both studios, together with Froyle Tiles craft manufacturer, were utilised for glazing my bricks for case study 1. Hand-glazing and transportation of large numbers of bricks to small-scale studio facilities presented significant difficulties in the creation of the glazed bricks.[42]

During my glazing experiments I used traditional ceramic craft techniques to achieve ceramic craft qualities in a studio setting. Fired bricks that I had produced at the factory were decorated by spraying glazes, using wax resist to create surface

[42] This process is discussed in detail in case study 1, section 4.5.5.

patterns, and by brushing and layering underglazes (Figures 4.16 and 4.17). However, these techniques require the involvement of an artist or a craftsperson and particular firing temperatures. My experimentations used double firing: the first of unglazed pieces and second - the glaze firing. At the same time it has been acknowledged in my communications with manufacturers, that double-firing significantly adds to the cost of manufacturing making bespoke pieces produced in this way prohibitively expensive.

Fig. 4.16. *Bricks made and fired at the factory and glazed at a ceramic studio* (2017)

Fig. 4.17. *Bricks made and fired at the factory and glazed at the ceramic studio. Left: bricks painted with underglazes and glazed with clear glaze. Right: application of reactive glazes, tin glaze over ash dark blue glaze creating a mottled effect, wax resist used to create a Damask pattern* (2019)

During my visits to Boston Valley Terra Cotta, USA in 2018; Darwen Terracotta, UK in 2017 and St. Joris brick factory in the Netherlands in 2016 (St. Joris, 2021), I identified that the glazing of architectural ceramics in an industrial setting, on a large scale, often involves one firing to reduce manufacturing costs. In this process the glaze is applied to the unfired clay and fired once. H.G. Matthews, the only brick factory in the UK that manufactures glazed bricks, glaze fired bricks. Building upon this insight, I trialled glazing of unfired bricks and fired them in a studio kiln at 1050°C, a temperature used in standard industrial brick kilns (Figure 4.18). My initial tests highlighted the need for future research and testing, in industrial settings, to facilitate this cost-effective process.

> ***Insight 4.14:*** *Once fired glazing process represents a cost-effective solution in the manufacturing of bespoke bricks.*


Fig. 4.18. *Testing once-fired glazing at Central Saint Martins ceramic studio. Left: glaze applied to sections of unfired brick. Right: fired glazed bricks* (2019)

4.2.5 Glazing in industrial settings

I established that the colours achieved in the brick factories, which have no glazing facilities, are limited to the use of materials that do not affect manufacturing and firing processes.[43] Therefore, I have only used coloured sands, engobes and metal oxides mixed with decorating slips in my colour explorations at the Ewhurst factory. My subsequent glaze research and experimentations in an industrial setting were possible at a glazing facility at the H.G. Matthews factory, where gas and electric kilns dedicated to glazing are utilised to provide a diversity of brick textures and colours. Development of bespoke glazes for particular architectural projects at the factory is enabled by a glazing specialist who has a background in ceramic craft

[43] Certain ceramic materials and glazes can contaminate other products placed in the same firing.

making. Metal oxides and salts are used in glazes and together with the hand application of glazes provide ceramic craft qualities in bricks.

> ***Insight 4.15:*** *The presence of a specialist with a knowledge of ceramic craft making facilitates the creation of craft glazes and ceramic craft qualities in industrial manufacturing.*

My explorations into surface qualities at the factory included the use of glazes used at the factory, which I applied to my designs (Figure 4.19).

Fig. 4.19. *'Jacquard' bricks glazed with copper and cobalt oxides added to a clear glaze available at the factory* (2019)

Glazes were applied to my ornamental bricks that had been machine-made at the factory, to explore various surface qualities. The image on the left shows the glaze brushed on in a painterly manner to preserve the non-slip quality of the sandy surface of the bricks; making them usable as paviours. The image on the right shows the glaze applied by a slip trailer into the indentations of the brick to be used on vertical surfaces to aid water run-off (Figure 4.20).

> ***Insight 4.16:*** *Application of glaze by hand using ceramic craft techniques can provide a diversity of ceramic craft qualities and physical characteristics.*

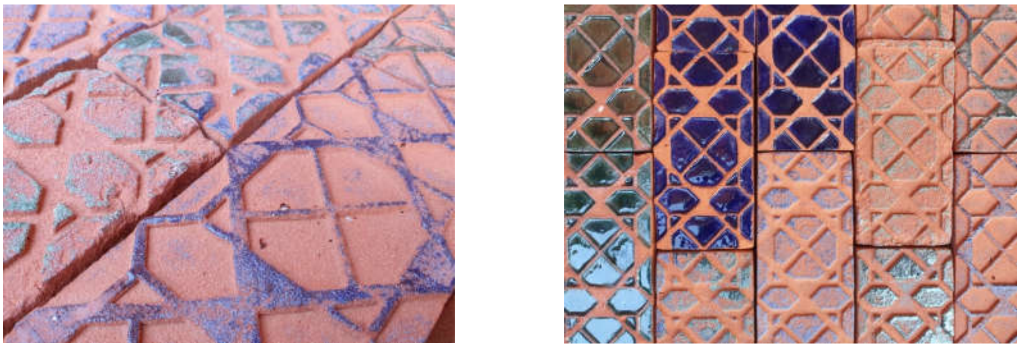


Fig. 4.20. *Ceramic craft qualities achieved by various glaze application techniques* (2020)

I have also undertaken experimentations with water-soluble salts to further explore the creation of ceramic craft qualities in bricks. Soluble salts are used in pottery and ceramic art to provide a number of ceramic aesthetics including a water-colour effect, as the colour saturates and spreads through the clay. The distinct characteristic of soluble salts, that the colour achieved penetrates the surface of the piece to a depth of a few millimetres, can be advantageous for architectural applications as the colour becomes integral to the body of the piece rather than creating a thin coating that can be chipped off. Extensive research into the use of soluble salts on porcelain pieces has been carried out and described by Arne Ase (Ase, 1989). However only limited research has been done on the use of these for architectural ceramics. My experimentations with sodium chloride solution with the addition of copper and cobalt oxides applied to my bespoke designs are shown on Figure 4.21. Further research would be advantageous for the development of these solutions.

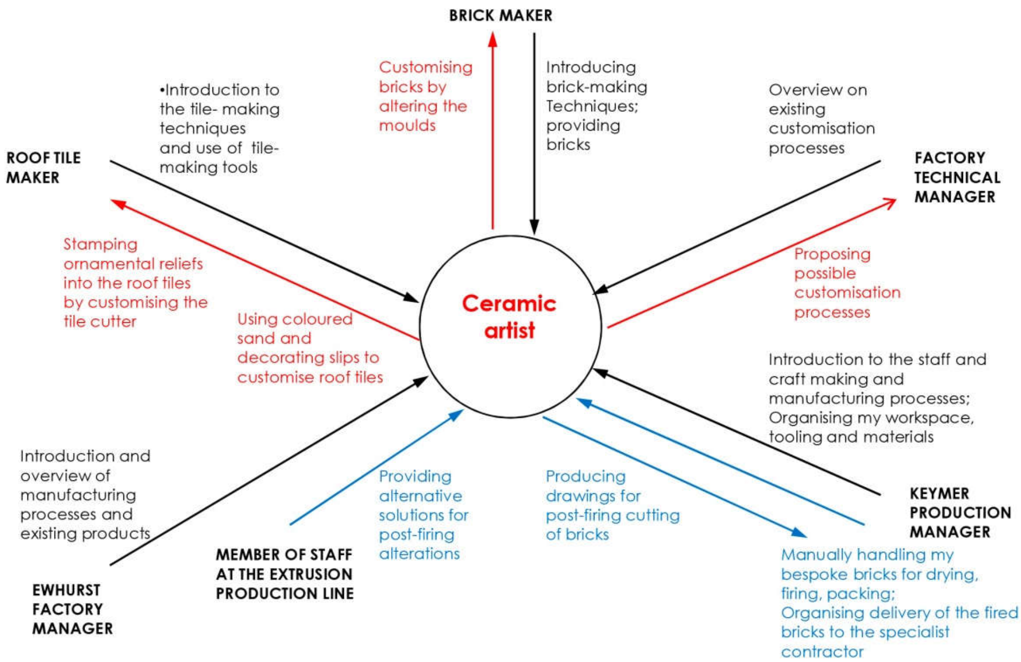
> ***Insight 4.17:*** *Use of soluble salts in architectural ceramics can facilitate the creation of colour that is integral to the body of the ceramic pieces.*

Fig. 4.21. *Left: salt with copper oxide applied to 'double-curve' coping bricks. Right: salt with cobalt and manganese oxides applied to the 'Jacquard' bricks* (2020)

4.3 Knowledge exchange and facilitation at the factories

My engagement at brick factories, as a ceramic artist, aided the development of my designs through knowledge exchange and facilitation by the manufacturers. A space at the factory allocated for my experimentations, the availability of materials and ready-made products for my tests, help with handling and firing of my work and the knowledge exchange between myself and the makers at the factory were the key enabling factors that aided my design and material experimentations. Figure 4.22 describes the knowledge exchange at the Ewhurst factory that took place during my material research and production of case study 1.



Knowledge exchange and facilitation during the preliminary research period.

Information exchange and facilitation during the case study 1.

Fig. 4.22. *Knowledge exchange between myself and staff at the Ewhurst factory in 2017-2018*

While investigating the automated and hand-made manufacturing processes at the Ewhurst factory through observation, photographing, video recording and note-taking, I had many informative conversations with technical specialists, managers, and makers, which led to the development of collaborative relationships. Cash and Goncalves (Christensen *et al.,* 2017, p.504) note that knowledge sharing can manifest itself as engagement, physical interaction and direct question asking. During my work on case study 1, I engaged in conversations with the tile and brick makers and the manager while physically producing the bricks alongside the makers. These activities and interactions resulted in knowledge sharing that led to identifying the enabling and inhibiting factors linked to the manufacturing of bespoke bricks.

My conversations with a former roof-tile maker, who is now responsible for tooling and quality control, revealed that in his own time he had experimented with standard roof tiles, making new shapes and arranging them in various assemblies. By doing this he had created different tiled roof patterns. These designs however were not taken further by the management at the factory. In a subsequent conversation with the manager of the factory, it became apparent that the Keymer department was working at full capacity producing standard range heritage products which are made-to-order for particular projects and there were no resources that could be allocated for innovation and bespoke product development (Jupp, 2019).

Insight 4.18: *High demand for standard products inhibits innovation and customisation in volume brick manufacturing.*

Figure 4.23 demonstrates how the material knowledge of the maker enabled innovative interventions for tile-making at the factory. Hand-crafted tools made by the maker are used for handling and drying roof tiles. Through our conversations, it became apparent that these interventions came about through his everyday practice of making tiles and by responding to the material properties of clay.

Insight 4.19: *Maker's material knowledge leads to optimisation of manufacturing processes.*

Fig. 4.23. *Facilitating tools: hand-made profiles and trays used for shaping and handling roof ridges and valleys* (2019)

Two examples of knowledge exchange described below demonstrate how my work at the Ewhurst factory (2017-2018) led to the creation of new products. My engagement at the H.G. Matthews factory (2020-21) facilitated the creation of ceramic craft qualities for my case study 2.

During my material experimentations at the factory, I was asked by one of the makers to produce a door number plaque out of a roof tile, as a present. I shaped the tiles using existing profiles, wooden stamps used at the factory and my own laser-cut elements. Several plaques were created and decorated with decorating clay slip and manganese oxide coloured sand used at the factory (Figure 4.24 and 4.25). The door plaques were subsequently fired at the factory. Following this, the maker went on to produce various designs using standard tiles within the next few months. These were displayed as new custom-made “Heritage” products available at the factory (Figure 4.25).

Insight 4.20: *Engagement of an artist at the factory can bring about the creation of a new product.*

Fig. 4.24. *Making the door plaques from roof tiles by cutting the profiles, stamping and inlaying with white decorating slip* (2017)

Fig. 4.25. *Left: my door number plaque; right: wall cabinet in the factory showing custom-made door number plaques produced by the tile maker at the factory* (2019)

From October 2019 I was engaged with the H.G. Matthews brick factory in connection with my case study 2. The qualities and the application of glaze for this project evolved through my collaboration with the glazing specialists, from the initial tests in October 2019 to the final results of glazing pier caps in May 2020. Figure 4.26 shows the initial test pieces in which the glaze was applied too thinly, resulting in uneven coverage.

Fig. 4.26*. Initial test glazing by the factory staff for case study 2* (Photo: Pepper, I. 2019)

The model bricks that were developed for the interviews with expert stakeholders, were used in my discussions with the makers at the factory to demonstrate the interrelation of form and surface qualities (Figure 4.27). The scale model bricks showed how the depth of colour of the translucent glaze depends on the colour of the clay body and the form such as indentations, which cause the glaze to "pool" resulting in deeper colour. Full-scale bricks were glazed following these discussions.

Fig. 4.27. *Left: scale model bricks used for discussions with staff at the factory*; *right: full-scale brick glazed by the glaze specialist* (2020)

Following our discussions, the pier caps for my case study 2 were glazed by the glazing specialist.[44] The glaze, applied by a brush, pooled and ran, accentuated by the shape of the brick, echoing the water runoff from the top surface creating a glaze drip at the edges of the piece (Figure 4.28).

[44] Case study 2 is described in section 4.6.

Fig. 4.28. *Pier caps for case study 2 glazed by the glaze specialist at the H.G. Matthews factory* (2020)

4.4 Craft special bricks

The outcomes of my material research and design experimentations were formalised in a collection of 'craft special' bricks. Designs included in Table 4.1 demonstrate the progression of my experiments that challenge existing manufacturing processes used at brick factories: i) for designs 1 & 2 only ready-made extruded and mould-made bricks were used to create customised designs; ii) designs 3-6 were made in custom-made brick moulds; and iii) designs 7-10 were manufactured by customising the machine brick making process.[45]

[45] Detailed description of craft special bricks created for my case studies 1 and 2 are included in sections 4.5 and 4.6.

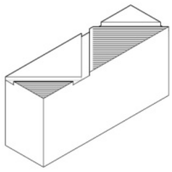
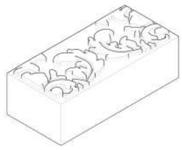
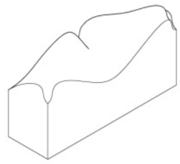
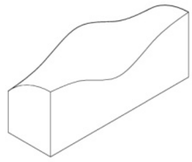
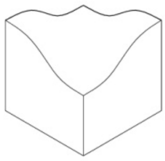
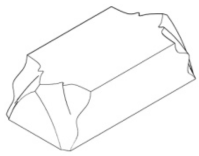
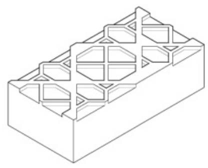
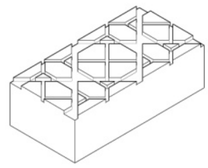
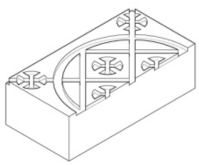
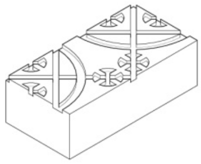
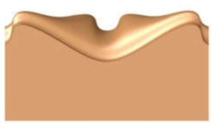
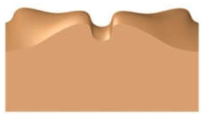
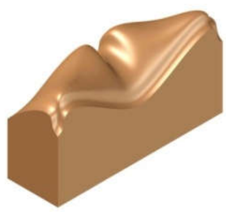
 1. 'Diagonal' brick	 2. 'Jacquard' brick	 3. 'Contour' brick	 4. 'Double-curve' brick
 5. 'Double-curve square' brick	 6. 'Cross-road 3 aspect brick and coping	 7. 'Cross-road East-1' brick and paviour	 8. 'Cross-road East-2' brick and paviour
 9. Cross-road West-1' brick and paviour	 10. 'Cross-road West – 2'. Brick and paviour		

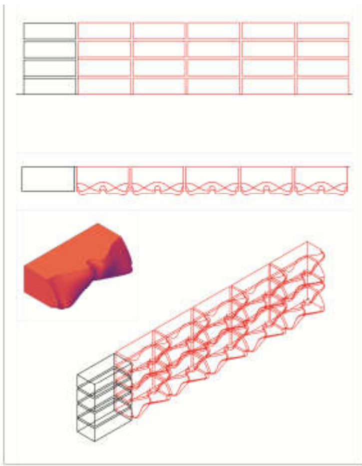
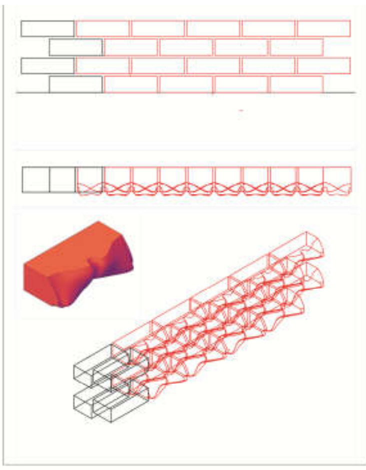
Table 4.1. 'Craft-special' bricks, paviours and brick copings.

Data sheets that were created for each of the designs contain the record of my material research and design experimentations which explore the colour, textures and forms that can be created in an industrial setting by combining ceramic craft, digital and industrial processes. The drawings, information on prototyping, materials, manufacturing and ceramic craft techniques employed in forming and decorating of each of the designs are set out in data sheets. Photographs evidencing the exploration into the surface qualities created by the application of sand, decorating slips, underglazes and glazes are included. In addition, a number of assemblies that can be created using each of the modular units are included in the data sheets. These were created to demonstrate possible affordable solutions for the creation of diverse aesthetics, responding to the constraints in industrial manufacturing of DFACs previously identified. Table 4.2 shows an example of a data sheet produced for each of the 'craft special' bricks.[46]

'Contour' brick	
1.Materials	Wealden brick clay, (Ewhurst, Surrey), shrinkage of clay for hand-made bricks 13% in firing @ 1050°C
2. Manufacture methods	Hand made in a wooden mould and hand-made in a plaster mould
3. Ceramic craft techniques	Glaze applications
4. Digital processes and tools	CNC milling used for brick moulds
5. Unit drawings	  Front view Side view   Rear view Top view  Axonometric view

[46] Data sheets for my 'craft special' bricks are included in Appendix B.

6. Prototypes and moulds	
• Plaster prototype made from CNC milled wooden mould	
• Brick plaster mould and unfired bricks made in the mould	 
7. Variables	
• From front to back: Sandy surface achieved in the wooden mould, smooth surface achieved in the plaster mould	

• Dark blue glaze with tin glaze sprayed over, applied to the brick made in a wooden mould	 
• Green copper glaze applied to the brick made in a plaster mould	 
• Underglazes and clear glaze applied to the brick made in a plaster mould	 
8. Assembly drawings	
	 Stacked bond  Stretcher bond

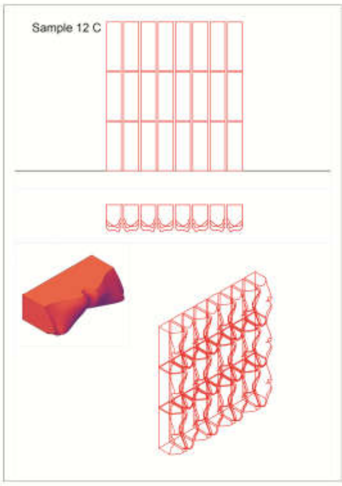
	 Vertical stacked bond
9. Assembly photographs	

Table 4.2. Data sheet on ‘Contour’ brick.

4.5 Case study one: Ceramic City Bench

> *'Always design a thing by considering it in its next largest context- a chair in the room, a room in a house, a house in an environment, an environment in a city plan.'*
> *Eliel Saarinen*

Fig. 4.29. *Ceramic City Bench installed at Bow Churchyard* (Photo: Sanvito, A. 2018)

4.5.1 Introduction

The Ceramic City Bench project was one of the two case studies undertaken as part of my practice research. The bench was created for an open design competition organised by the London Festival of Architecture (LFA) in collaboration with the City of London Corporation and was installed in the City of London in June 2018. The aim of the LFA, which was in its fourteenth year, was to promote architecture and make it accessible to the general public and bring positive changes to the public realm.

The bench made out of bespoke bricks, was designed and manufactured in collaboration with a manufacturer (OB. 4) and its installation was facilitated through collaboration with a specialist brick contractor. Critical analysis of the design and manufacturing processes allowed for the identification of the key enabling and inhibiting factors in response to RQ1. My analysis of the relationships between the stakeholders of the project, the distribution of power and decision making in relation to land ownership, planning, construction working hours and site access contributed to the key findings. The knowledge exchange that took place between the project participants was recorded and analysed. This highlighted the crucial factors that influenced the design, craft techniques, choices of manufacturing processes and construction which enabled the structural integration of bespoke bricks into the public bench answering RQ2. During this project I undertook the roles of both architect and ceramic artist.

4.5.2 Key project information

The requirements of the competition were to create ten public benches, each providing seating for a minimum of two people, to help to enliven and re-purpose streets and forgotten public spaces in the City. The designs were to discourage skateboarding and rough sleeping. Each bench was to be safe, robust and offer a low-cost design solution. A budget of £800 was allocated for the design, production and installation of each bench.

The stakeholders involved in the creation of the Ceramic City Bench contributed to the design, manufacture and the structural integration of bespoke DFACs and the installation of the bench into the public realm. The constraints imposed by the project parameters had to be addressed and negotiated during the course of the project. LFA collaborated with the City of London Corporation to accommodate the benches into the public realm for the period of the festival. However, the site allocated by the client for the Ceramic City Bench - in front of 17th century St Mary-le-Bow Church - belongs jointly to the City of London Corporation and the Church of England. This fact added complexity to my relationships with the client and the two land owners, regarding access to the site and highlighted the issues connected with construction in the public realm. Health and safety requirements, restricted working hours imposed by the City of London Corporation, regulations regarding noise and disturbance for office workers and worshippers of the church were accommodated by the specialist contractor, who had extensive experience of working in urban locations. Wienerberger UK brick manufacturer produced the bricks while I carried out the design and craft making.

Location	St Mary-le-Bow Churchyard, London
Project dates	March 2018-June 2018
Project participants	
Client	London Festival of Architecture
Land owners	City of London Corporation Church of England
Local authority	City of London Corporation
Architect, Ceramic artist	Maria Gasparian
Engineer	Arup Consulting Engineers
Specialist contractor	Swift Brickwork Contractors
Manufacturer	Wienerberger UK, Keymer factory

Table 4.3. Key project information

The benches, designed in various materials, remained in their locations for four to six weeks.
The competition required the first proposal to be submitted on 19th April 2018. The winning entrants were to develop the design and produce their pieces by the end of May, with construction of the benches taking place on 1st June. As shown in Table 4.6, this gave an initial design time of one month. Design development and manufacture were also to take one month. Due to the restrictions of working in the City, the assembly on-site was to take place during one weekend.

The short timescale of the project imposed constraints on the design and manufacturing of bespoke DFACs, my material of choice. As there was no time allocated for design and experimentation for this project, it was necessary to use designs, ceramic craft techniques and manufacturing processes which I had tested beforehand.

> ***Insight 4.21:*** *Constraints on time for material research and experimentation during the project limits the design and material choices.*

2018	March	April	May	June	July
Competition announced	22nd				
Design time		19th			
Manufacturing					
Construction on site				6-7th	
Demolition					7th

Design

Production

Bench placed on site

Fig. 4.30. *Project key dates*

4.5.3 Project Context

The selected benches were placed in various locations in the City of London. Most of the sites were located next to landmark buildings; however some were in featureless spaces between high rise buildings constructed predominantly out of glass, metal and concrete which has created a monochrome and uninviting environment (Figure 4.31).

Addressing the given brief, and in accordance with OB 4, I carried out historic and local context analysis in order to design a site-responsive intervention. The analyses were done through desktop literature studies to identify local history, a photographic survey and observations of the area to inform my design (Figure 4.32).

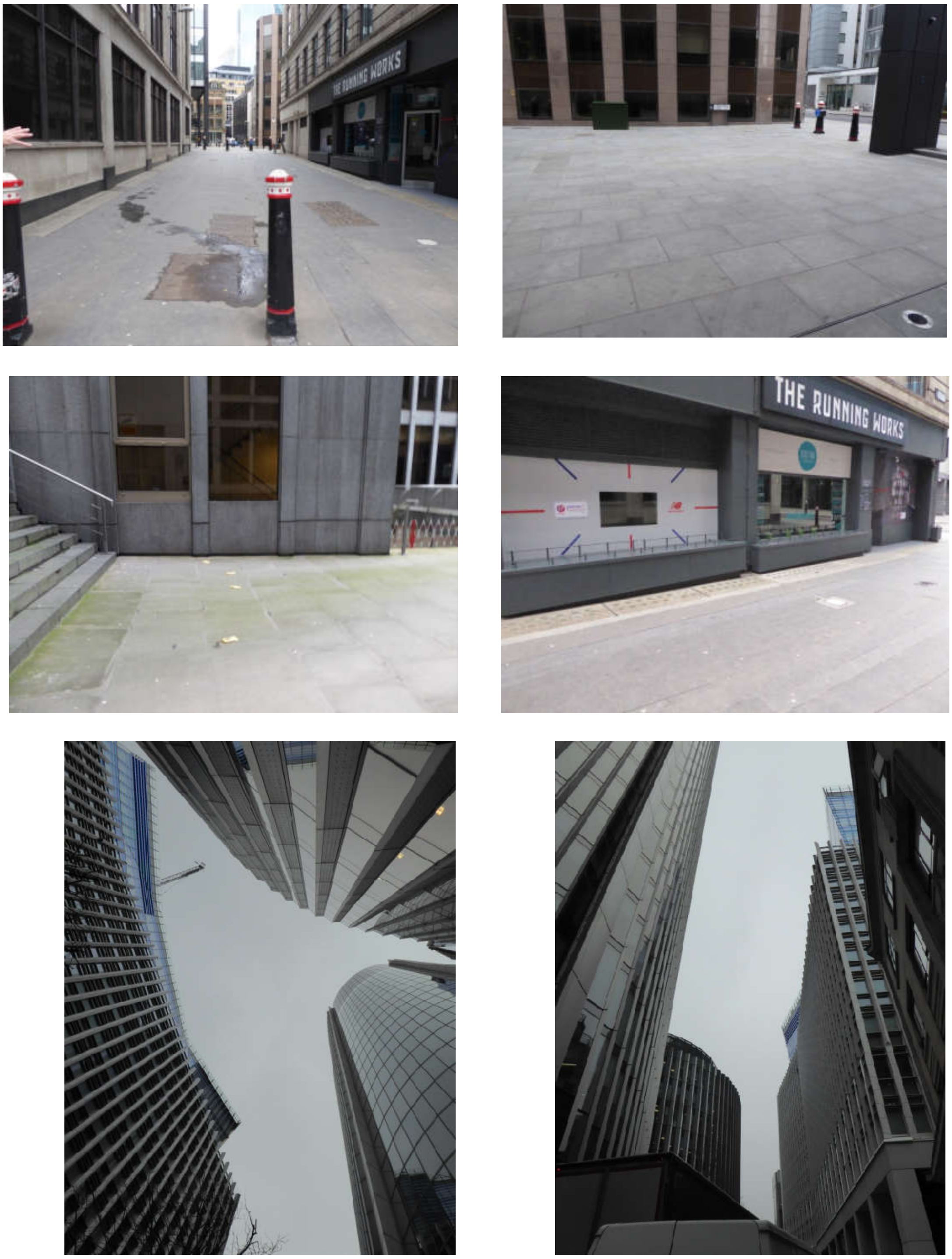


Fig. 4.31. *Photographic survey of the given sites external spaces and adjacent buildings.* (2018)

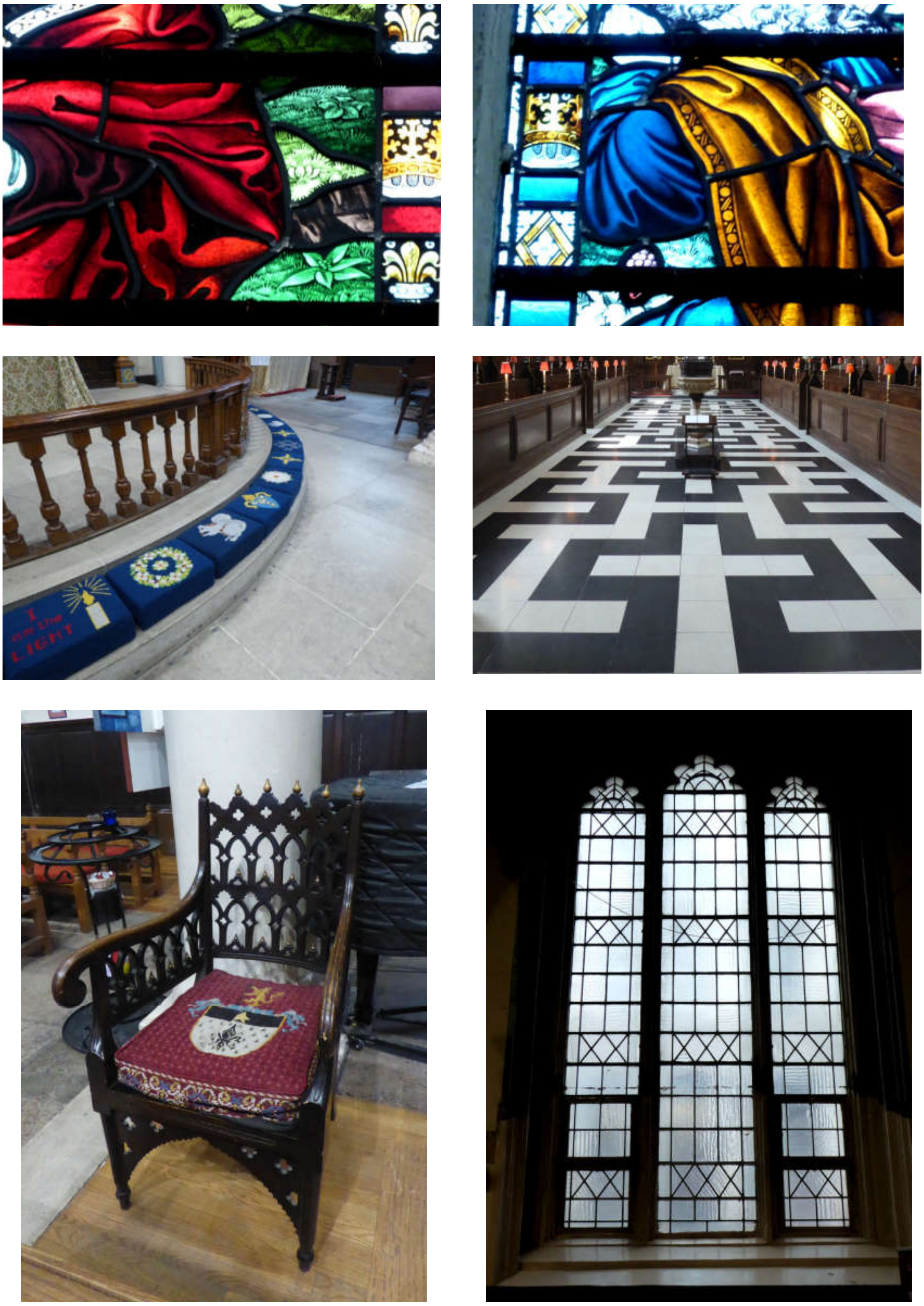


Fig. 4.32. *Local context: stained glass windows of local churches, contrasting patterns of St Mary-le-Bow church floor, geometrical patterns of leaded windows and heraldry of the City Guilds embroidered on the cushions* (2018)

4.5.4 Design intent

Responding to Saarinen's proposition to 'Always design a thing by considering it in its next largest context', this project included the creation of bespoke crafted bricks which were integrated into a bench, while the bench was integrated into a city location, through the creation of site-responsive design.

The design for the bench was developed to take account of the criteria set in the brief by the LFA and in line with my guiding principles described in section 4.1.2: provide individuality and identity in urban spaces, engage with people and provide human scale through the use of site-responsive ceramic interventions, as summarised in my design statement:

> "The proposed City bench will be constructed out of standard clay bricks that have been sculpted while raw, coloured and glazed. The colours and motifs of the seat offer a playful pattern that reflects the history of the site and will contrast with the monochromatic urban surroundings. The bench is arranged in various heights and offers a flexible seating arrangement for people to rest, have lunch and work. It aims to attract different ages. The colours and patterns of the surface of the bench are inspired by the multi-layered context of the City of London that has been for centuries a place for trade, exchange and religious diversity. The tactile surface of the bench offers surface qualities that would be difficult to achieve outdoors with any other material, offering passers-by a place to sit, connect and feel at home."

4.5.5 Design, craft and manufacturing processes; Ceramic craft and material qualities

The design development for the Ceramic City Bench was a non-linear, iterative process that was influenced by a number of constraints throughout the project. In this case study, the utilitarian requirements were to create a bench that would be load-bearing, weatherproof and robust to accommodate use by people in the public realm. Figure 4.33 outlines how the timescale of different aspects of the project have overlapped. It highlights the importance of preliminary material research which had taken place a year prior to the project. The decisions on ceramic craft making and manufacturing processes for the bench during the one month production period, as well as the architectural design process, were directly informed by the preliminary experimentations and material research that I had carried out at the Wienerberger Ewhurst brick factory (section 4.2).

Insight 4.22: *Material research and experimentation carried out prior to the project enabled the creation of bespoke bricks under a tight timescale.*

	September 2017- February 2018	March 2018	April 2018	May 2018
CERAMICS				
Preliminary Material Research, Testing, Design development				
Design of ceramic elements for the bench				
Production of ceramic elements for the bench				
ARCHITECTURE				
Design				
Design Coordination				

Ceramic Practice, preliminary experimentations

Ceramic Practice

Architectural Practice

Fig. 33. *Comparative timeline for ceramic and architectural practices* (2021)

4.5.5.1 Design process

By taking on the professional roles of architect and ceramic artist, I generated the overall design of the bench, produced the ceramic design and physically made the decorative elements of the bench in collaboration with the manufacturer. Fulfilling two roles meant that the design development, aided by the information exchange between the ceramic and architectural practices took place concurrently, in contrast to the situation when these roles are carried out by different parties. For the critical analysis of this case study, the professional roles of the architect and the ceramicist were separated, aiming to add multiple perspectives to the description of the design and making processes. Figure 4.34 describes the design process for this case study, highlighting this information exchange between my ceramic and architectural practices. While the preliminary material research and experimentations provided information that supported the overall design development, "project parameters" which consisted of the constraints and requirements set in the client's brief affected the ceramic and architectural design.

Insight 4.23: *Continuous knowledge exchange between the ceramic artist and architect enables ceramic and architectural design development.*

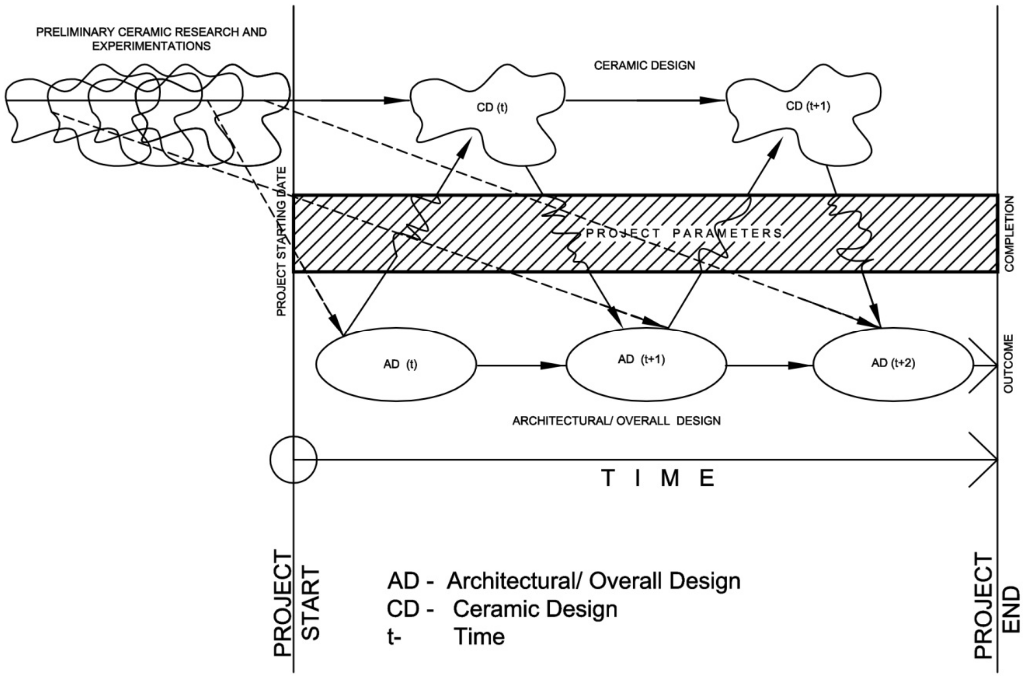


Fig. 4.34. *Design process and information exchange between ceramic and architectural practices* (Adapted from Maher (1996) and Dorst and Cross (2001))

Figure 4.35 shows the factors that affected the project including project constraints set down in the client's brief, the relationships between the project participants, existing manufacturing processes and facilities and my guiding principles.

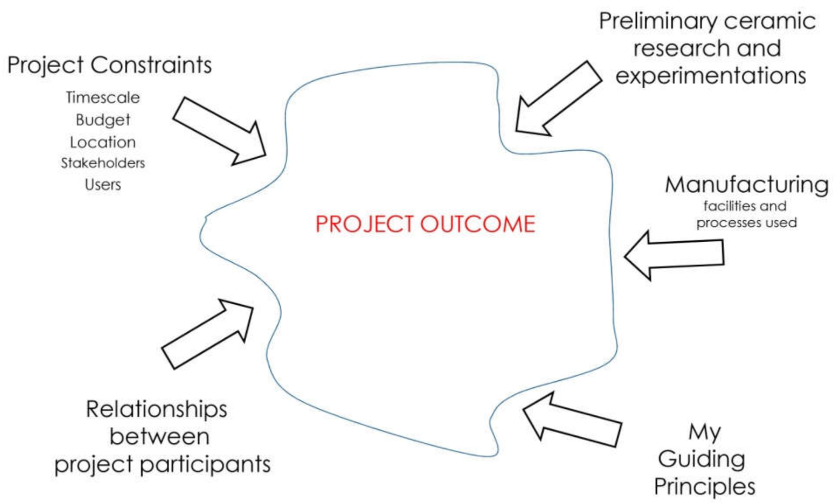


Fig. 4.35. *Factors affecting the outcome of the project*

The choice of ceramic materials was informed by the insights gained from my preliminary material research and experimentations and affected the aesthetics of the bench (Figure 4.36). Lawson (1994) proposes that means facilitating design such as the palette of materials, sketches and layouts, which he defines as "primary generators", could "bring order and form to early phases of the design process" (Figure 4.37). My context analyses including the colours of the stained glass windows, patterns and historical detailing affected the aesthetics of the bench, whilst my knowledge of manufacturing aided the choice of low-cost solutions. My knowledge of the drying time for solid and perforated bricks made it evident that no solid bricks could be used because of the insufficient time available in the project programme. Therefore, perforated extruded bricks were used to provide robust self-supporting construction, while brick perforations were utilised to create decorative elements. The carved extruded bricks were used to created the “back-rests” of the bench, referencing the crenulations of medieval city walls. These elements also provided obstacles to skateboarders by producing an uneven edge.

> ***Insight 4.24:*** *Preliminary knowledge of manufacturing processes enabled the design, craft making and manufacturing of bespoke bricks.*

> ***Insight 4.25:*** *Bespoke ceramic elements created through customisation of existing products can offer site-specific, low-cost, robust solutions.*

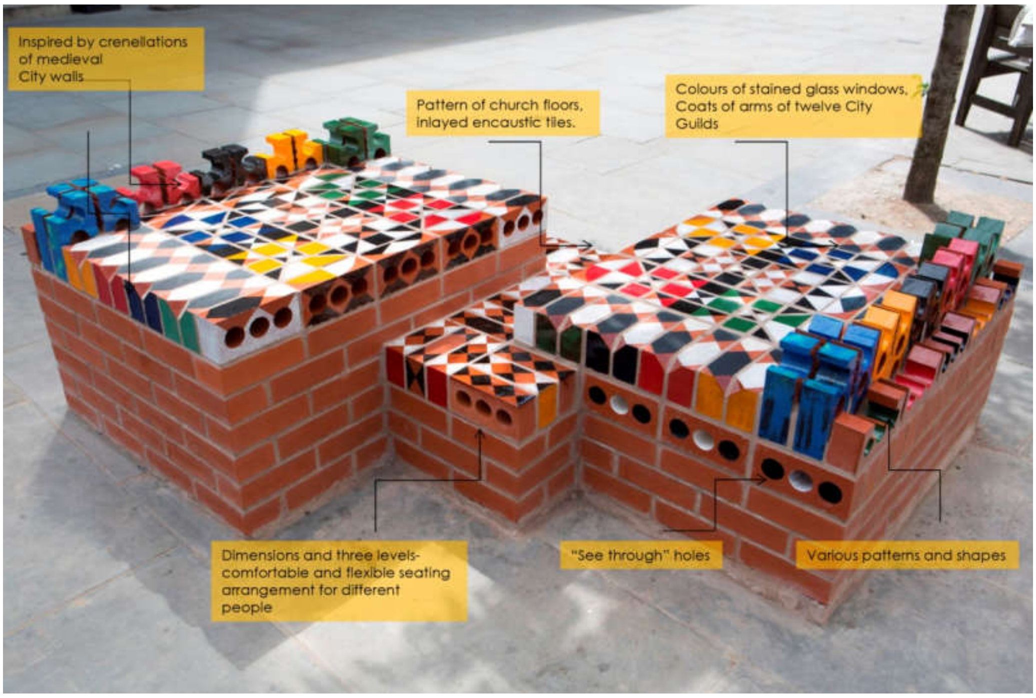


Fig. 4.36. *Context-responsive design of the bench* (2018)

Fig. 4.37. *Initial sketches, models and mockups* (2018)

Iterations of the design were made throughout the design stage and manufacturing process until completion on site, with continuous information exchange between myself, the engineer, manufacturer and specialist contractor. These iterations optimised the design to fit the time frame, as well as to minimise the wastage of materials. The elevation shown at the bottom of Figure 4.38 was altered following my discussions with the contractor and included brickwork around all of the surfaces of the bench.

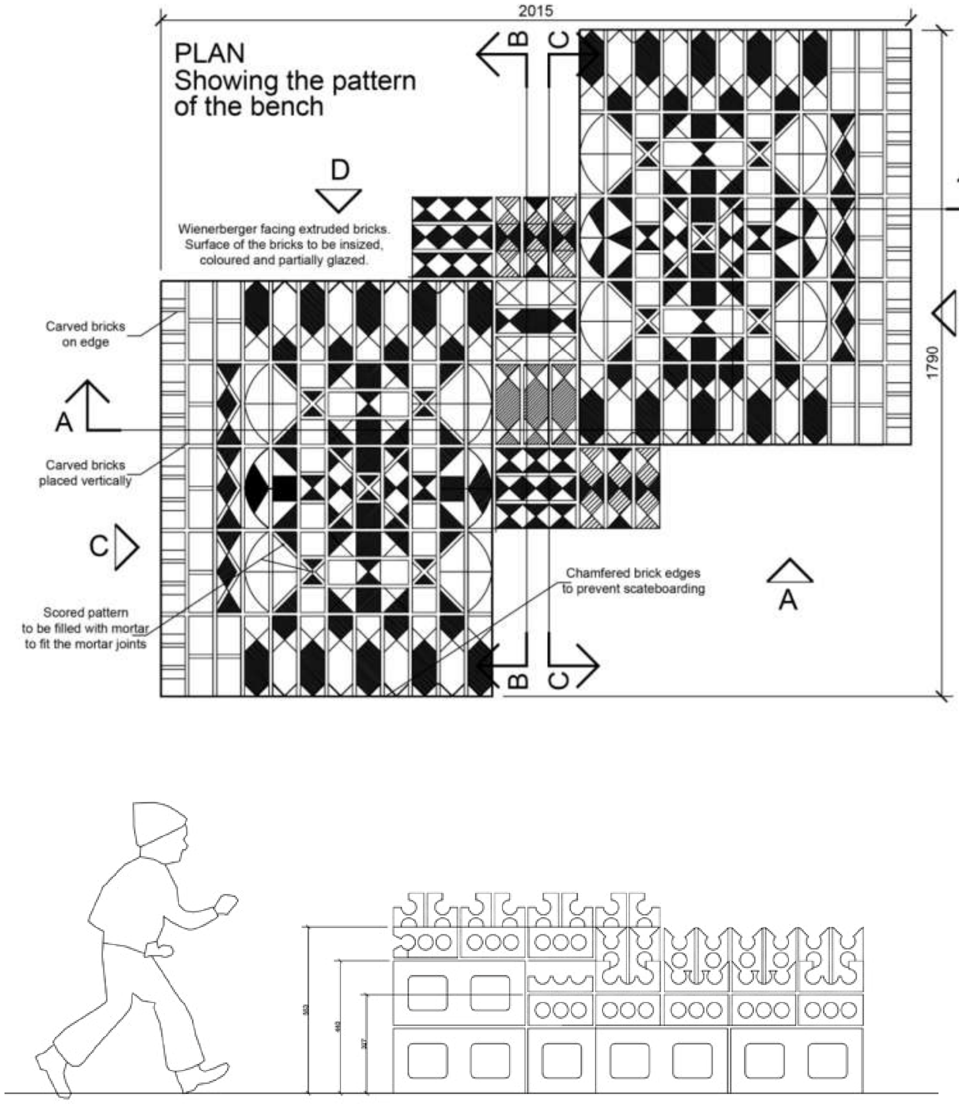


Fig. 4.38. *Plan and elevation drawings of the bench, produced for the brick contractor*

4.5.5.2 Ceramic craft and manufacturing processes

The decorative bricks used for the City Ceramic Bench were made by manually modifying standard engineering bricks at the Ewhurst factory. I carved the raw extruded bricks by hand and decorated with coloured underglazes. Both unfired and fired bricks were decorated to speed up the process and minimise the risk of failure during firing which would negatively impact the production schedule.

Carved unfired bricks were fired in one of the gas tunnel kilns used for extruded standard bricks. In this standard firing process the uniform bricks are transported and placed into the kiln by robots. However, the decorative bricks produced for the bench would be damaged by this process. The factory staff facilitated the process of firing the bespoke bricks by manually packing them into and unpacking them from the large tunnel kiln [47] and later, by packaging them manually for shipping to London.

> ***Insight 4.26:*** *Bricks of non-standard shape have to be handled manually at the factory, which leads to increased time and labour compared to standard procedures.*

The ceramic craft techniques used to provide patterns and colours for the bespoke bricks were chosen to fit the short program of the project. Coloured underglazes were applied to the fired and unfired pieces. Image on the top left of Figure 4.39 shows the patterns achieved on the stretcher side of the bricks by three layers of underglazes applied evenly by brush to reach an intense colour. The 'crenellations' of the bench were decorated with blue, black and light-green underglazes which were applied in a painterly way with a brush to provide colour variations. Ceramic craft techniques using wax resist and masking parts of the brick were employed to achieve the patterns (Figure 4.40).

[47] Tunnel kilns are used in brick manufacturing for continuous firing of large number of items. Bricks are loaded onto the moving platforms which move through the kiln over a period of 2-3 days.

Fig. 4.39. *Coloured and glazed bricks for the top of the bench* (2018)

Fig. 4.40. *Making in the factory: carving unfired bricks, decorating unfired and fired bricks with underglazes* (2018)

Glazing the bricks presented a challenge in the manufacture of the bench, highlighting the limited facilities for glazing bricks in the UK. Some of the bricks were glazed by the Froyle Tiles craft manufacturer. These partially failed and were re-glazed in London at the ceramic studio at Central Saint Martins college, and Regent College London, Kingsbury (Figure 4.41). The difficulties of transportation, handling and the limited capacity of the ceramic studios kilns presented challenges.

> ***Insight 4.27:*** *Lack of industrial facilities for glazing bricks inhibits the creation of bespoke bricks.*

Fig. 4.41. *Challenges of glazing bricks. Clockwise from top left: transporting the bricks by car to Froyle Tiles, Hambledon; spraying the bricks with glaze at Central Saint Martins ceramic studios, London; firing glazed bricks at the ceramic studio at Regent College London, Kingsbury* (2018)

The making and decorating processes during this project highlighted the unpredictability and risks associated with craft making of bespoke DFACs. Figure 4.42 includes the challenges arising from modifying the shape and surface of standard products. Within the tight timescale of an architectural project, the risks associated with novel processes undertaken by designers, makers and manufacturers can inhibit the choice of bespoke DFACs. On another hand, preliminary material research and testing prior to the project can facilitate the incorporation of innovative processes and products.

> ***Insight 4.28:*** *Risks associated with untrialled craft making in the manufacture of bespoke DFACs can inhibit their creation and integration.*

Fig. 4.42. *Challenges in the production of bespoke designs. Left: glaze over underglazes flaking in the cooling process. Right: warping of clay caused by uneven shrinkage due to quick drying* (2018)

4.5.6 Relationships and knowledge exchange

The relationships between organisations and individuals during the design, manufacture and construction of the bench described in Figure 4.43 highlight the links that facilitated these processes. Specialist skills possessed by each of the project participants and the knowledge exchange between them enabled the design, manufacture and craft making of bespoke bricks and the construction of the bench.

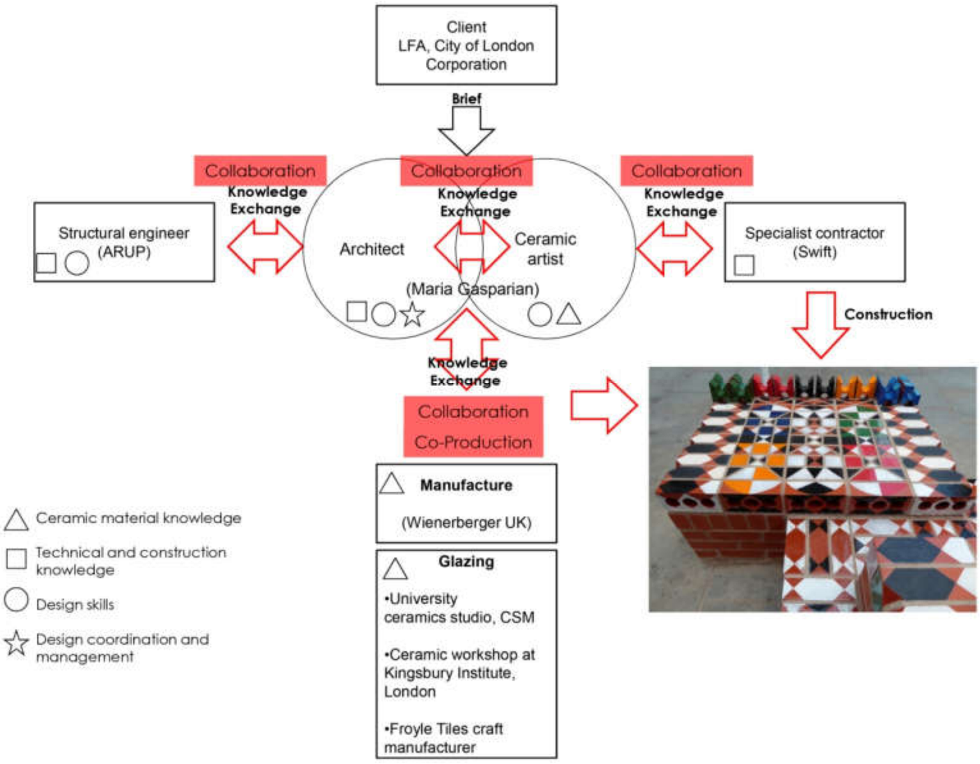


Fig. 4.43. *Organisations and individuals, their role and relationships in facilitating the commissioning, design, manufacture and construction of the Ceramic City Bench*

Continuous knowledge exchange between the ceramic and architectural practices was necessary for the design development, craft making and manufacture of the bespoke DFACs. This exchange was taking place continuously during the project, as the roles of the architect and ceramic artist were undertaken by one person. Collaboration with the brick manufacturer was established at an early stage through knowledge exchange during the material research and experimentations at the factory. This was the basis for the collaborative relationships with factory staff which enabled the making of the bench with support from the management and workers at the factory. The knowledge exchange and collaboration with the structural engineer at the early stages of the project facilitated the choice of the cost-effective supporting structure made out of concrete blocks, which were quick to construct. Later, the engagement with the specialist brick contractor enabled construction to progress within the tight time and budget constraints.

The examples of information exchange and enabling relationships between myself and the workers at the factory are described in Figure 4.44. Envisaging the use of fired extruded bricks to produce decorative detailing, I sent the drawings to the manufacturer prior to my visit, showing the cuts to be made to the bricks. However, the trial of cutting bricks with the bandsaw at the factory failed. Following this, a member of staff at the factory produced one of the elements by grinding the bricks to create chamfers designed to discourage skateboarding. The rest of the detailing was created by manually cutting unfired bricks.

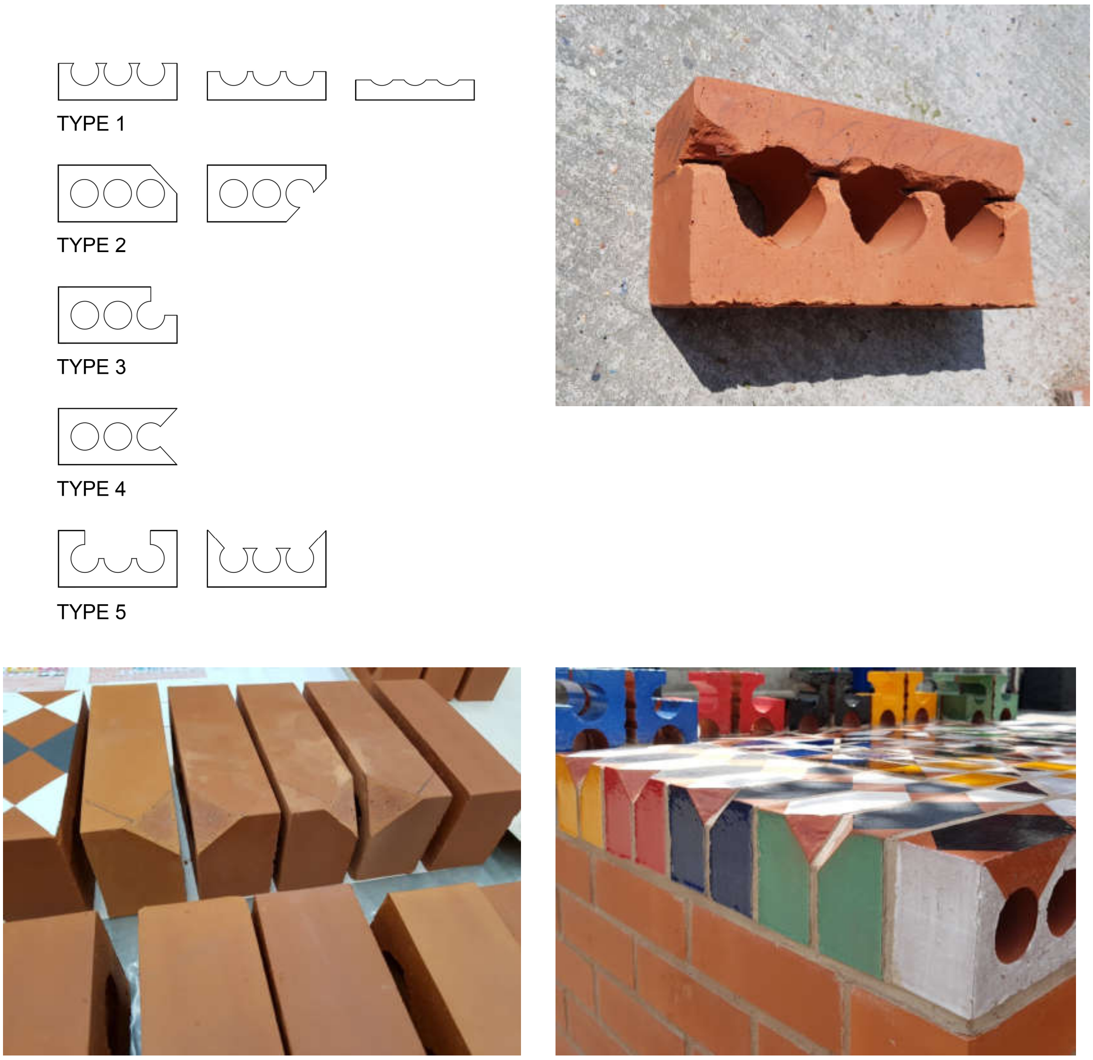


Fig. 4.44. *Co-creation, information exchange and facilitation by the manufacturer during the production of the bench* (2018)

Figure 4.45 shows the bricks being installed by the Swift contractor’s specialist bricklayer using epoxy quick setting mortar, which enabled the construction on site within the given timeframe. The use of a traditional mortar would not have given enough time for the mortar to reach its full structural strength. The image on the right shows the lightweight inner structure proposed by the structural engineer which enabled quick construction and a robust solution for the bench.

Fig. 4.45. *Examples of information exchange and facilitation. Left: decorative bricks adhered with a special epoxy mortar by the bricklayer. Right: lightweight inner structure proposed by the structural engineer* (2018)

4.5.7 Summary of insights from case study 1

The enabling and inhibiting factors relating to the design, manufacture and installation of the bespoke brick bench were brought into focus by the critical analysis of the project constraints, design and manufacturing processes, relationships and knowledge exchange between the stakeholders of this project. The collaboration and knowledge exchange at all stages of design, craft making, manufacturing and construction were critical to the design development and manufacture of the bench (Insight 4.24; Figures 4.40 and 4.49). The development of the bespoke ceramic designs was facilitated by the knowledge exchange and collaborative relationships between the factory staff and myself. This, together with the working relationships with the structural engineer and the specialist contractor enabled the creation of the Ceramic City Bench within the tight project constraints set out in the brief by the client.

The client's brief created boundaries, against which I could test the feasibility of the creation of bespoke DFACs. What came to light was that timescale and cost are major constraints in the design, manufacturing and structural integration of bespoke DFACs. While the lack of time for material research and experimentation during this project limited the design and material choices (Insight 4.22), the material research and experimentation carried out before case study 1 enabled the creation of ceramic craft qualities in bespoke bricks (Insight 4.23). At the same time my preliminary knowledge of manufacturing processes informed my design, craft and manufacturing choices (Insight 4.25). Responding to the budget limitations, the bespoke ceramic elements that were created through the customization of existing products in the factory offered low-cost, robust solutions (Insight 4.26). It was highlighted that there are risks associated with untrialled craft processes in the manufacture of bespoke DFACs. These can inhibit the creation of bespoke designs due to the unpredictability of results and project time limitations (Insight 4.29).

The practice recommendations addressing the constraints present in this case study are included in Table 4.4 and can be adapted and applied to other projects with similar parameters.

	Constraints	**Implications**	**Practice recommendations**
1	Design Time: 4 weeks	Insufficient time to carry out material research and experimentation in industrial settings (section 4.2)	Use materials and design solutions from earlier research and experimentations
2	Manufacturing time: 3 weeks	A limited range of ceramic products can be produced in this time (section 4.1)	Use and customise ready-made products e.g. carve hollow extruded bricks to allow quick drying
3	Construction time: 2 days	Insufficient time to use traditional construction methods	Use solutions that allow quick assembly while providing structural stability e.g. epoxy mortar
4	Budget: £800	Insufficient budget to fulfil the brief	Use low-cost solutions such as ready-made and

		(my preliminary knowledge of material and construction costs)	customised bricks. Gain sponsorship from the manufacturer and the contractor through project publicity
5	Timescale of competition programme	No time to collect feedback from stakeholders and no public involvement for consultation	Use insights from existing precedents
6	Demolition: 1 Day	Difficulty of preserving bespoke DFACs	Manual removal of decorative layer to preserve individual units

Table 4.4. Constraints, implications and practice recommendations for ceramic artists and architects

While the insights from case study 1 contributed to the key findings of this research, case study 2 set out to examine the research aspects that could not be explored because of the constraints of case study 1.

Fig. 4.46. *Decorative bricks mortared to the base and ready for pointing* (2018)

4.6 Case study 2: Ornamental Wall

'Regardless of which social system prevails in the world or its parts, a softening human touch is needed to mould societies, cities, buildings, and even the smallest machine-made objects into something positive to the human psyche...'
Alvar Aalto

Fig. 4.47. *'Clinker'* [48] *front garden wall located at the neighbouring house* (2019)

[48] Clinkers (a homophone from the colliding fired clay pieces) are overfired ceramic waste material that accumulates at the bottom of the stockpile kiln.

4.6.1 Introduction

I initiated case study 2 as a self-directed project which started in March 2019 and was completed by May 2020. The brief for case study 2 was to rebuild a front garden wall of a residential house and thereby to contribute to the context of the street through ceramic craft qualities and bespoke DFACs, following my guiding principles. The enabling and inhibiting factors and relationships between the stakeholders of this research were analysed during the design and manufacturing of the Ornamental Wall (RQ 1).

Reflecting on the analysis of case study 1 and addressing the research questions, the parameters of this case study were set to explore further the aspects of design, craft making and manufacture of DFACs, focusing in particular on the factors which could not be studied during case study 1 because of the project constraints. While case study 1 had a tight timescale dictated by the client's brief, the programme for case study 2 was set by myself and included time for material research and experimentation. I was able to investigate the craft and manufacturing processes in depth and the ceramic craft qualities of bespoke DFACs through engagement with two industrial manufacturers (RQ 2, OB 2, OB 4, OB 5). My collaboration with H.G. Matthews, a small-scale craft brick manufacturer enabled my investigation into colour glazing in an industrial setting.

Bespoke brick designs for the Ornamental Wall were developed at the Central Saint Martins college Digital Fabrication Bureau and the ceramic workshop. Communication with the staff working in the workshops assisted my design iterations. Digital tools and techniques were utilised to model the complex 3D forms and textures of the bespoke bricks.

4.6.2 Key project Information

Location	Barnet, London
Project dates	April 2019- September 2020
Project participants	
Clients	Owner of No 1 * Avenue (Maria Gasparian) and Owner of No 3 *

	Avenue
Local Authority	London Borough of Barnet
Architect, Ceramic artist	Maria Gasparian
Facade designer/ material specialist	Alexis Harrison, ARUP Consulting engineers
Digital prototyping and tooling	Staff at Digital Fabrication Bureau at CSM
Plaster mould-making and tooling	Staff at ceramic studio at CSM
Wooden mould-making and tooling	Staff at woodwork workshop at CSM
Brick Manufacturers	Wienerberger UK and H.G. Matthews
General Contractor	A to Z contractors
Specialist contractor/bricklayer	Thomas Agnski

Table 4.5. Key project information

While the programme of this case study was set out to incorporate material research and experimentations, the precise time allocation was based on my knowledge of manufacturing processes following my preliminary ceramic research and case study 1 (Figure 4.48).

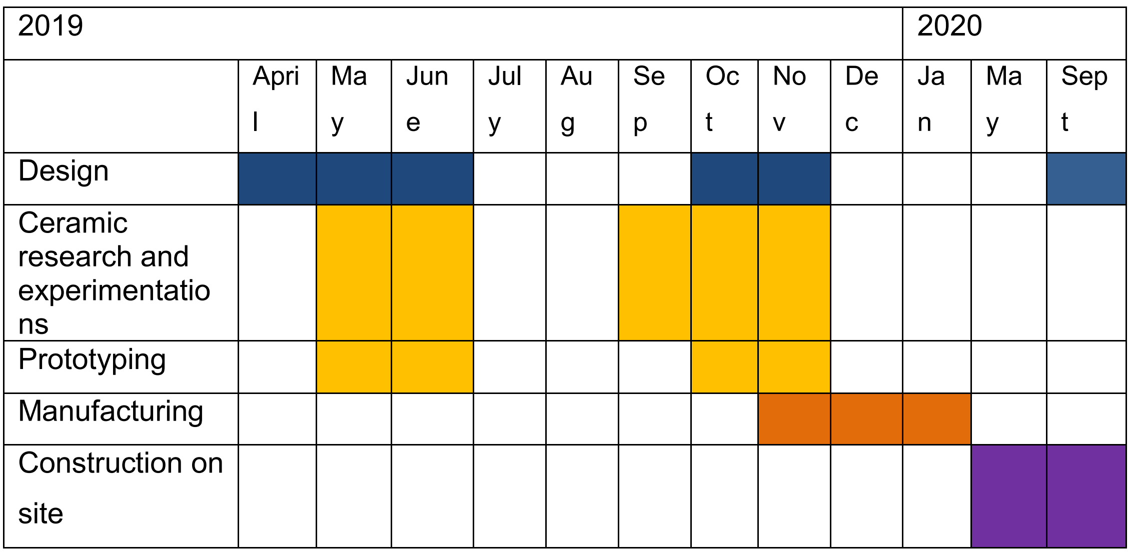


Fig. 4.48. *Timescale of case study 2*

4.6.3 Project context

The local historical and material context influenced the design, material choices, craft techniques and manufacturing methods for the Ornamental Wall. The context of this project, in contrast with the city-centre location of case study 1, is a suburban residential street in North London. The original front garden wall that was replaced in the course of this project faced the public highway and separated the 1910 semi-detached house from the public pavement (Figure 4.49). Front gardens as a typology were introduced to English houses in the 19th century to provide privacy and physically separate the semi-private realm from the public street. Gardens surrounding houses were one of the features of the picturesque suburbs at the time, evoking a feeling of proximity to nature in opposition to the "increasingly hostile inner-city environment" (Miele, 1996). The area was developed in response to the poor living conditions of workers in the expanding inner city at the beginning of the 20th century.

The romantic movement of the early 19th century originated as a reaction to industrialisation and provided a basis for late Victorian and 20th century suburban developments which aspired to imitate images of rural England, with architectural detailing derived from vernacular architecture. The vocabulary of the vernacular revival included timber framing, pitched roofs with jutting gables, covered with clay tiles and ornamental finials, roughcast surfaces and textured traditional materials (Miele, 1996). The designs for the bespoke bricks developed for this case study - as well as the craft making and manufacturing processes - were developed in response to these historical and local contexts, including the social, political and aesthetic values of the Arts and Crafts movement which led to the development of the area and informed the aesthetic vocabulary and detailing of houses.

Fig. 4.49. *The original front garden wall and houses featuring steep tiled roofs, prominent, jutting gables and timber framing* (2019)

Both the exteriors and interiors of the houses on the street feature detailing demonstrating craftsmanship through the use of natural materials. These include stained glass doors and windows, clay ornamental roof finials, and ceramic, wrought iron and brass surrounds for fireplaces, featuring abstract floral motifs (Figure 4.50).

Fig. 4.50. *Interior detailing of the house* (2019)

A number of front garden walls along the street were built following the architects' preference for tactile "picturesque" materials. Hand-made bricks, tiles and 'clinker' bricks were used to provide feature inserts into the walls. Some of the walls have uneven, rough surfaces and rich colour and texture variation (Figure 4.51).

Fig. 4.51. *Walls along the street built using tactile materials* (2019)

The original wall was made out of solid handmade bricks, with the coping bricks made out of a different clay fired to a higher temperature to withstand water ingress. The wall also featured two decorative inserts made out of clinker bricks that are characteristic of the area. The material became popular with Arts and Crafts architects for its tactile qualities such as rough texture, colour variation and uneven surface, and was used in many feature walls built during this period in the area (Figures 4.52). My bespoke decorative bricks were designed and manufactured in response to the richness of the existing context, utilising ornamentation, ceramic craft qualities and characteristics of coloured glaze.

Fig. 4.52. *The original wall that was replaced* (2019)

4.6.4 Design intent

The brief for the project following negotiations with the neighbour was to replace the existing front garden wall that had become structurally unstable with a wall of the same size and configuration. Set in a sensitive local context, and responding to the neighbours' requirement to make the new intervention "subtle", the proposed wall was designed to be context responsive. The aim of the design was to contribute to the streetscape and aid a sense of ownership among the neighbours, through the integration of bespoke DFACs that reflect locality and site-specificity, and at the same time, question the notion of a wall being a physical non-permeable boundary through the introduction of decorative and tactile elements into the structure. Taking advantage of the waterproof qualities of glazed ceramics, glazed brick cappings and pier caps that channel water off the top of the wall were designed in order to investigate how function and decor could be integrated simultaneously into the structure.

4.6.5 Design, craft and manufacturing processes; Ceramic craft and material qualities

The design process for this case study was non-linear and iterative. Overall design for the wall ran in parallel with the ceramic experimentations and prototyping, which highlighted the necessity for continuous communication and information exchange between architectural and ceramic practices.[49]

> ***Insight 4.29:*** *Time for material testing, experimentation and prototyping built into the programme of the project enables the design development, craft making and manufacture of bespoke DFACs.*

The new wall was designed to be "not higher than existing" to ensure that no planning permission was needed, while rigidity, load-bearing capacity and protection from the ingress of surface water were the utilitarian properties necessary for the wall to be “structurally sound and maintained" (Planning Portal, 2021). I specified the thickness, structural detailing and materials for the wall following a consultation with a facade specialist.

> ***Insight 4.30:*** *Knowledge of planning and technical requirements and knowledge exchange with technical specialists enables overall design and structural integration of bespoke DFACs.*

To construct the visual and material language in response to my guiding principles, I surveyed the local context by photographing, sketching and modelling the ornamental features and detailing of the house and the elements of the street. The iterative design process included initial free-hand sketches, 2D scale drawings and 3D computer models that enabled physical prototyping using CNC milling, laser cutting and plaster casting. These aided the manufacture of bespoke bricks that combined digital, hand-craft and industrial processes. Figure 4.53 shows how the abstract designs for the facing bricks were developed through the use of floral motifs taken from the house interior.

> ***Insight 4.31:*** *The design development, craft making and manufacture of bespoke bricks requires continuous exchange between the practices of ceramic artist and architect.*

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[49] Experimentations that facilitated and preceded the final designs for the wall are included in section 4.2.

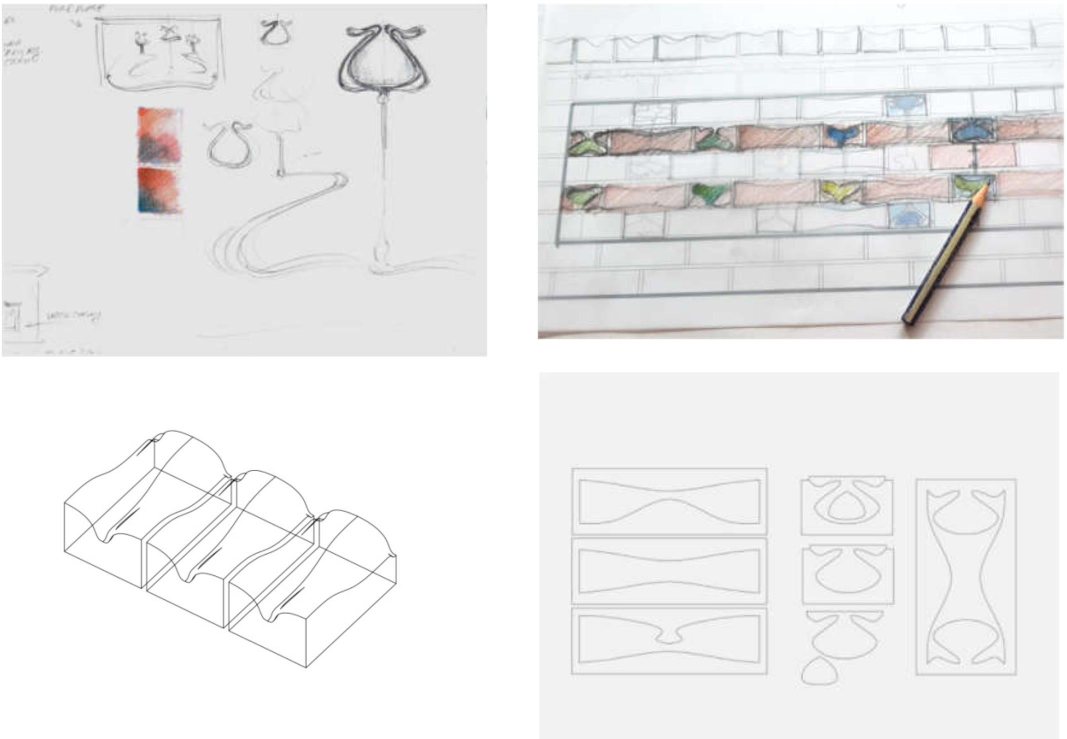

Fig. 4.53. *Design development. Clockwise from top left: sketches of fireplace detailing; The abstract motifs of the detailing used as relief for the wall; Drawing of laser cut profiles used for creating the brick relief: 3D models of capping bricks* (2019)

To introduce low relief to the face of the brick, I initially hand-carved unfired standard extruded bricks using laser-cut profiles (Figure 4.54). Reflection on the manual process resulted in altering the carving profiles and relief designs.

Fig. 4.54. *Manual carving of extruded bricks to achieve low relief.* (2019)

Considering the labour-intensive and time-consuming process of hand-carving, led me to develop an alternative method of relief application to the standard factory hand-made bricks, that of customisation of brick moulds.[50] The bespoke bricks for the Ornamental Wall were made at the Ewhurst factory using the same amount of clay, manufacturing time and standard drying and firing processes used for solid handmade bricks, thereby offering a cost-effective solution. Custom-made moulds, 3D inserts and laser-cut profiles produced at the Digital Fabrication Bureau facilitated the manufacturing of bespoke bricks. Added to this, the time allocated for manufacturing enabled the creation of solid ornamental hand-made bricks that have longer drying and firing times than extruded pieces.

> ***Insight 4.32:*** *Use of university digital facilities enables prototyping and tooling that facilitate the creation of bespoke bricks.*

> ***Insight 4.33:*** *Knowledge of manufacturing processes and early experimentations enable the development of innovative cost-effective solutions.*

> ***Insight 4.34:*** *Knowledge of the manufacturing time enables project programming to facilitate the creation of bespoke DFACs.*

To achieve relief ornamentation, plywood profiles were introduced to the 'bed' of the standard brick moulds to achieve modulation in the depth of the surface of the wall from shallow to deep. The bespoke elements were produced collaboratively, working alongside the makers at the factory. The bricks were made by the brick makers, while I hand-carved the bullnose corners for the wall and stamped them with the abstract floral motif, using curved plywood profiles (Figure 4.55). The deeper and more intricate reliefs were introduced towards the top of the wall while the lower part was kept shallower to attract less dirt sprayed off the ground during rain (Figure 4.59).

> ***Insight 4.35:*** *Prototyping in the industrial setting facilitates development of innovative products and processes.*

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[50] My investigation into manufacturing processes and customisation, and my design experimentations described in section 4.2 enabled the development of innovative method of relief application.

Insight 4.36: *Working alongside the staff at the factory enables knowledge exchange and co-creation to take place.*

Fig. 4.55. *Brick making process. Clockwise from the top: plywood cut-outs designed to create the relief surface by layering a standard mould*; *bricks made by a brick maker, modified by myself using plywood profiles and stamps* (2020)

The overall design of the wall was influenced by the way the individual modules were created. To construct the wall I have utilised the 'rat-trap' brick bond, which is characterised by the bricks placed on edge with the 'bed' forming the face of the wall. The choice of this brick bond was influenced by the fact that the decorative patterns were produced on the 'bed' in a standard brick-making process. The bricks on edge are alternated with brick 'headers' (Figure 4.56 and 4.59).

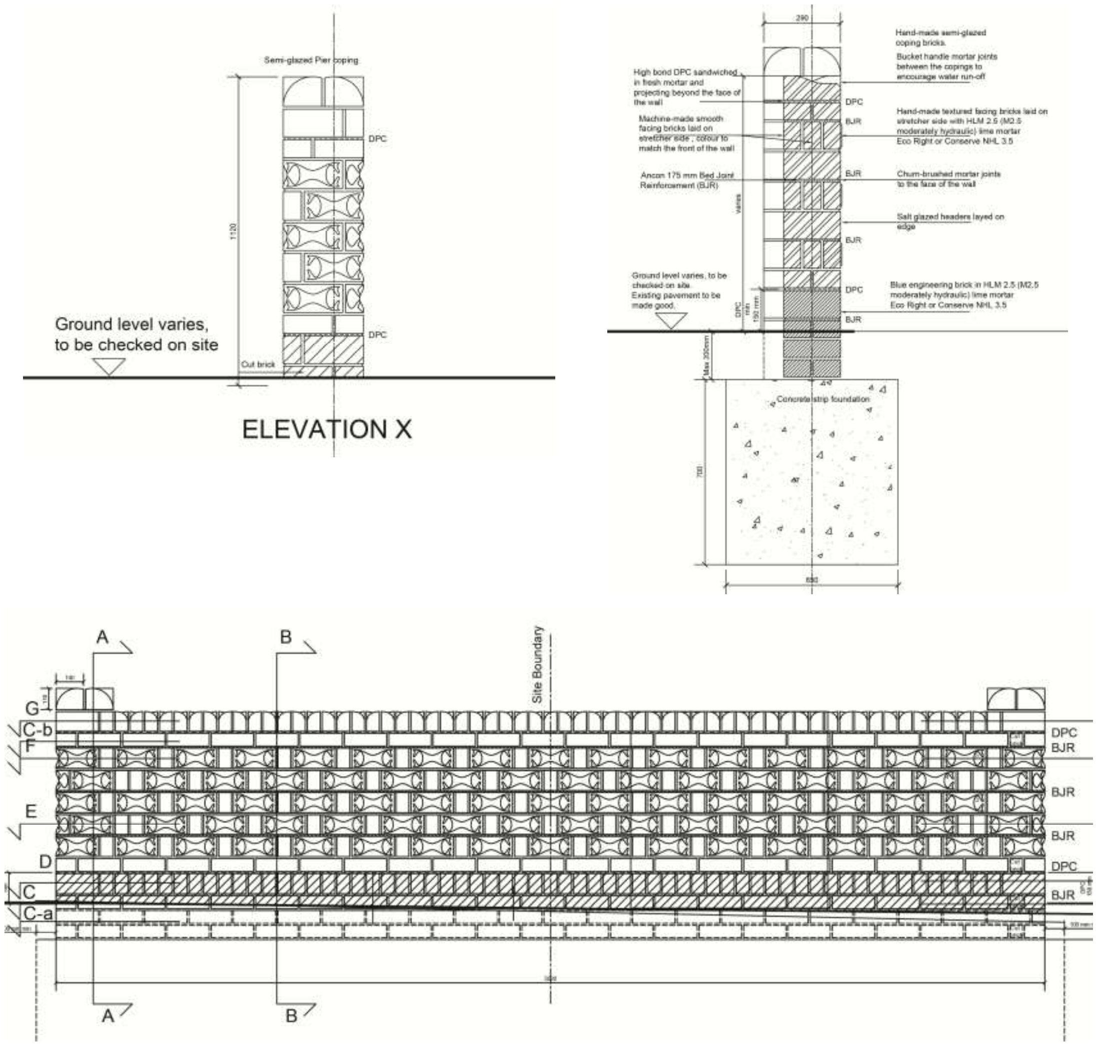

Fig. 4.56. *Drawings used for the information exchange with the engineer and utilised in the construction process by the bricklayers. Clockwise from top left: side elevation, section and front elevation of the wall*

The property of glazed ceramics to hold and channel water was explored in the design of the brick cappings. Double-curved 3D glazed sculptural elements were designed to channel water off the top of the wall. Following my design experimentations described in section 4.2.3.2, the CNC milled reliefs were incorporated into custom-made moulds by the makers at the factory; the moulds were used for manufacturing the capping bricks (Figure 4.57). As there were no glazing facilities at the Ewhurst factory, the brick cappings and bullnose bricks were shipped to the H.G. Matthews brick factory, where these were glazed. [51] The bricks

[51] The glazing process and knowledge exchange with the glazing specialists is described in section 4.2.5.

were then subsequently transported to the site in London, where the construction of the wall was carried out over two days by specialist bricklayers (Figure 4.58).[52]

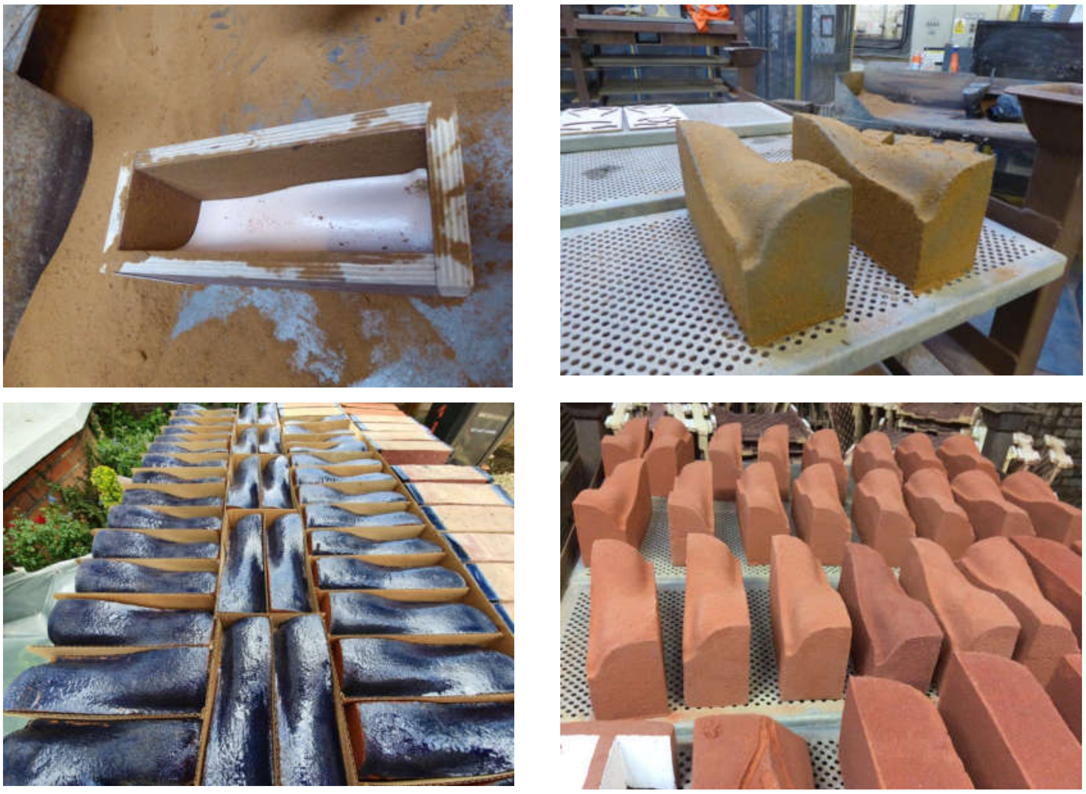

Fig. 4.57. *Manufacture of capping bricks: Clockwise from top left: wooden mould with CNC milled insert, unfired capping bricks made in a mould, fired brick cappings, cappings glazed at the H.G. Matthews factory and delivered to the site* (2020)

[52] Due to factory closures caused by the COVID-19 pandemic, there was a delay in glazing the bricks and the construction of the wall was postponed until May 2020.

Fig. 4.58. *Construction of the wall. Clockwise from top left: pouring the concrete foundation, setting out the brickwork, levelling the top row of bricks and pointing the brick cappings with traditional lime mortar* (2020)

Fig. 4.59. *Detailing of the Ornamental Wall. Clockwise from top left: ‘rat-trap’ brick bond made with bespoke ornamental bricks and salt-glazed ‘headers’ manufactured at H.G. Matthews factory; double-curved brick cappings; semi-glazed bullnose bricks* (2020)

Fig. 4.60. *Ornamental wall completed in May 2020* [53] (2020)

The pier caps for the wall were made out of customised ready-made pieces in order to speed up the installation (Figures 4.61). H.G. Matthews' ready-made 'standard special' brick corners were used to fit the geometry of the piers that were already built. Each pier cap was made out of four ready-made pieces that were cut using a band-saw at the factory, glazed and assembled to channel water off the top surface. Figure 4.62 shows the detailing and images of the complete wall.[54]

> ***Insight 4.37:*** *Engaging with an industrial manufacturer which has glazing facilities, enables the creation of glazed decorative bricks, and the development of ceramic craft qualities.*

[53] Pier caps were manufactured and installed in September 2020 due to the COVID-19 factory closure.
[54] The detailed record of design, making and construction of the Ornamental Wall is included in Appendix A.4.

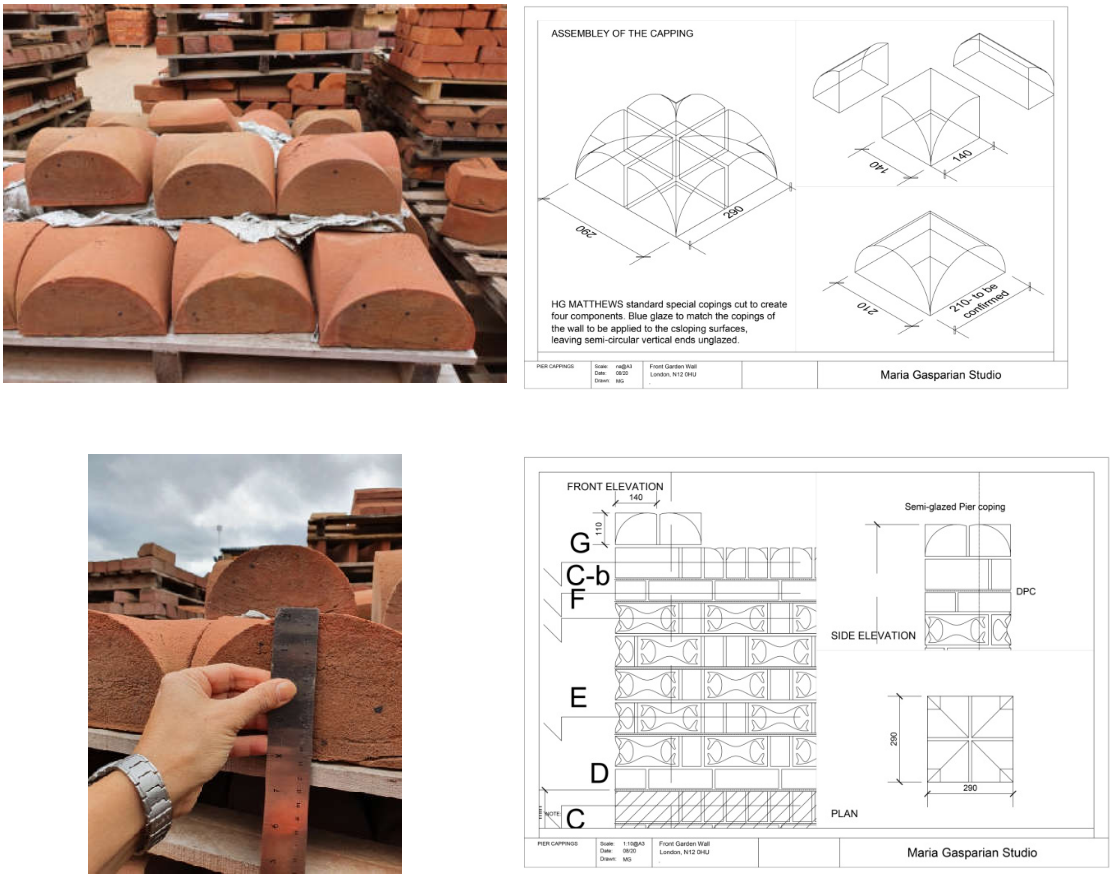

Fig. 4.61. *Design of the pier caps* (2020)

Fig. 4.62. *Completed Ornamental Wall. Clockwise from top left: glazed pier caps installed; Wall integrated into the streetscape* (2020)

4.6.6 Relationships and knowledge exchange

Collaborations and knowledge exchanges took place during this case study facilitating the design, material research, experimentation, prototyping, craft making, manufacture of ornamental bricks and the structural integration of these into a front garden wall (Figure 5.63). The knowledge exchange between myself, in the capacity of ceramic artist and architect, and the other participants of the project enabled the design development, prototyping and material experimentation leading to design iterations and manufacture of final pieces for the wall.

Innovative brick designs were developed through digital prototyping and tooling, aided by knowledge exchange with the staff at the Digital Fabrication Bureau (see sections 4.2.3). My design development, experimentation and engagement with the makers at the Ewhurst brick factory led to co-creation of bespoke ceramic pieces, which resulted in optimisation of bespoke designs, customised brick-making processes and in-house mould-making. My work at H.G. Matthews brick factory aided the glazing of the ornamental corners and brick cappings, while knowledge exchange with glazing specialists facilitated the development of ceramic craft qualities (section 4.2.1.).

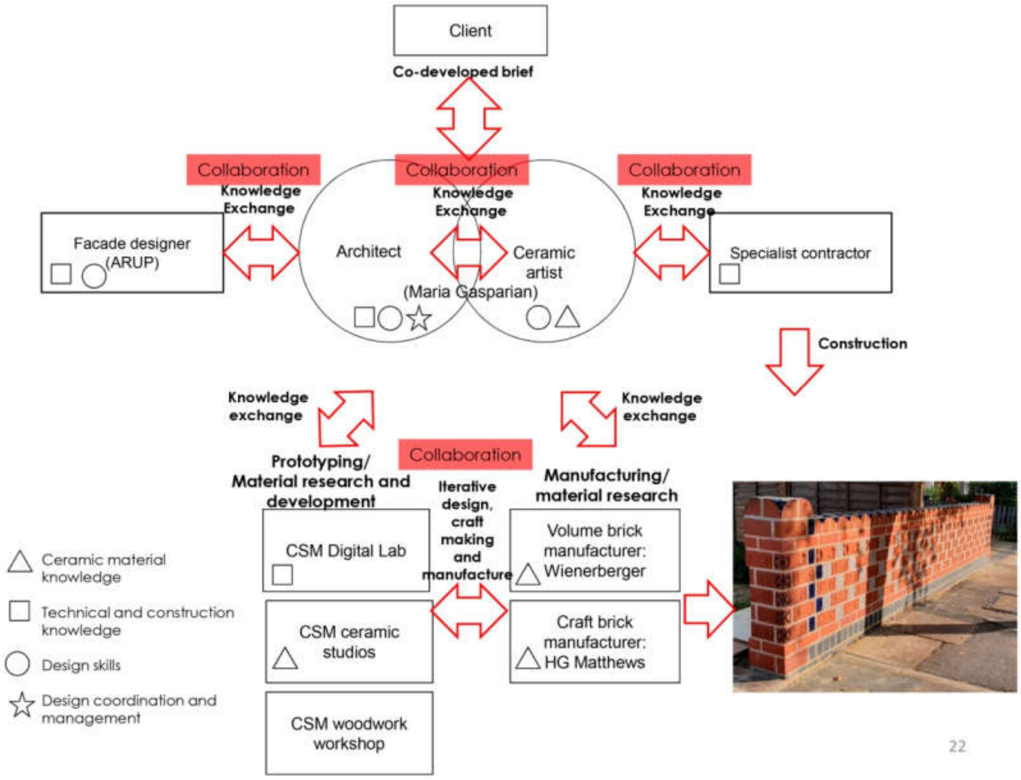

Fig. 4.63. *Relationships of project participants, information and knowledge exchange during the design, craft making and manufacture of bespoke bricks for the Ornamental Wall*

To ensure the structural stability of the wall, I consulted a specialist facade designer who has extensive experience of brickwork detailing. He provided advice on the structure and reinforcement of the wall, and the mortar and brick pointing techniques. Our information exchange took place through annotated sketches which are shown in Figure 4.64.

Finally, my collaboration with the bricklayers on site enabled the construction and structural integration of the bespoke bricks, while the traditional mortar and pointing of the brick joints were implemented as a result of my earlier information exchange with the facade designer.

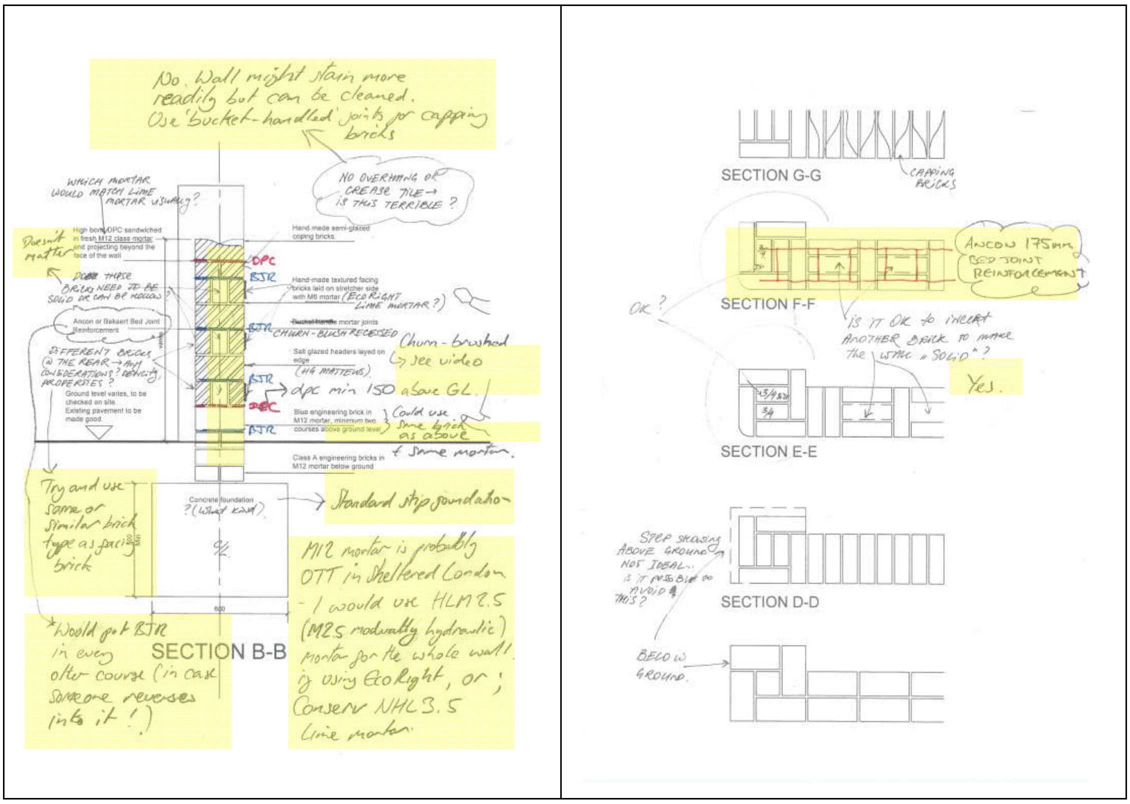

Fig. 4.64. *My information exchange with the specialist facade designer*

4.6.7 Summary of insights from case study 2

My practice during the course of design, prototyping and manufacturing of the Ornamental Wall provided insights into material and ceramic craft qualities, ceramic craft and manufacturing processes, and the relationships between the stakeholders. Engaging with industrial manufacturers, staff at the digital facilities, material workshops and ceramic studio, facade designer and contractors during this case study has elucidated that the design development, craft making and manufacture of bespoke bricks requires collaboration between the specialist practices leading to knowledge exchange.

My knowledge of manufacturing processes and early experimentations enabled the development of innovative cost-effective solutions. The time for material testing, experimentation and prototyping built into the programme of the project allowed me to iterate the designs building on the results from my ceramic experimentations and to further develop the aesthetic material vocabulary that can be achieved by combining digital and craft techniques with industrial manufacturing processes answering RQ 2.

Use of the university digital facilities aided the creation of tools that facilitated prototyping in the industrial setting and facilitated the development of innovative bricks and processes. At the same time, working alongside the staff at the factory enabled knowledge exchange and co-creation to take place. Engaging with an industrial manufacturer which has glazing facilities enabled the creation of glazed decorative bricks and the development of ceramic craft qualities. My collaboration with the bricklayers onsite ensured the construction of intricate brick detailing.

4.7 Conclusion

While the precedents and contextual review included in Chapter 3 mapped out the area of this research and generated emerging insights, this chapter investigated the relationships between the stakeholders and the factors that facilitate the creation of bespoke DFACs through my transdisciplinary practice (RQ1). The processes which can facilitate the creation of ceramic craft qualities, combined with the material qualities required for the structural integration of bespoke DFACs were explored through my material research, experimentations and two case studies. Use of digital tools and techniques and explorations into ceramic glazing contributed to the creation of my case studies which featured bespoke decorative bricks integrated into the structures. My practice development brought to light the facilitating role of personal engagement and knowledge exchange at the factories (Insights 4.24, 4.35, 4.37). My ceramic making, communication and co-creation with brickmakers led to the successful customisation of industrial processes and the manufacture of innovative bespoke DFACs (Insights 4.20, 4.36).

It has been established through my practice, that collaboration and knowledge exchange between the architect, ceramic artist, and industrial manufacturers can facilitate the creation of bespoke bricks (Insights 4.11, 4.23). The collaboration with engineers and specialist contractors - which are an established part of architectural practice – enable integration of bespoke bricks into structures (Case study 1 and 2).

This is shown in the analytical diagrams included in case studies 1 and 2 (Figures 4.43 and 4.63). Figure 4.65 demonstrates the enabling links between the practices established through the case studies: The roles of ceramic artist and architect are separated here, to highlight the links between each practice with other stakeholders. While the constraints of case study 1 limited my ceramic experimentations during the project, case study 2 explored the enabling role of digital and material workshops and their staff in design development and material research (Insights 4.6, 4.8, 4.32).

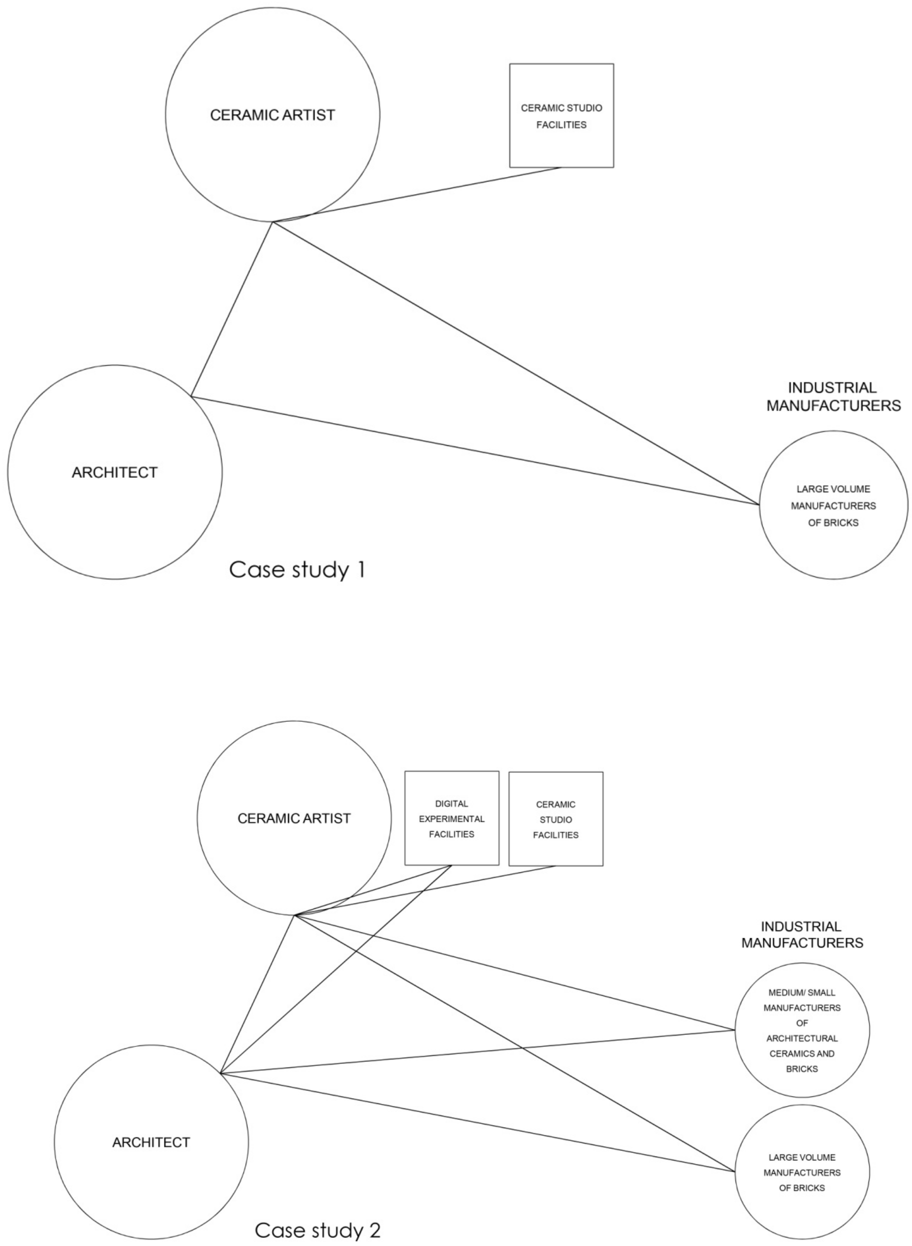

Fig. 4.65. *Collaborative links established between the stakeholders during case study 1 and case study 2*

It has been shown in this chapter that a knowledge of manufacturing processes and preliminary material research and experimentation are critical for design development, craft making and manufacturing of DFACs in the tight timeline of a project (Insights 4.3, 4.10, 4.22, 4.24, 4.29, 4.33, 4.34, case study). At the same time, material research and experimentation included in the programme of the project facilitate project-specific innovative solutions (case study 2).

It was established that the university digital and craft workshops can facilitate material research, experimentation, prototyping and the creation of tools for use in industrial settings (Insight 4.8, 4.32). At the same time, flexible manufacturing facilities that produce heritage and ‘standard special’ bricks within large volume brick manufacturing allow the production of small quantities of bespoke bricks (Insight 4.12).

Digital tools that can customise standard products and manufacturing processes, without adding to the production time, were explored through my practice. It was shown that whilst traditional ceramic craft techniques applied to standard clay products aid the creation of ceramic craft qualities, utilising makers’ material knowledge and individual input facilitates innovation (Figure 4.66).

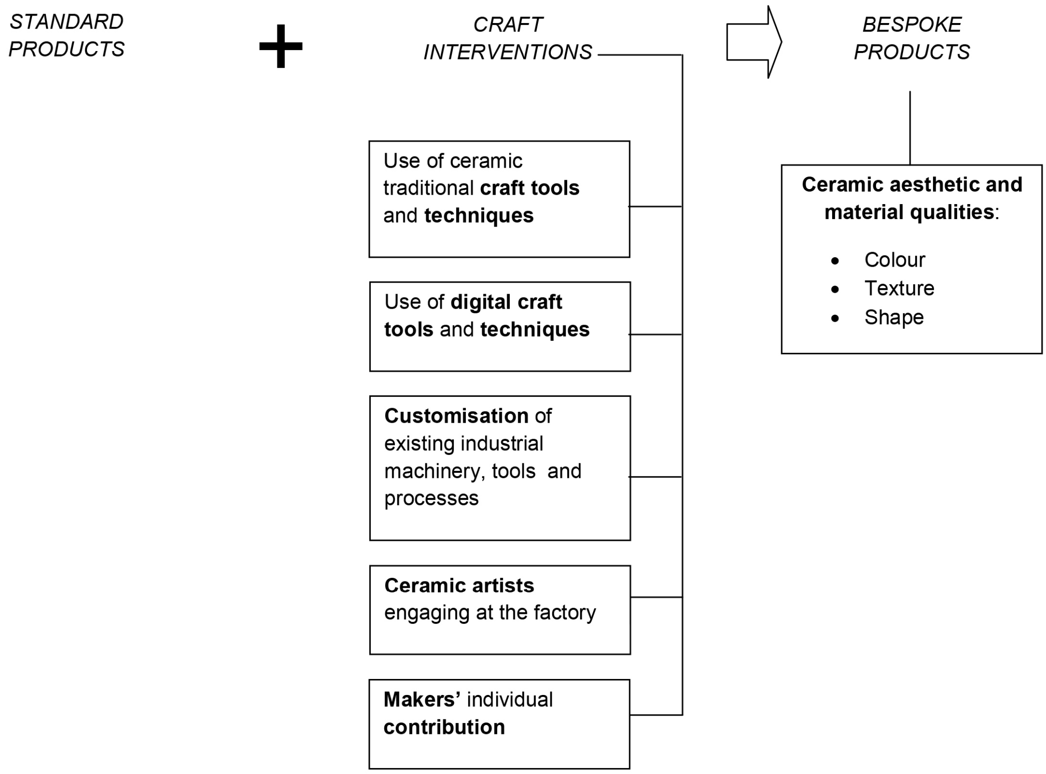

Fig. 4.66. *Interventions into manufacturing processes which facilitate the creation of bespoke DFACs*

While aiming to establish how to facilitate the practice of ceramic artists, architects and industrial manufacturers in the creation of bespoke DFACs, it is critical to engage with representatives of these sectors to elicit critical feedback on my emergent insights and to gain a richer understanding of the factors that facilitate and inhibit the design, craft making and industrial manufacture of bespoke DFACs. In order to achieve this, I set out to engage with expert stakeholders of this research through semi-structured, in-depth interviews.

CHAPTER 5
ENGAGEMENT WITH EXPERT STAKEHOLDERS: INTERVIEWS

5.1 Overview

My communications with the stakeholders involved in the design, manufacture and structural integration of DFACs is an intrinsic part of this research and has contributed to the key insights, included in Chapters 3 and 4, addressing my research questions.

This chapter comprises an analysis of my engagement with expert stakeholders through semi-structured interviews (hereafter referred to as Engagement). The objective of the interviews is to gain a deeper understanding of the relationships between the practices of ceramic artists, architects and industrial manufacturers, as well as the factors that inhibit and facilitate the design, craft making and industrial manufacture of bespoke DFACs (RQ 1). Through this process, critical feedback can be gained on the findings that emerged from the analyses of historic and contemporary precedents, context analysis and my practice investigations by drawing out new insights.

To facilitate the discussion on ceramic craft qualities and the material qualities of DFACs and the ceramic craft and manufacturing processes used to achieve these qualities (RQ 2), I shared my ceramic practice with the expert stakeholders in the form of 'cultural probes'[55]: scale model bricks and accompanying documents containing photographs of full-scale pieces.[56]

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[55] The use of cultural probes was originally proposed by Gaver, who used physical objects to "provoke inspirational responses from elderly people in diverse communities" (Gaver et al., 1999). Detailed information on my use of cultural probes is included in section 5.3.

[56] Originally the engagement with expert stakeholders was planned to take place during the exhibition of my ceramic practice in May 2020, where the physical installation of my ceramic work was designed to provide the basis for the engagement and feedback. Due to the COVID-19 pandemic, the exhibition was cancelled and a new form of engagement, comprising in-depth qualitative interviews with selected expert stakeholders was designed and took place online.

5.2 Interview planning, process and analysis

5.2.1 Purposeful sampling

A group of participants was selected for in-depth interviews using several strategies (Galletta, 2013). Initially, ten individuals representing each of the following groups of professionals, ceramic artists, architects, and manufacturers engaged in the creation of bespoke DFACs were selected by using: i) my professional contacts established during my contextual review and my case studies; ii) annual publications of the Brick Awards and Architects Journal, which outlined projects that included bespoke DFACs; and iii) the *Hand Held to Super Scale: Building with Ceramics* exhibition, which featured bespoke DFACs included in architectural projects.[57] These projects were used to identify project participants as potential interviewees (Building Centre, 2020).

Four of the projects included in the exhibition, were used in this research: 24 Savile Row (CP.2) and the Victoria and Albert Museum shop ceramic floor (CP.4). These projects were analysed as my precedents and formed the basis for the semi-structured interview with Richard Miller, the director of manufacturer Froyle Tiles. The Mapleton Crescent development and the Learning and Teaching Centre at Brunel University projects provided details for three of the participants for the semi-structured interviews. The Mapleton Crescent project was used as a basis for discussion with both the architect and the ceramic artist. This gave multiple perspectives on the factors that facilitated the project and the relationships within the project team.

A list of twenty participants was created through a selection process, eighteen of whom were subsequently approached by email to invite them to participate in my research. Some stakeholders were not able, for various reasons, to take part in the research. Consequently, ten expert stakeholders were interviewed and the information gathered was analysed. The interviews provided the insights that contributed to the key findings of this research.

[57] *Hand Held to Super Scale: Building with Ceramics* exhibition took place at the Building Centre in London in 2019-2020, showcasing contemporary projects with bespoke DFACs in the UK, Europe and the USA during the past 10 years. These included custom-made glazed facade systems and ceramic wall and floor ceramic tiles.

5.2.2 Interview planning

Potential participants were initially approached by an email with follow-up telephone calls. The email introduced the topic of research, outlining the relevance of the subject to the participant's practice and the purpose of the interview. It also included the duration of the interview and how the data obtained in the interview will be used (Galletta, 2013). For participants who agreed to take part in the research, an introductory letter containing a consent form, based on the approved University of the Arts form, was sent out to them to be signed by each participant. The letter was followed by the cultural probes which were sent in the post.

The COVID-19 pandemic restrictions at the time of the interviews led to the interviews taking place over a video conferencing platform. Video and audio recordings of the interviews were made with the consent of the participants. Subsequently the interviews were transcribed, coded and analysed.

5.2.3 Emergent themes and insights

The emergent themes and sub-themes identified through the context analysis, the precedents and my case studies, as shown in Table 5.1, formed the topics for discussions in my semi-structured interviews. The interviews added a nuanced understanding of these topics and brought to light new themes, connected to the aspects of design, craft making and industrial manufacture of bespoke DFACs. Some of the insights that emerged from the interviews address more than one theme. Grouping the insights within these themes, summarising them and layering data from the other parts of this research aided in the writing up of the key insights included in section 5.6. These, in turn, contributed to the key findings of this research.

Themes	Sub-themes
Design, ceramic craft and manufacturing processes	• Design process • Ceramic craft processes • Industrial manufacturing processes
Collaboration and knowledge exchange	• Project coordination by the architect • Ceramic artist's engagement at the factory • Co-creation • Industrial manufacturer's support • Facilitation by makers • Specialist contractor's support
Cost	• Cost of manufacturing • Cost of material research and experimentation/R&D • Cost of testing and certification • Design costs
Digital tools and processes	• Digital design tools • Digital fabrication • Digital prototyping
Facilities	• Ceramic studio facilities • Digital fabrication facilities • Experimental facilities • Factory facilities
Flexibility of manufacturing	
Innovation	
Legislation	
Material and ceramic craft qualities	• Ceramic craft qualities • Ceramic material qualities
Material research and experimentation/ Research & Development (R&D)	
Planning	
Risk	• Risk associated with use of craft processes
Scale of manufacturing	
Specialist knowledge and skills	• Ceramic material knowledge • Design skills

	• Knowledge of manufacturing processes • Knowledge of construction
Testing and certification	
Time	• Time for architectural design • Time for material research and experimentation/ R&D • Time for manufacturing • Time for construction • Time of specialists' involvement
Value added by bespoke DFACs	

Table 5.1: Themes and sub-themes generated from contextual review, precedent analysis and my case studies

5.3 Cultural probes

The idea of cultural probes was introduced by Gaver in 1999: physical objects were given to research participants to generate ideas and qualitative feedback (Gaver et al., 1999). Abildgaard suggests that material artefacts can act as an "elicitation device", to aid the qualitative interviewer by providing specificity and can be used to "aid narrative structure, guiding and prompting participants" (Abildgaard, 2018, p.8). Cultural probes in this study were introduced into the interview process, in order to facilitate the discussion of ceramic craft and material qualities of DFACs. My probes were comprised of ceramic scale model bricks, annotated photographs, drawings, and the Participant Information Document, which demonstrated ceramic craft qualities.

Boxes, each containing a set of 1:3 scale model bricks (Figure 5.1), a table of photographs (Table 5.2), and drawings showing various brick bonds (Figure 5.4) were sent to the architects and manufacturers to demonstrate the materiality of ceramics, including surface qualities and a variety of textures and forms. Ceramic artists, who work with clay and have an appreciation of ceramic craft qualities, were sent only the photographs of the model bricks and drawings showing their structural integration.

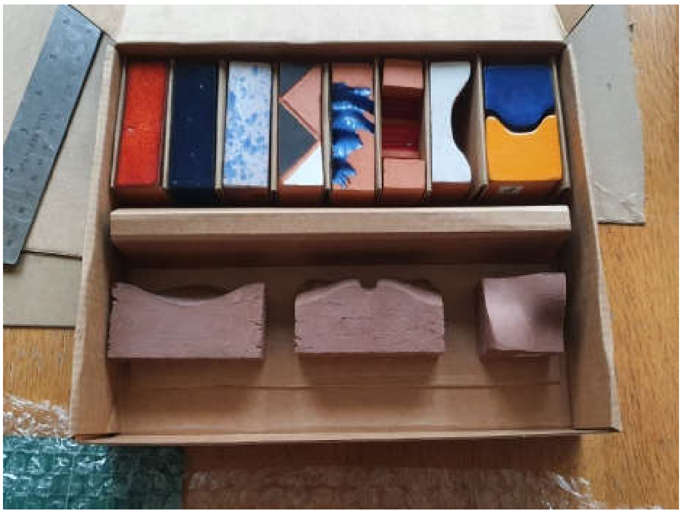

Fig. 5.1. *Set of model bricks posted to selected stakeholders* (2020)

The forming and decorating techniques that I used to make the model bricks correspond to the fabrication processes used in industrial manufacturing and to the traditional ceramic craft techniques used in ceramic craft making. Figure 5.2 shows the tools and processes that I used to produce the bricks at the ceramic studio at Central Saint Martins (CSM). The laser-cut extrusion dies were made at the CSM Digital Fabrication Bureau.

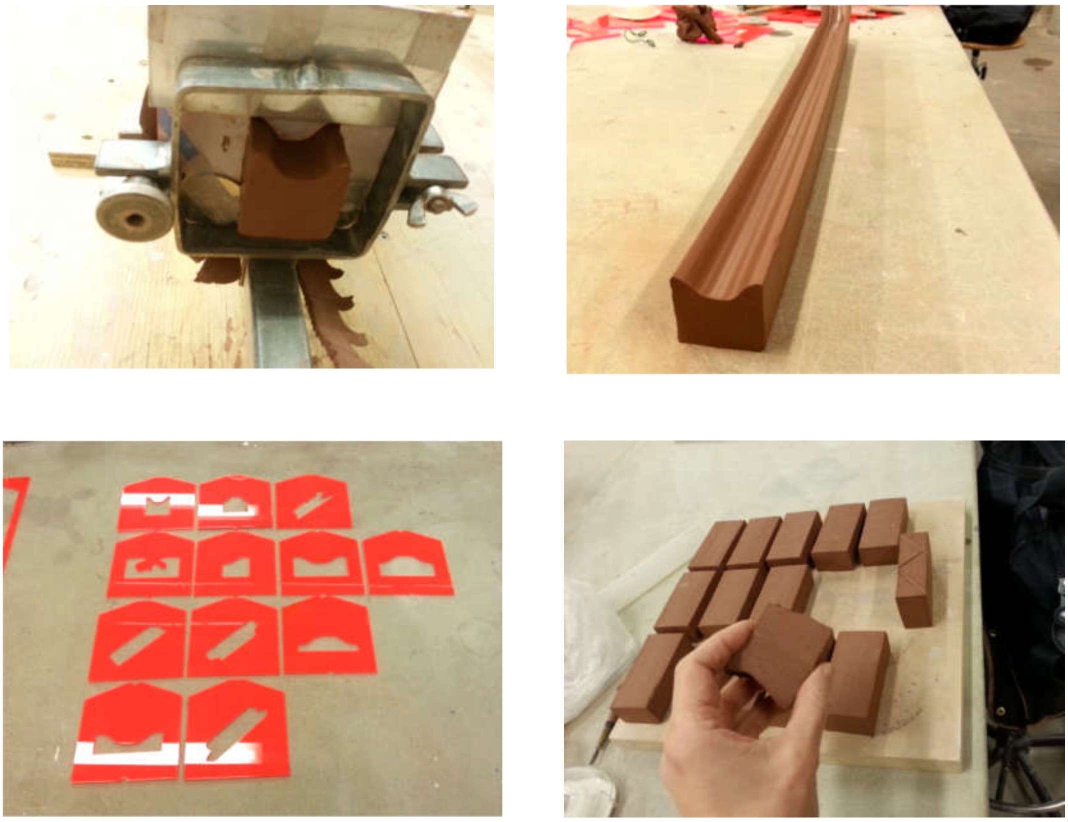

Fig. 5.2 *Hand-made extrusion representing the industrial process on a smaller scale* (2020)

Digital fabrication techniques were used in three of the model bricks to create deep relief and complex curves, which cannot be achieved through an extrusion method (model numbers 10, 11 and 12, Table 5.1). CNC milled prototypes were used for making plaster moulds for the models (Figure 5.3).[58]

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[58] Making of full-size bricks of the same geometry was tested in collaboration with the manufacturers as described in Chapter 4, section 4.2.3.2.

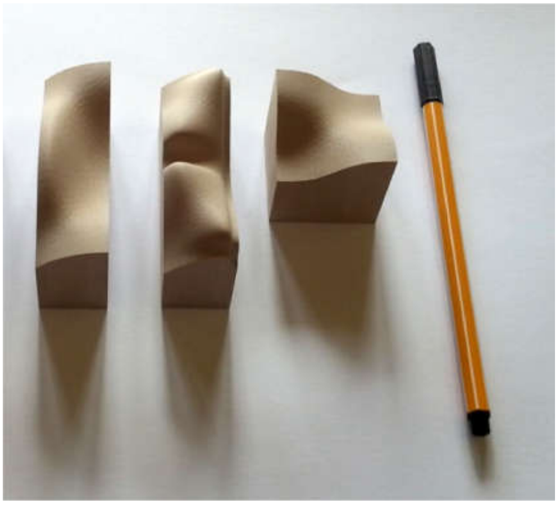

Fig. 5.3. *CNC milled model prototypes* (2020)

To facilitate the discussion of manufacturing methods during the interviews, I indicated the processes that would have been used for the manufacturing of full-size bricks in an industrial setting in Table 5.2. Ceramic craft techniques and decorating processes were also included in the table next to the photographs of the bricks to aid the discussion on ceramic craft qualities. An examination of the colour, texture and shape of the model bricks and the information on manufacturing methods, led to the discussions with the manufacturers on the design and manufacturing possibilities that can facilitate the creation of bespoke DFACs and aid diverse aesthetic outcomes in full-scale products and assemblies.

Table 5.2 shows the models arranged in a progressive set, from flat glazed surfaces to a deep relief and complex curves demonstrating the creative possibilities in the creation of bespoke decorative bricks. Brick model numbers 1 and 2 show colour glaze applied to the facing surfaces. Model number 3 demonstrates the use of cobalt oxide sprayed over a tin glaze, creating varied patterns. Number 4 shows the use of decorating colour slips and a scoring of the surface which allows for the creation of patterns when laid in different brick bonds. Model number 5 includes a hand-carved surface created by manipulating a textured metal wire creating bespoke sculptural forms. Model number 6 is a scale model of a decorative brick used in my case study 1 (Chapter 4). Models 7, 8 and 9 are made by using custom-made extrusion dies highlighting the cost effective method of achieving various brick shapes. Models 10, 11 and 12 demonstrate complex curves that can be achieved by hand-making process using customised moulds.

Models	Colour & Texture; Materials used to achieve the colour and texture	Shape of the brick; craft techniques used to achieve the shape	Industrial forming methods to manufacture full-size bricks
 1	Red shiny earthenware glaze	Standard rectangular	Extruded through standard die
 2	Blue-grey shiny earthenware glaze	Standard rectangular	Extruded through standard die
 3	White shiny tin glaze, cobalt oxide sprayed over the glaze	Standard rectangular	Extruded through standard die
 4	Black and white decorating slips	Standard rectangular; Surface of the brick scored manually	Extruded through standard die

 5	Blue- grey shiny earthenware glaze	Standard rectangular; Carved manually with wire	Extruded through standard die
 6	Coloured underglaze and transparent shiny glaze over	Standard perforated; Carved manually with a blade	Extruded through standard die
 7	White decorating slip and matt transparent glaze	Bespoke shape	Extruded through bespoke die
 8 & 9	Coloured underglazes and shiny transparent glaze	Bespoke shapes	Extruded through bespoke dies
 10	n/a	Bespoke shape	Pressed in bespoke mould

 11	n/a	Bespoke shape	Pressed in bespoke mould
 12	n/a	Bespoke shape	Pressed in bespoke mould

Table 5.2. Images of 1:3 clay model brick and notes on forming and decorating methods corresponding to the industrial manufacturing processes and ceramic craft techniques

Figure 5.4 shows the drawings that accompanied the model bricks both in hard copy and electronically. The aim of the drawings was to demonstrate how bespoke bricks can be structurally integrated into standard wall constructions, achieving diverse aesthetics.

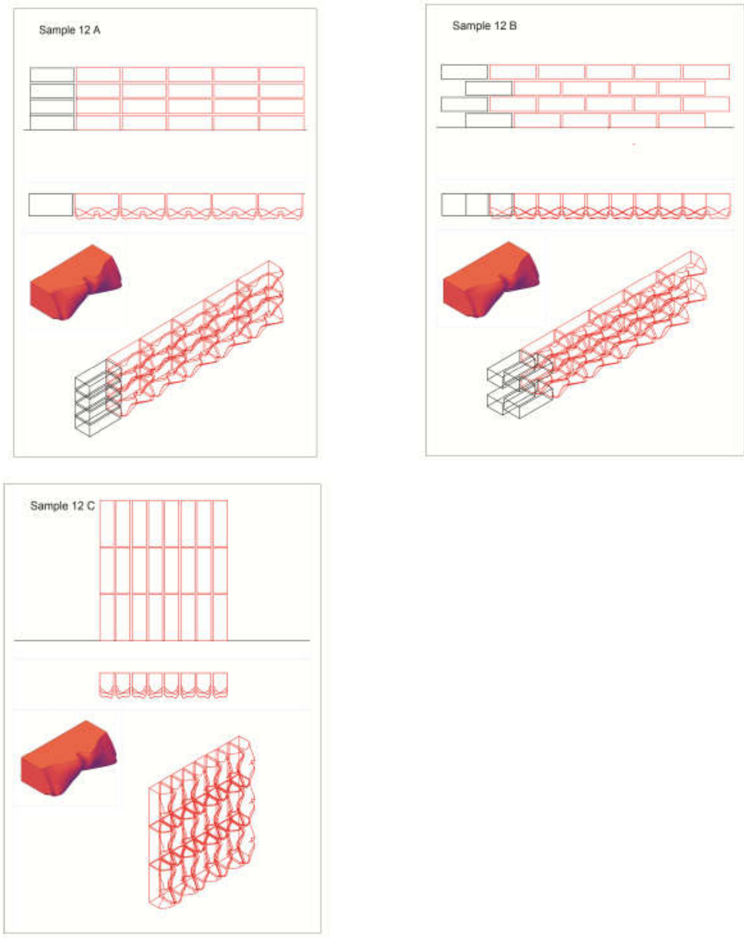

Fig. 5.4. *Drawings showing assemblies of bespoke bricks (Model 12) within a standard brick wall. Bespoke bricks are shown in red, standard bricks are shown in black*

The role of the Participant Information Document was to introduce my thesis to the expert stakeholders, during the Engagement and to facilitate discussion on the material and ceramic craft qualities of bespoke DFACs. The document was structured to focus the discussion onto the key areas and themes of this research, aiming to bring to the forefront the functional and aesthetic possibilities of bespoke DFACs, and decorative bespoke bricks in particular. It included an abstract of my thesis and the aims of this research as well as images of historic precedents, my two case studies, and details of how my ceramic practice had developed through this research. Three categories of non-standard bricks[59] were included in the document setting the UK brick context.

[59] See Definition of terms, Chapter 1.

5.4 Participants of the Engagement and interview content

Table 5.3 includes the ten expert stakeholders who were interviewed as part of the Engagement. Architectural projects, featuring the bespoke DFACs included in the table were utilised to identify potential interviewees, helped to structure the interviews and aided discussion. Six of those interviewed were engaged in these architectural projects. I approached ceramic artists, architects and manufacturers in each of the projects to gain multiple perspectives on the creation and structural integration of bespoke DFACs. My communications with the stakeholders are identified in the table.

I interviewed three representatives of UK brick manufacturers: Nigel Dyer, the Heritage Services Manager at Wienerberger Ewhurst factory, whose facilities I utilised during my practice investigation; Andy Batterham, who I approached because he is responsible for innovation at Ibstock Plc, one of the UK's leading brick manufacturers; Alex Patrick-Smith, the director of Ketley Brick manufacturer was approached to investigate manufacturing processes and opportunities within medium-scale brick manufacturing.

Duncan Hooson, a ceramic artist and educator was approached to discuss the issues connected to the education of ceramic artists and ceramic art practice in the UK connected with the creation of bespoke DFACs.

Project	**Project Team**		
	Architects	**Ceramic artists**	**Manufacturers**
'The Interlock', London	Billy Mavropoulos, Bureau de Change Architects	n/a	John Richardson, Forterra
Mapleton Crescent, London	Tom Mitchell, Metropolitan Workshop Architects	Loraine Rutt	John Wimbush, NBK Terracotta (not interviewed)
Al Hikma Mosque, Aberdeen	Shahed Saleem, Makespace Architects	Lubna Chowdhary	n/a
Learning & Teaching Centre,	Michael Fostiropoulos,	Lydia Johnson, Fettle Studio	John Wimbush, NBK Terracotta

Brunel University, London	Penoyre & Prasad Architects (not interviewed)		(not interviewed)
Brick relief for a pharmaceutical company headquarters, Surrey	n/a	n/a	Nigel Dyer, Wienerberger Heritage services
n/a			Andy Batterham, Ibstock Brick Plc
n/a			Alex Patrick-Smith Ketley Bricks
• 24 Savile Row. • Victoria & Albert Museum shop floor, London	• Stephen Pey, EPR Architects • Guan Lee, Grymsdyke Farm (neither interviewed)	Kate Malone (not interviewed)	Richard Miller, Froyle Tiles
n/a		Duncan Hooson, Stage 1 Leader, BA Ceramic Design, Central Saint Martins	

In-depth semi-structured interviews Personal communications during personal meetings, via emails and telephone conversations

Table 5.3. Expert stakeholders identified and interviewed during the Engagement, July - September 2020

Each of the expert stakeholders contributed personal insights into design, craft making and manufacturing of DFACs and highlighted the relationships between the specialist practices and industrial manufacturing. The stakeholders, set out below, are in the order in which they were interviewed.

Richard Miller: Ceramic artist, Owner, Froyle Tiles

I interviewed Richard Miller, the owner of Froyle Tiles, a small-scale craft manufacturer, to investigate in detail the factors that facilitated the flexibility of the company, allowing for the manufacture of bespoke DFACs for 24 Savile Row (CP. 2) and the Victoria & Albert Museum shop ceramic floor (CP.4). New insights became apparent through detailed discussion and contributed to the understanding of inhibiting and facilitating factors in the manufacture of bespoke DFACs.

Miller noted that flexibility of manufacturing is enabled by the small-scale of the factory and the craft processes that they use. At the same time, the small capacity of the factory is an inhibiting factor in the manufacture of DFACs for large architectural projects. The high cost of testing, certification and insurance of bespoke DFACs that are created through craft processes is a major inhibiting factor for small manufacturers. This, together with the small capacity of their facilities, inhibits the involvement of individual artists and small ceramic workshops in the craft making and manufacture of bespoke DFACs.

While highlighting that the knowledge exchange within the project team on the 24 Savile Row project was the key enabling factor, Miller noted that the collaboration between multiple stakeholders on an architectural project is rare in ceramic makers' and craft manufacturers' practices. He also stated that his training in ceramic art and craft making facilitated his collaboration with the ceramic artist and the creation of craft qualities within an industrial setting.

Miller explained that involving the developer, planners, contractor and project managers in the creative process and inviting them to the factory at different stages of production facilitated their understanding of the design, craft and manufacturing processes, aiding their commitment to the material.

Loraine Rutt: Ceramic artist

The interview with Loraine Rutt was structured around her involvement in the Mapleton Crescent development, a ten-storey residential building clad in glazed ceramic extruded panels. She collaborated with Metropolitan Workshop Architects and facilitated the development of ceramic glazes, which linked the building to the site through colour and reflective qualities.

The interview brought to light that Rutt's early communication with the architects through her seminars at the architect's offices familiarised the architects with ceramic craft qualities and processes. Rutt explained that the architect's commitment to the DFACs as a cladding material in the early stages of the project enabled the material development and experimentation. Her early involvement in the project and the creation of the glazed samples at her studio facilitated planning approval and negotiation with community groups, thus enabling the project.

Rutt was engaged throughout the construction stage of the project and supported NBK Terracotta, a large volume manufacturer in the development of glazes that fulfilled the architect's brief. Responding to her samples, the standard stock glazes used at the factory were adapted for the project. Even though the aesthetic qualities of the end product were different from the samples produced in the studio, the subtle ceramic qualities were achieved through this collaboration.

Rutt noted that scaling up the making of bespoke ceramics at the factory is an inhibiting factor as it presents "the affordability of the unknown" and might result in increased costs. She also observed that the interruption of the production flow in high-volume manufacturing incurs large expenses.

Having an understanding of hand-drafted architectural drawings, as her father was an architectural draughtsman, Rutt noted the effect of the use of CAD on the duration of the design and drawing processes. While architectural production sped up, the craft processes, such as ceramic making, require more time. The difference between these two processes has to be taken into account by architects when planning the use of bespoke DFACs.

Rutt asserted that research and development (R&D) should be included in the project programme and needs to take place at the beginning of the project to enable the manufacturing of bespoke DFACs.

She suggested that crafted ceramics, that are within people's reach, provide tactile quality and human scale and can bring richness and interest to the buildings.

Duncan Hooson: Ceramic Artist, Co-founder of Clayground Collective, Stage 1 Leader, BA Ceramic Design, Central Saint Martins, UAL

Ceramic artist, author and educator, Duncan Hooson contributed insights into ceramic art practice and the education of ceramicists in the UK. Hooson's ceramic practice which includes public art commissions, collaborations with architects and the challenges connected to these projects, were discussed during the interview.

Hooson noted that working on architectural projects is challenging for ceramic artists. Publically engaged projects that involve communities in the making of ceramic artwork incorporated into the building raise concerns from architects as the physical results are often inconsistent. Producing the artwork himself, while "taking ideas of public and other groups" was a solution that facilitated the incorporation of the ceramic artwork into the building.

Explaining the main strands in ceramic education in the UK and the challenges for the creation of DFACs, Hooson noted that ceramicists graduating in the 1960s and 70s "either went into studio pottery or sculptural ceramics". The course at Central Saint Martins produced specialists for industrial ceramics; however, the majority of contemporary craft courses in the UK explore only the material and craft processes. Ceramic students find it challenging to work on collaborative projects, and for many makers, working with architects "is not their primary purpose".

Discussing the gap between ceramic and architectural practices Hooson noted: "As an architect … you can alter our built environment. People who chose ceramics…want to make objects." He suggests that "education, ambition, [and] a mindset" are the factors that would aid ceramic artists in the creation of bespoke DFACs.

Noting that students of ceramics do not associate bricks with ceramics, Hooson asserted the importance of making students aware of the ceramic environment: "Not only is it under our feet, we are surrounded by it as a society." Assumptions of students of ceramics and ceramic practitioners that brick is not a "contemporary" material inhibit their involvement in the creation of bespoke DFACs. Hooson stated that good precedents are critical to encourage the student to create bespoke DFACs. He suggested that a project, an exhibition or a book bring stakeholders together and facilitates knowledge exchange.

Andy Batterham: Director of Technical Services, Ibstock Brick Plc

My interview with Andy Batterham brought to light the insights into the changes that Ibstock Brick Plc, one of the UK's largest brick manufacturers, went through in the last two decades. Challenges connected to the manufacture of bespoke clay products within large volume production, including the reduced number of flexible small-scale facilities and diminishing craft skills were brought to light. He noted that: “The last few years have been about volume, volume house builders and efficient factories.”

Batterham noted that market forces lead innovation and dictate the aesthetic choices for the new clay products at Ibstock. Large house builders, who are Ibstock’s main client, do not require bespoke products. Most of the special shapes produced by the company are ‘heritage’ products. Batterham noted that: “The ability to apply different glazes and finishes has almost gone from Ibstock, all glazed bricks are supplied by a partner company in Holland.”

Batterham explained that while the collaborations with UK universities are seen by the company as a potential source of innovation, these are not utilised enough. Ibstock sponsored students to travel in Europe and the US to explore aesthetic trends but the new designs created by the students were not utilised in manufacturing.

Discussing brick manufacturing costs, Batterham noted that while materials are inexpensive, human labour is the biggest expense, the second being energy consumption. Batterham acknowledged that digital tools can reduce the cost of production but while Ibstock’s concrete division utilises these, the clay division lags behind.

Billy Mavropoulos: Founder and director, Bureau de Change Architects

I interviewed Billy Mavropoulos in connection with ‘The Interlock’, a project that featured a facade made with bespoke bricks manufactured specifically for this project by Forterra, a large-scale brick manufacturer.

Mavropoulos noted that the early commitment of the client enabled the development of bespoke bricks and their inclusion into the project. The bespoke facade linked the building to the surrounding urban context, added commercial value to the project and was used as a marketing tool by the client.

Mavropoulos stated that collaboration within the multidisciplinary project team enabled the creation and integration of bespoke DFACs. The appointment of a specialist brick contractor was critical to enable the construction of intricate cladding which could not be erected by a general contractor. Digital design tools used in the architects' office facilitated the creation of bespoke geometry and supported the iterative design process. Engaging directly with the manufacturer from the project's early stages facilitated design development, optimization and affordability of bespoke DFACs. Architects' factory visits and understanding of manufacturing processes, timing and costs enable the design process.

Mavropoulos acknowledged that the risks associated with the cost and additional time connected to the creation of bespoke DFACs inhibit their integration into buildings. However, Forterra the manufacturer who took the risk on the project, enabled innovation.

Nigel Dyer: Heritage service manager, Wienerberger UK

My interview with Nigel Dyer brought to light the flexibility of manufacturing processes in the Heritage department of Wienerberger, a large-scale brick manufacturer.

The focus of the interview was the creation, by the factory staff, of a brick relief for the entrance to a pharmaceutical company headquarters. Dyer explained that an in-house craftsman, who previously created small-scale, one-off clay pieces enabled the creation of the artwork. The maker's craft skills together with craft manufacturing processes and small-scale kilns used at the factory enabled the manufacturing process.

Dyer stated that whilst there is a demand for decorative brickwork in heritage projects, there is a lack of skilled craft brickmakers who can create decorative bricks. Discussing digital tools, Dyer noted that the digital equipment that exists at the factory is not usually utilised for small projects. Instead, hand-modelling is used for making wooden and plaster moulds and a local pattern maker is involved in the production of wooden detailing from drawings when required.

The challenges of glazing clay products in the UK was highlighted by Dyer; these include a lack of specialist facilities and processes that require labour, leading to the high cost of manufacture. He noted that while UK Wienerberger factories do not produce glazed products, these are imported from the company's Belgian factories.

Reflecting on the material testing for clay products Dyer noted that one-off bespoke pieces made for restoration projects are not tested because of the short production time. Small batch products are tested in-house, whilst new products developed for mass production are tested in the company's R&D department in Belgium.

Tom Mitchell: Associate, Metropolitan Workshop Architects

Tom Mitchell was the project architect for the Mapleton Crescent development, which comprised a facade made out of extruded ceramic profiles. The interview highlighted relationships between the architects, ceramic artist and the manufacturer, unpacking the modes of knowledge exchange at various stages of the project.

The interview brought to light that the seminars presented by the ceramic artist Loraine Rutt at the architects' offices three years before this project contributed to the architects' understanding of ceramic craft qualities and processes, facilitating the choice of ceramics for Mapleton Crescent and other projects undertaken by the company. Mitchell noted that the durability, low maintenance, ease of replacement together with the aesthetic qualities of ceramics were the key considerations that made DFACs the material of choice for the project.

Architects' investigation into the manufacturing processes through early engagement with the manufacturer highlighted major factors, such as the duration of firing and thickness of the ceramic panels, that affect the cost of DFACs. This understanding of manufacturing processes facilitated the creation of bespoke cost-effective designs.

Mitchell noted that their practice works with ceramic artists in public realm improvement projects in order to provide "something of real value to the local community". For the Mapleton Crescent development ceramic artist Loraine Rutt was appointed by the architects to develop the craft qualities of glaze. She also collaborated with the manufacturer to facilitate the creation of the aesthetics required by the architects.

Mitchell stated that the project participants who took part in a collaborative "proactive, positive design process" facilitated the project.

Shahed Saleem: Founder and director, Makespace Architects

I interviewed Shahed Saleem in connection with the Al Hikmah Mosque in Aberdeen, for which he collaborated with ceramic artist Lubna Chowdhary in the creation of ornamental ceramic tiles embedded into the facade of the building. Aesthetics and the role of ornamentation were discussed in connection with narratives and links to the local community.

Saleem noted that the glazed ceramic elements were used to accentuate part of the building through their colour, texture and sheen. He explained that ceramics were included in the building because of their long tradition in Islamic art and architecture, whilst the mosque project aspired to connect the building with its place and context. Bespoke hand-made DFACs were included in the building to express the idea of craft, which is an important narrative in Islamic buildings, “to bring in craftspeople and to work together”.

Saleem highlighted that the small size of the tiles made it possible for these to be produced in the artist’s studio. Variation in colour and uniqueness of each tile were the qualities sought by the architect. Saleem states that the tiles were not part of the structure, therefore Building Regulations approval was not sought for the ceramic elements and the tiles were attached to the facade with an adhesive.

Saleem noted that the architects’ assumptions about the high cost and feasibility of bespoke DFACs can inhibit their inclusion in buildings.

Lydia Johnson: Architect and ceramic artist, Founder, Fettle Studio

Lydia Johnson was one of the curators of ‘*Hand Held to Super Scale: Building with Ceramics’ exhibition on architectural ceramics* (Building Centre, 2021). I interviewed her in connection with her involvement in the Learning & Teaching Centre project for Brunel University in London. Johnson collaborated with Penoyre & Prasad Architects, developing coloured glazes and prototypes for the ceramic cladding. Her early involvement in the project enabled the creation of glaze samples and tile geometry that facilitated the planning application. Johnson’s involvement was extended to the collaboration with NBK Terracotta manufacturer to optimise the choice of glaze and to achieve the desired ceramic aesthetics within the budget limitations.

Discussing Johnson’s interdisciplinary background and practice, it was highlighted that cross-disciplinary specialists can facilitate knowledge exchange and support the architects, ceramic artists and manufacturers in the creation of DFACs. Johnson noted that the architects visiting her ceramic studio enabled a collaborative and iterative design process. Her factory visits and meetings with material and technical specialists facilitated knowledge exchange and co-creation. Her exploration into manufacturing processes identified that the consistency of factory-based fully automated processes such as glaze spraying makes it difficult to achieve craft surface qualities. She also noted that in-depth glaze research requires dedicated time and budget within the project program and overall budget.

Johnson stated that her access to experimental facilities at Grymsdyke Farm enabled digital prototyping and mould making, while the physical prototyping allowed her to develop the tactile qualities of the ceramic pieces.

Discussing ceramic aesthetics, Johnson noted that the craft qualities of a glaze applied to the cladding can enable multiple readings of the facade - from a distance and close by. The colour of the glaze for the ceramic cladding was developed to respond to the narrative and purpose of the building.

Alex Patrick-Smith: Managing director, Ketley Bricks

My interview with Alex Patrick-Smith focused on the importance of innovation within brick manufacturing which enables the creation of bespoke DFACs. The flexibility of manufacture linked to the size of facilities and the volume of production were brought to light. Patrick-Smith stated that medium-size manufacturing provides both capacity and flexibility enabling the creation of innovative DFACs for medium to large architectural projects.

He noted that innovation can be triggered by engagement with other stakeholders. Factory visits by the architects and designers that enable their understanding of manufacturing processes and the opportunities in the creation of DFACs is an important facilitating factor. Cross-fertilisation of ideas is brought about by the ceramic artists working alongside the makers at the factory.

Digital technology and digital fabrication which allows in-house customisation of tools, reduces tooling costs and enables the flexibility of manufacturing. Patrick-Smith noted that the architects' knowledge of manufacturing processes reduces the perception of risk and facilitates the inclusion of DFACs into projects.

5.4.1 Positioning of expert stakeholders

The diagrams shown in Figures 5.3, 5.4, and 5.5 demonstrate the position of the expert stakeholders' practices on the intersections of ceramic art, architecture and industrial manufacturing. While the diagrams also include the stakeholders who were identified during the precedents and context analyses (Chapter 3), the participants of the Engagement are highlighted in yellow. The position of the stakeholders in the diagrams reflect the collaborative relationships between the practices that facilitate the creation and integration of bespoke DFACs.

It became evident, through the interviews, that Duncan Hooson and Lubna Chowdhary collaborated with architects to integrate their DFACs made in a studio setting into the buildings and urban spaces. While Hooson acknowledged the challenging nature of the structural integration of studio-made bespoke DFACs, Chowdhary's small-scale individual tile inserts for the Al Hikmah mosque were integrated into the finished structure, making the installation easier.

At the same time, ceramic artists Lydia Johnson and Loraine Rutt collaborated with both architects and industrial manufacturers, aiding the design development of bespoke DFACs for large-scale facade cladding facilitating the creation of ceramic craft qualities in an industrial setting (Figure 5.5). The position of Malone, Haenen, Brayman and Jetten at the intersection of the three sectors also demonstrated the enabling nature of collaboration between the ceramic artists, architects and industrial manufacturers in the creation of bespoke DFACs which combined ceramic craft qualities and the material qualities necessary for their integration.

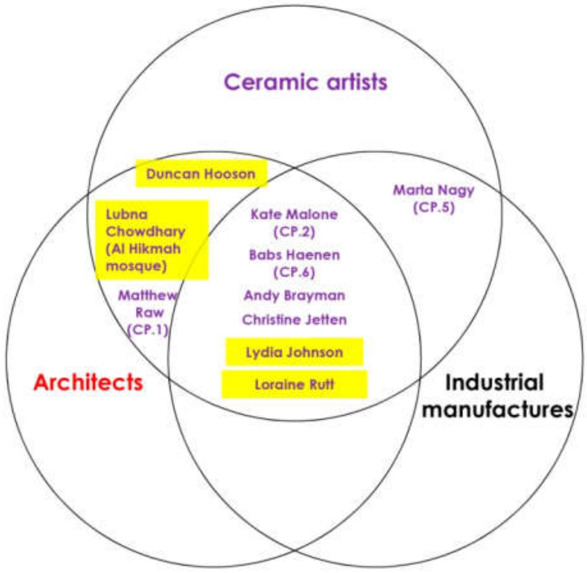

Fig. 5.5 *Ceramic artists identified through the precedents, context analyses and the Engagement (highlighted in yellow)*

It was highlighted through the interviews that the collaboration of Bureau de Change Architects with high volume brick manufacturer Forterra facilitated the design and manufacture of a facade constructed of 'non-standard special' bricks[60]. Makespace architects collaborated with ceramic artist Chowdhary, while Penoyre and Prasad Architects and Metropolitan Workshop Architects worked with Johnson and Rutt respectively. (Figure 5.6).

[60] See Definition of terms, Chapter 1

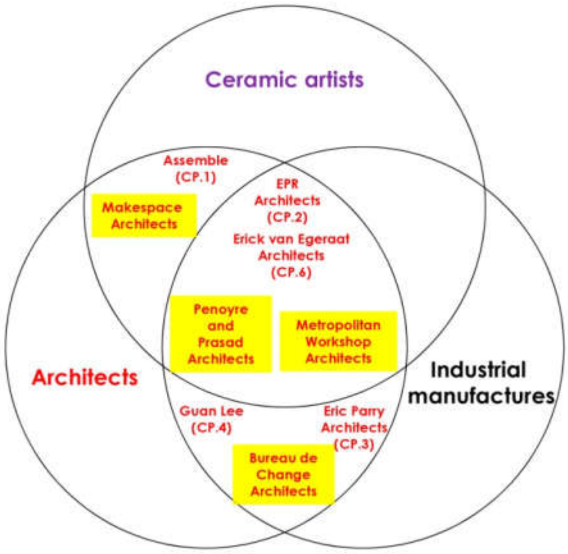

Fig.5.6 *Architects identified through the precedents, context analyses and the Engagement (highlighted in yellow)*

It is evident in Figure 5.7 that none of the UK brick manufacturers investigated through the interviews during the Engagement collaborated with ceramic artists in the creation of bespoke bricks. It can be argued that the lack of 'craft special' bricks[61] manufactured in the UK is a reason for the lack of diversity in ceramic qualities in brick buildings, which was identified through my context analysis.

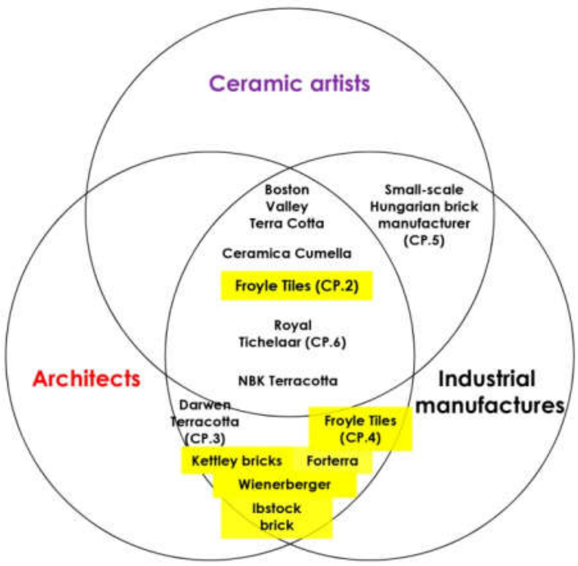

Fig.5.7 *Industrial manufacturers identified through the precedents, context analyses and the Engagement (highlighted in yellow)*

[61] See Definition of terms, Chapter 1

5.5 Case interview: Billy Mavropoulos, Bureau de Change Architects

To illustrate the methods utilised in the interviews, this section includes an extract from the analysis of the interview with Billy Mavropoulos, the Director of Bureau de Change Architects, whose project, ‘The Interlock’, featured bespoke bricks designed and manufactured in close collaboration with the brick manufacturer (Williams, 2019).[62]

All of the interviews followed a similar structure and include: i) photographs related to the project discussed; ii) interview questions included in the table, which were drawn prior to each interview and were used to guide the conversation; iii) a table that included the interview analysis, which contained three columns with the headings: “Quotes” related to the research questions extracted from the interview transcripts, “Insights” elucidated from the quotes and “Themes” which included both the themes that emerged from the previous sections of this research and themes that came about through the interview[63]; and iv) a summary of the insights that came through the interview analysis.

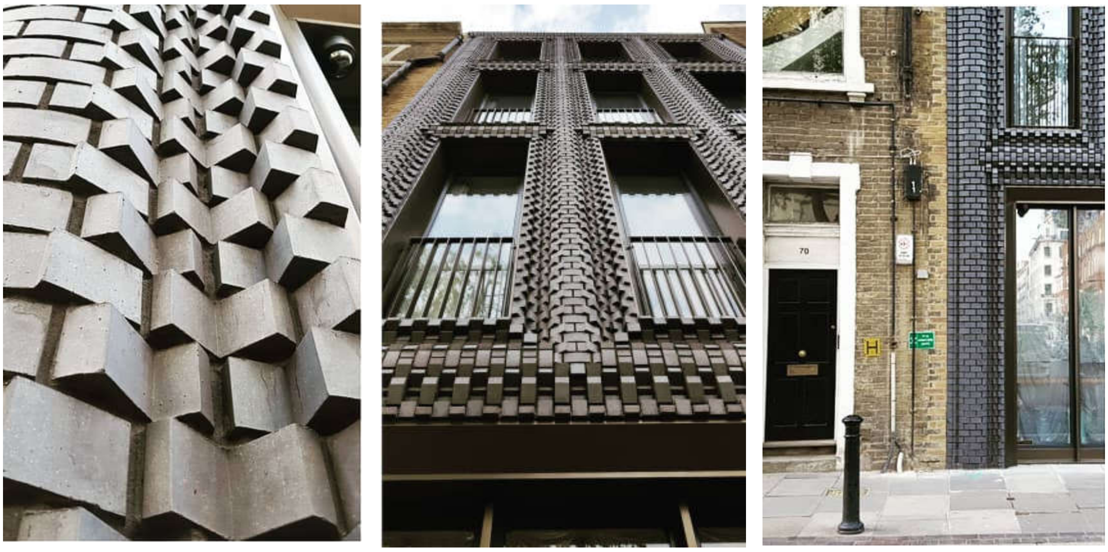

Fig. 5.8. *The Interlock, London. Images from left to right: “Aggressive cogs”: the detail of “rotating” bricks animating the window openings; the elevation with articulated window reveals; new elevation responding to the scale and rhythm of the neighbouring building* (2019)

[62] The full transcript of the interview is included in the Appendix D
[63] The new themes are shown in blue in the table.

5.5.1 Interview questions

Questions planned for the interview	Themes that emerged from contextual review, precedents and case studies
<u>Opening section</u>	
Could you describe your design process?	
How do materials and aesthetics drive your designs?	
What is your professional background?	
<u>Middle Section: questions specific to the project and related to the emergent themes</u>	
What major problems arose during the project (The Interlock)?	
What were the enabling factors in the project (The Interlock)?	
Did you use decorative bespoke bricks before in other projects?	• Ceramic material knowledge • Knowledge of manufacturing processes
When do you (usually and in this particular project) commit to a material in your buildings?	• Ceramic material knowledge • Knowledge of manufacturing processes
How did you communicate with others during the project (manufacturer, engineer, specialist contractor)?	• Collaboration and knowledge exchange
When did you engage with Forterra? (the brick manufacturer)	• Industrial manufacturer's support • Time for manufacturing • Timing of specialists' involvement
How did you work with Forterra during the project?	• Industrial manufacturer's support • Collaboration and knowledge exchange
How did Research and Development (R&D) take place for this project? Who usually does R&D at Forterra?	• Material research and experimentation/ R&D • Innovation

	• Industrial manufacturer's support
Did you use digital technology for this project, and if yes, when?	• Digital tools and processes
Did you get any support from/ had difficulties with planners?	• Planning
Closing section	
What did you learn from this project?	
How did this project affected your practice?	
What would you do differently now, with the knowledge you gained?	
Would you like to ask me anything?	

Table 5.4. Interview questions to Billy Mavropoulos

5.5.2 Interview analysis

Quotes	Insights	Themes
A lot of actors need to be in place for it [the project] to work.	Multidisciplinary team of stakeholders enables the project	• Collaboration and knowledge exchange
"It's not marble bathrooms that increase the value of the flat. It's the building that the flats are in. People walk down the street and see it. It becomes your [client's] brochure. That facade will become the graphics of your marketing material. It will become the narrative of the project and how you sell it. It will bring you money."	Bespoke facade adds commercial value to the development and can be used as a marketing tool by the client.	• Value added by bespoke DFACs
What can you do on your one	Bespoke characteristics and	• Value added

[development] that would make it unique? It means you can ask for a premium price.	"uniqueness" can bring a premium value to the building	by bespoke DFACs
You will consistently have moments when the client will say: "this is over budget so we will do a normal facade."	There is a continuous risk for bespoke, non-standard elements being excluded from the project	• Risk associated with increasing cost of production
This isn't happening, we don't have time for this, it is going to take too long.	As above	• Risk associated with increasing time of production
If you get them (the client) on board from the beginning, you make them believe in it (in bespoke elements) as much as you believe, then you are in a better position	Client's commitment to bespoke DFACs at the early stages enables the project	• Early commitment of the client
It starts in a very selfish way. As with most creative things. In doing what we do we have more fun. it is very personal.	Architect's self-expression facilitated the bespoke design	• Personal expression of the architect
So it is about the surroundings the context and the people	Bespoke DFACs provided the link to the surrounding context	• Site-responsive design

Table 5.5. Extract of the analysis of the interview with Billy Mavropoulos

5.5.3 Summary of the interview insights

- Collaboration within a multidisciplinary project team enables the creation and integration of bespoke DFACs.

- Bespoke DFACs add commercial value to buildings by making them "unique".
- The risks associated with the cost and additional time connected to the creation of bespoke DFACs inhibit their integration into buildings.
- Early commitment from the client enables the inclusion of bespoke DFACs into a project.
- Bespoke DFACs can provide a link to the surrounding urban context.
- A manufacturer's early involvement and continuous collaboration facilitate the manufacture of bespoke designs.
- The specialist knowledge of makers and manufacturers facilitates the creation of bespoke designs.
- Small scale manufacturing equipment enables the flexibility of processes.
- The involvement of a specialist contractor enables the structural integration of bespoke bricks into the facade.
- Architects' factory visits and understanding of manufacturing processes, timing and costs enable the design process.
- Engaging directly with the manufacturer facilitates design development, optimization and the affordability of bespoke DFACs.
- Collaboration with the manufacturer facilitates new techniques and aesthetic possibilities.
- The manufacturer taking a risk in the creation of bespoke products enables innovation.
- Clay bricks provide diverse aesthetics through their 3D form and decorative qualities.

5.6 Discussion of insights from the Engagement

5.6.1 Specialist knowledge and skills

I have established thorough the precedents in Chapter 3, that ceramic artists' and architects' ceramic material knowledge, technical knowledge and knowledge of manufacturing processes facilitate the creation of bespoke DFACs. The importance of introducing DFACs into the curriculum of ceramic artists and architects was brought into focus during the interviews.

The interview with Duncan Hooson highlighted a lack of awareness among ceramics students about the potential of DFACs and the need to develop collaborative working in order to facilitate their engagement with other practices.

> "…when talking to students, when you ask them ten things that are made of clay. You would think the first thing they would say…is bricks. It isn't…. There's this thing about awareness".
> "The people who come into the course aren't anticipating to be challenged in the way that working in a team does…."

> ***Insight 5.1:*** *There is a lack of awareness among university ceramics students of DFACs.*

> ***Insight 5.2:*** *Collaborative skills gained by students of ceramics can facilitate their involvement in the creation of DFACs.*

Hooson noted the lack of precedents of bespoke bricks' use and the lack of literature associated with them:

> "What struck me was the exhibition at EKWC, the brick catalogue[64], was a real turning point in artists' understanding about what a brick could be."

> ***Insight 5.3:*** *There is limited literature on decorative bricks that can raise ceramic artists' awareness of the material and the creative opportunities.*

I identified through the precedent analysis and this was reinforced by the Engagement that architects' prior knowledge of ceramics facilitated the appointment of ceramic artists from an early stage in these projects, which facilitated the creation of bespoke DFACs. Ceramic artist and architect Lydia Johnson and architect Neil Deely, Director at Metropolitan Workshop architects, were introduced to ceramics during their Master's Degree in Architecture.

> ***Insight 5.4:*** *Introducing ceramics into architectural education facilitates the creation of DFACs.*

[64] Hooson refers to The Brick Project described in section 3.4.3, Chapter 3.

My interview with ceramic artist Loraine Rutt brought to light that her seminars at the Metropolitan Workshop architect's office, informed the architects on ceramics craft qualities and ceramic craft techniques. This facilitated future projects that included DFACs undertaken by the company.

> ***Insight 5.5:*** *Ceramic artists can inform architects on ceramics craft qualities and ceramic craft techniques, thus facilitating design of bespoke DFACs.*

I identified through the contextual review that the links between universities and industrial manufacturers facilitate innovation in the manufacturing and development of bespoke DFACs. Andy Batterham, Director of Technical Services at Ibstock brick manufacturer noted in the interview that while the company supports links with universities in the UK, these are not utilised to their full potential.

> "They [students] do projects at looking at what's happening in mainland Europe with colours and textures in brickwork and how they're being used and feed that back to us to give us ideas and inspiration to maybe develop new products…
> Student collaboration is really important, and we need to do more with the schools of architecture. We have a long history with them, but there is more we can do."

During my visit to Ibstock's Eclipse factory in 2019 I was shown two of the brick designs produced by architectural students in 2018. The designs were prototyped at one of the Ibstock factories and were assembled into panels at the factory (Figure 5.9); however, these designs were not in production at the time of my visit.

 

Fig.5.9. *Two designs produced by the architecture students for Ibstock* (2019)

> ***Insight 5.6:*** *There is potential for architectural and ceramics students to have an input into the manufacturing of bespoke DFACs, however, there is limited exchange between the universities and brick manufacturers in the UK.*

5.6.2 Collaboration and knowledge exchange

The interviews evidenced that the knowledge exchange and collaborative links between stakeholders facilitated the creation of bespoke DFACs. Director of Bureau de Change architects Billy Mavropoulos noted:

> "We don't feel like we need to make everything ourselves or invent everything ourselves... It's more like we need to find the right person to tell us how this is done. That is why we work so closely with so many fabricators… Who would be better than the people that make the bricks?... You have to speak to the person that makes the thing."

> ***Insight 5.7:*** *Collaboration with material specialists and manufacturers facilitates architectural design, which is necessary for the creation of bespoke DFACs.*

I identified that the material knowledge of ceramic artists Loraine Rutt and Lydia Johnson assisted in the development of ceramic craft qualities of DFACs. This was done through knowledge exchange with both the architects and the manufacturers. Rutt describes her engagement in the Mapleton Crescent project:

> "They [architects] were saying 'we are going to NBK [the manufacturer] we understand a bit of the process, but we don't know the chemistry, how things work, where there is room for variation. We want to capture the essence of what you can do in the studio and get that into factory production' "

> ***Insight 5.8:*** *Ceramic artists' involvement in architectural projects facilitate the creation of ceramic craft qualities in DFACs.*

Knowledge exchange with the architects was enabled by the talks run by the ceramic artist at the architects' office prior to the project. She noted:

> "I realized quite early on…that they understand what they don't understand. They know the questions to ask. … They wanted to understand more about how to get a certain quality of glaze and to understand more about how glaze and ceramic manufacturing works, so that they could then go to the manufacturer with a very specific request of how they wanted to treat the building."

In both the Mapleton Crescent and Brunel University projects, ceramic artists worked with industrial manufacturers to facilitate the "translation" of craft qualities created in ceramic studios into the industrial processes. Facilitation in the creation of ceramic craft qualities in manufacturing by ceramic artist Christine Jetten, Andy Brayman and Kate Malone was discussed in Chapter 3. However, while Jetten, Brayman and Malone spent considerable time working with the manufacturers to customise industrial processes and develop new glazes, Rutt and Johnson had limited involvement at the later stages of the projects, which resulted in adapting existing industrial glazes to achieve the aesthetics required by the architects.

> ***Insight 5.9:*** *Collaboration between ceramic artists and industrial manufacturers can facilitate the creation of ceramic craft qualities in industrial settings, however, customisation of ceramic materials and processes needs time to be allocated within the project program.*

My interviews with representatives of industrial manufacturers during this Engagement evidenced that the knowledge exchange that takes place between the ceramic artists working at the factories and factory staff leads to innovation in manufacturing. This was also seen during my practice investigations at the factories (Chapter 4) and through the examples of ceramic designer's practices included in my contextual review (Chapter 3). Describing ceramic artists producing their artwork in a factory Alex Patrick-Smith, the owner of manufacturer Ketley brick, noted:

> "We've had many artists do different things…and there are guys [staff at the factory] making handmade stuff. They then communicate and engage and they like it. There's a cross-person realisation of ideas… We like it and we encourage it where it's not necessarily for any commercial benefit but for a wider understanding of pushing the envelope really. Because artists are more likely to engage in things that are just non-standard."

> ***Insight 5.10:** Ceramic artists working at a factory facilitate the innovation of processes and products.*

The process of architects gaining knowledge from factory visits was also highlighted during the interviews. Patrick-Smith noted:

> "When you walk around the factory you see things. I don't think that one has ever walked out of my office not feeling interested in the process or that they've learnt something."

> ***Insight 5.11:** Visits to factories facilitate understanding of manufacturing processes.*

For example, architect Tom Mitchell noted that visits to the factory and communication with the manufacturer aided his understanding of the manufacturing processes, and this enabled the design of bespoke elements for the facade:

> " It comes back to the point… about the cost being related to the thickness of the profile and not the complexity of it... As it transpires, every single die they make, they have to rebuild after…three or four thousand square metres anyway. So even if you wanted to do the simplest rectangle, that die would become useless after a certain amount. So that's the reason why it doesn't matter what sort of profile you go for anyway."

> ***Insight 5.12:** Architects' early engagement with the manufacturer and manufacturing processes enables the design of bespoke DFACs.*

The interviews during the Engagement highlighted how the knowledge exchange between architects and industrial manufacturers can lead to the creation of cost effective solutions while designing bespoke DFACs. Architect Billy Mavropoulos described the iterative process assisted by the manufacturer:

> "The expensive thing is the die. So the more dies you make the more money you spend. We said how can we minimise the types and we rationalised the design. We ended with 100 different bricks rather than 1000. That brought it down to 40 types. From which we made 44. We have 50 quotes from them (the manufacturer) and each time the price was lower."

Insight 5.13: *Collaboration between architects and industrial manufacturers can lead to the creation of cost effective solutions for bespoke DFACs.*

5.6.3 Early involvement of material specialists; Material research and experimentation/ R&D

While I have identified through the precedent analyses that the early involvement of ceramic artists can facilitate the creation of ceramic craft qualities, the analysis of the interviews in the Engagement revealed how early involvement of material specialists - ceramic artists and industrial manufacturers - can facilitate the planning process, design development, material research and experimentation and the manufacture of bespoke DFACs. It became apparent through my interviews with Miller, Rutt, Mavropoulos, Mitchell and Johnson, that providing detailed information for bespoke DFACs at the early stages of architectural projects is essential for ensuring their inclusion in projects. However, to include detailed material information on bespoke elements, the material research and experimentation/R&D has to be carried out at an early stage of a project. At the same time, material experimentation and R&D are excluded from the RIBA Plan of Work, thereby prohibiting the essential input from material specialists. Material Prescriptive Information[65] for projects is usually provided by the design team at Stage 4 (Figure 5.10). As shown on Figure 5.10, the RIBA Plan of Work has a linear progression and separate stages for design and manufacturing (Stages 0 to 4 – Design, and Stage 5 - Manufacturing and Construction).

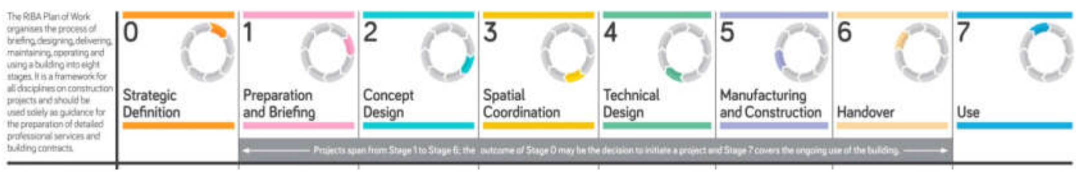

Fig. 5.10. *Fragment of the diagram showing the RIBA Plan of Work 2020*

It has been established, through the interviews, that committing to the use of DFACs in the Client Requirements (Stage 0) and including detailed material information and

[65] Prescriptive Information is defined in RIBA Plan of Work 2020 as: “Complete, instructive information used to manufacture and construct the Building Systems, produced by the design team or the construction team” (RIBA, 2021).

samples of bespoke DFACs in the planning documentation (Stages 2-3) are instrumental in securing DFACs in the project and in achieving ceramic craft qualities. In addition to this, inclusion of a particular manufacturer in the tender documentation[66] for a Design and Build Contract (such as that at Mapleton Crescent) allows the continuous dialogue between the architect and the manufacturer. Moreover, engaging with the manufacturers and involving them in the design development allows the architect to optimise the design and to achieve affordable manufacturing methods.

> ***Insight 5.14:*** *Early involvement of material specialists is essential to provide material research and experimentation/ R&D to facilitate the inclusion, design development and integration of DFACs in the projects.*

In the projects for Mapleton Crescent and Brunel University, ceramic samples and glaze tests provided by the ceramic artist, were included in the planning documentation, used as part of the negotiation with the planners, client and community organisations enabling the projects. These materials were also used at the later stages for negotiations with the manufacturers on ceramic craft qualities.

> ***Insight 5.15:*** *Early glaze tests and samples facilitate the planning process, and negotiations with the client and community groups.*

5.6.4 Flexibility of manufacturing

The ability to intervene in the manufacturing processes was defined by Richard Miller of Froyle Tiles as the 'flexibility of manufacturing'.[67] I have identified through the analyses of the precedents and my practice development, that flexibility of manufacturing which facilitates the fabrication of bespoke DFACs, is connected to the scale of production. My interviews with representatives of manufacturers confirmed that large volume manufacturers of bricks fabricate predominantly standard products, so there is little intervention possible in the fully and semi-automated industrial processes employed at mass-producing factories. Discussing ceramic craft qualities and high-volume manufacturing, Richard Miller noted:

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[66] Tender documentation is usually produced at the stages 3-4.
[67] See the Definition of terms, Chapter 1

“…the bigger producers have less flexibility…you end up with something that's always slightly compromised on the initial intention, just because you need something certified that's been through a factory.”

This was made evident in the interviews discussing Mapleton Crescent, and the Teaching and Learning Centre for Brunel University projects where the craft qualities of the glazes developed by the ceramic artists could not be reproduced in an industrial setting, but had to be adapted to existing manufacturing processes.

At the same time, the flexibility of manufacturing that is facilitated by the incorporation of hand-made processes in manufacturing has an added factor of risk. David Pye (1968) called the craftsmanship that provides variability the “workmanship of risk”. In contrast to this, he described the processes of mass production, which provide uniformity as “the workmanship of certainty". Furthermore, he notes that in a craft process "the quality of the result is at constant risk during the process of making."

The interview with Miller highlighted that while the ceramic craft qualities, sought by the architects, can be produced by ceramic artists and small flexible manufacturers, “the workmanship of risk”- or the uncertainty about the physical properties of bespoke craft products necessary for their integration into buildings presents a major inhibiting factor.

Insight 5.16: *The risk associated with craft making processes is an inhibiting factor in the creation of DFACs.*

While the facilitating role of small-scale manufacturing in the creation of bespoke DFACs was identified in Chapters 3 and 4, the difficulties encountered by small-scale manufacturers surfaced in the Engagement. Miller noted that the low capacity of small manufacturers and craft makers is an inhibiting factor in the production of DFACs.

“I speak to a lot of makers and lots of people are being approached about architectural projects, and sure capacity is very often an issue and how that is integrated into industrial production to allow that capacity.”

He also stressed:

> "…if it's something you've made yourself, it's very difficult to convince insurers, as it is extremely expensive to get insurance… mainly because when you're making ceramics in the way we do it, they're small batches. So essentially you'd have to have every batch tested. There's so much variation that it's very difficult to get certification based around one product".

> ***Insight 5.17:*** *Low capacity, the cost of material testing, and the price of indemnity insurance linked to bespoke ceramic products manufactured by small and medium manufacturers, ceramic workshops and individual artists is a major inhibiting factor in the creation of bespoke DFACs.*

Discussing Froyle Tiles' involvement in the 24 Savile Row project (CP.2) in the interview, Miller explained that the insurance for the facade cladding was made possible by the fact that standard, tested proprietary tiles were used as a base for the bespoke glaze.

> "…the beauty of Savile Row is that we took an existing format, a system that's proven and certified in terms of application to the surface of the building, and we kind of modified it, we intervened."

> ***Insight 5.18:*** *Utilising tested, factory-produced ceramic elements permits the insurance of bespoke DFACs.*

The enabling capacity of a medium-size manufacturing facility that includes both capacity and flexibility, was highlighted by Alex Patrick-Smith, the owner of Ketley Brick:

> "We're… down the middle of that to take the projects that the big guys don't want to do, but that the smaller guys doing crafts stuff just haven't got the capacity to do."

> ***Insight 5.19:*** *Medium-size manufacturers can facilitate the fabrication of bespoke DFACs because they provide both capacity and flexibility.*

Nigel Dyer, the Heritage service manager at Wienerberger UK, explained that the Heritage facilities have the flexibility to produce small batch and one-off products because they employ makers who produce hand-made roof tiles and bricks as well as special detailing. It was also revealed that one-off heritage bespoke bricks do not undergo the lengthy testing process as do all the standard products. Dyer noted that this is due to the small scale of jobs, the short production time and the fact that one-off elements are not going to be repeated. This flexibility of the Heritage department was utilised during my practice investigations and enabled me to create bespoke decorative bricks in collaboration with brickmakers, as explored in Chapter 4.

> ***Insight 5.20:*** *The heritage facilities of large brick manufacturers provide flexibility of manufacture through employing craft makers and hand-made processes.*

At the same time, the representatives of brick manufacturers, Batterham, Dyer and Patrick-Smith, stated in the interviews that a large number of small-scale factories and workshops producing decorative bricks and architectural detailing in the UK have been closing down during the last twenty years, with craft skills being lost, thus inhibiting the production of bespoke bricks.

> ***Insight 5.21:*** *The closure of small-scale brick factory facilities results in a loss of craft skills and inhibits the manufacture of bespoke bricks.*

5.7 Conclusion

The insights from Chapter 3 and 4 were the basis for the Engagement which consisted of semi-structured interviews with expert stakeholders, that I carried out to gain an in-depth understanding of the key aspects that facilitate and inhibit the creation of bespoke DFACs. The representatives of ceramic artists, architects and industrial manufacturers involved in the creation of bespoke DFACs contributed their expert perspective, aiding my investigation. The insights that came forth during the semi-structured interviews corresponded to the themes that were identified in the previous sections of this research and brought forth new insights that contributed to the key findings included in Chapter 6.

Collaboration and knowledge exchange between the architects, ceramic artists and industrial manufacturers were acknowledged by the interviewees to be a key enabling factor in the creation of DFACs (Insights 5.7, 5.9).
I have identified that introducing the DFACs to the university architectural and ceramic courses would be beneficial to both ceramic artists and architects and will facilitate the creation of DFACs and their structural integration (Insight 5.1, 5.4). The lack of links and the potential for collaboration between the brick manufacturers and universities in the UK which can support the creation of innovative designs and manufacturing processes became apparent through the interviews (Insights 5.6).

Interviews with the ceramic artists and architects highlighted that an early involvement of ceramic artists can facilitate the planning process, aid community engagement, enable design development and support industrial manufacturers in the creation of ceramic craft qualities (Insights 5.8, 5.14, 5.15).

It became evident through my interviews with architects that the inclusion of bespoke DFACs adds commercial value to their projects and links the buildings to their urban context through ceramic craft qualities. The client's commitment, collaboration with the manufacturers and the appointment of specialist subcontractors were noted to be enabling factors in the creation and structural integration of bespoke DFACs.

My interviews with the representatives of large brick manufacturers highlighted the challenges of the creation of bespoke products in high-volume production (Insights 5.21), whereas an interview with a small-scale craft manufacturer brought to light the challenges faced by individual artists, craft makers and small-scale manufacturers connected with their capacity, craft processes, certification and insurance of bespoke products (Insights 5.17).

The insights from the Engagement with the expert stakeholders contributed to the key findings of this study by aiding an in-depth understanding of the issues connected to the design, ceramic craft making, manufacturing and integration of bespoke DFACs. The aim of this study- to facilitate the practice of ceramic artists, architects and industrial manufacturers in the creation of bespoke DFACs - is addressed by the compilation of design recommendations and a facilitating framework based on the insights from this Engagement, the precedent analyses, contextual review and my practice investigation.

CHAPTER 6
CONCLUSIONS: FACILITATING PRACTICE

6.1 Overview

Over the course of this study, which brings together design, craft making and industrial manufacturing, I have explored how to facilitate the creation of bespoke DFACs by analysing and evaluating the relationships between the practices of architects, ceramic artists, and industrial manufacturers.

My strategic practice interventions, combining ceramic craft techniques, digital tools, and industrial manufacturing processes have explored how alternative approaches can facilitate the creation of bespoke DFACs that incorporate the ceramic craft and material qualities necessary for their structural integration, which is hindered in the current construction and manufacturing context.

My practice, used as a methodology to lead this research, sits at the intersection of three disciplines: architecture, ceramic art, and industrial manufacturing, allowing me to investigate and analyse the disjunction between the practices evident in the current context, as seen through my own work and by engaging with others.

As a result of this practice, I have been able to identify three aspects which will positively affect the process of creating of bespoke DFACs in the future: i) key findings that identify the factors enabling and inhibiting the creation of bespoke DFACs, which form the bases of design recommendations for ceramic artists, architects and industrial manufacturers; ii) findings from my ceramic practice investigation that include innovative methods and the processes for the design, craft making and manufacturing of ‘craft special’ bricks, which contribute new knowledge to the practices of architects, ceramic artists and industrial manufacturers; and iii) a facilitating framework that sets out existing and proposed collaborative links between the key stakeholders in the production of bespoke DFACs.

6.2 Contribution to knowledge

The key findings that address the gap in knowledge identified in this study, were derived at by utilising the insights from the contextual review and precedent analyses, my practice investigation and semi-structured interviews with expert stakeholders.

The initial analyses of the precedents in Chapter 3 were central to identifying the factors that both enabled and inhibited the creation of bespoke DFACs, highlighting the relationships between architects, ceramic artists, manufacturers and other stakeholders that enabled the creation of DFACs for architectural projects. My subsequent interviews with these expert stakeholders provided a deeper understanding of the nature of these relationships while the development of my design and ceramic practice, which took place in brick factories, further revealed the nature of enabling relationships within manufacturing and between manufacturers and other stakeholders.

As a result of these approaches, I have been able to develop a facilitating framework that unpacks models of the relationships between stakeholders, which enable knowledge exchange, as set out in section 6.2.3, with practical proposals developed in response to the constraints of industrial manufacturing included in section 6.2.2. The key findings addressing the stakeholders' practices, are set out in section 6.2.1. Recommendations based on my key findings were put together in relation to particular groups of stakeholders, to be disseminated beyond this research, through design guidelines, publications and presentations.

6.2.1 Key findings and recommendations

The key findings in this research were generated through analyses of the three main components of this study: i) contextual review and precedents; ii) the analysis of my practice, and iii) my interviews with expert stakeholders. The key findings outlined below identify the factors that enable and inhibit the creation of bespoke DFACs. These were generated to form the basis of design recommendations to ceramic artists, architects and industrial manufacturers. The recommendations have been distilled into a series of actions set out in Table 6.1 to be undertaken by the main stakeholders of this research: ceramic artists, architects, and industrial manufacturers. Developers and planners responsible for the commissioning and approval of materials are also included in the table, as they play a facilitating role.[68]

Addressing the evident disjunction between the practices engaged in the creation of bespoke DFACs, I found that a strategic intervention enabling knowledge exchange and collaboration between architects, ceramic artists and industrial manufacturers would facilitate the creation and structural integration of DFACs. This can be achieved through the early involvement of ceramic artists to secure planning permission for projects, affirm clients' commitment to the material, and support the creation of the ceramic craft qualities of DFACs produced in industrial settings (**r.1**).

In addition, it has been demonstrated that the ceramic craft qualities of DFACs can be achieved by engaging with ceramic artists, small-scale flexible manufacturers, and large industrial manufacturers who undertake restoration projects and use ceramic craft techniques in their processes (**r.2**).

The prior ceramic material knowledge of architects and designers aids material and manufacturing choices in projects, facilitates design development and affects the aesthetics of ceramic outcomes. Ceramic artists and manufacturers are therefore integral for introducing architects and other stakeholders to the materiality of ceramics. It therefore follows that seminars, hands-on sessions, workshops and visits to ceramic studios and factories can be employed as methods of introducing architects and other stakeholders to the ceramic craft and manufacturing processes, addressing the practice-orientated gap outlined in the creation and integration of bespoke DFACs in order to support design development and the creation of future opportunities (**r.3, r.4**).

Conversely, a knowledge of building regulations and construction requirements is essential to enable ceramic artists to design, make and facilitate the creation of bespoke DFACs. Therefore, seminars and publications on architectural ceramics, utilising ceramic art and craft platforms, as well as introducing architectural ceramics to the academic curriculum, would benefit ceramic artists, opening them up to opportunities for future commissions and contributing to developments in this field (**r.5**).

[68] The recommendations linked to the key findings discussed in the text are shown in brackets and included in Table 6.1.

Large industrial manufacturers engaged in mass production lack the flexibility found in small-scale producers of bespoke DFAC. It has been established that the flexibility of manufacturing is enabled by the presence of hand-made processes and by small-scale factory equipment. It is therefore recommended that flexible small- and medium-scale manufacturers should be engaged with by ceramic artists and architects to create bespoke DFACs for small-scale projects and to carry out material research and experimentation (**r.6**).

My research into brick manufacturing highlighted that the utilisation of small-scale heritage facilities which produce 'standard special' bricks within larger brick companies enables material research, experimentation and the small-scale batch production of DFACs. Such facilities can also be used by architects, ceramic artists and designers for small-scale projects, supporting the development of innovative products (**r.7**).

Material research and experimentation has been demonstrated to be a key factor for the creation of bespoke DFACs. As there is currently no provision in the RIBA 2020 Plan of Work for material research and experimentation, architects and clients must therefore, ensure that time and budget are allocated for material research and experimentation in projects involving bespoke DFACs (**r.8**).

It is shown in this study that material research, experimentation, samples and prototypes produced by ceramic artists for architects and industrial manufacturers enable the creation of ceramic craft qualities of bespoke DFACs in an industrial setting and support architects through design development. Since the processes for the creation of ceramic craft qualities achieved in a ceramic studio must be adapted to industrial manufacturing to take account of the processes used in factories, it is essential that there is knowledge exchange taking place between artists and industrial manufacturers to achieve ceramic craft qualities in industrially manufactured DFACs. (**r.9**) This knowledge exchange can be achieved by ceramic artists working in factories (**r.10**). Building on this insight, industrial manufacturers can promote knowledge exchange, which will benefit both artists and manufacturers by supporting artists' residency programs and by employing ceramic artists as material consultants (**r.11**).

It has been demonstrated that outsourcing material research and experimentation to flexible digital and ceramic studio facilities aids large industrial manufacturers in the design, development and manufacturing of innovative bespoke DFACs. The machinery and kilns that these facilities possess can replicate the firing temperatures and processes of large factory kilns, enabling the development of ceramic craft qualities that can be produced in an industrial setting, as well as aid the adaptation of ceramic craft techniques into factory processes (**r.12**). Industrial manufacturers can support material research, product development and innovation by investing in small-scale digital ceramic studio facilities or by instigating explicit collaborations with these facilities (**r.13**).

Multidisciplinary workshops and symposia, organised by industrial manufacturers and manufacturers' associations, can facilitate the creation of bespoke innovative solutions for DFACs. The outcomes of such workshops and symposia directly benefit industrial manufacturers as these innovative solutions can be used in factories. Architects, designers and ceramic artists will benefit by gaining knowledge of manufacturing processes and engaging with manufacturers opening up creative possibilities for their practice. Therefore, the development of multidisciplinary workshops organised by manufacturers and other stakeholders should be utilised to facilitate knowledge exchange and innovation (**r.14**).

Knowledge exchange between specialist practices taking place during multidisciplinary workshops and symposia often results in creative outcomes, which include publications and physical body of ceramic work. The contribution of these events, to the development of innovative bespoke DFACs, is made through the wider dissemination of their outcomes (**r.15**).

It has been established through this research that large-scale manufacturers of architectural ceramics and ceramic trade associations who promote collaborative links with universities by sponsoring experimental projects, facilitate academic research and innovation in the field of architectural ceramics. Hence, the links between universities and manufacturers should be developed to promote innovation in the field of architectural ceramics. This can be achieved through them collaborating with universities' architectural and ceramic departments, by utilising their innovative ideas and the technical and material knowledge of students, encouraging learning through live projects and apprenticeship schemes. This will lead to a benefit both for academia and industry (**r.16**).

Table 6.1 sets out design recommendations based on the key findings discussed above. These recommendations serve as a basis for future practice and design processes .

🟡 Planners and developers
🔵 Architects
🟠 Ceramic artists
🟢 Industrial manufacturers

Stakeholders	Design recommendations
🟠 🔵 🟡	r.1. Ceramic artists should be engaged in projects in their earlier stages to provide material research and experimentation, support architects through design development and facilitate the creation of ceramic craft qualities in an industrial setting.
🟠 🔵 🟡 🟢	r.2. Engaging with ceramic artists, small-scale flexible manufacturers and large industrial manufacturers who undertake restoration projects, facilitates the creation of ceramic craft qualities in bespoke DFACs.
🟠 🔵 🟢	r.3. Seminars, hands-on sessions, workshops and ceramic studio and factory visits can be utilised to introduce architects to ceramic craft and manufacturing processes in order to facilitate their material and design choices and support design development and project planning.
🟠 🔵 🟡 🟢	r.4. Introduction of clients and planners to the ceramic craft and manufacturing processes through factory and ceramic studio visits should be employed to aid appreciation of material and ceramic craft qualities, facilitating their commitment and planning process.
🟠 🔵 🟢	r.5. To facilitate knowledge of building and construction requirements connected with the creation of bespoke DFACs among ceramic artists, seminars and publications on DFACs, utilising ceramic art and craft platforms should be organised, along with an introduction of architectural ceramics to the academic curriculum.

	r.6. Architects and ceramic artists should engage with flexible small- and medium-scale manufacturers to create bespoke DFACs for small-scale projects and to carry out material research and experimentation.
	r.7. Small-scale heritage facilities within large brick manufacturing companies should be utilised for material research and experimentation to support the development of innovative products and the manufacture of small quantities of bespoke DFACs.
	r.8. Architects and clients must ensure that time and budget are allocated for material research and experimentation in projects involving bespoke DFACs.
	r.9. Processes for the creation of ceramic craft qualities achieved in a ceramic studio must be adapted to industrial manufacturing, taking into account the processes used in factories.
	r.10. Ceramic artists should be encouraged to work in factories to facilitate knowledge exchange between makers and material specialists.
	r.11. Industrial manufacturers can propagate knowledge exchange with ceramic artists that would benefit both artists and manufacturers by supporting artists' residency programs and by employing ceramic artists as material consultants.
	r.12. Small-scale machinery and kilns should be utilised to replicate firing temperatures and processes of large factory kilns, enabling the development of ceramic craft qualities that can be produced in industrial settings.
	r.13. Industrial manufacturers can enable material research, product development and innovation by investing in small-scale digital ceramic studio facilities or by instigating explicit collaborations with these facilities.
	r.14. Multidisciplinary workshops and symposia should be utilised to provide a platform for knowledge exchange between ceramic artists, architects and manufacturers and facilitate innovation.

🟠 🔵 🟡 🟢	r.15. Publications and physical displays of ceramic work should be employed to disseminate the outcomes of multidisciplinary workshops and symposia to ensure wider impact.
🟠 🔵 🟢	r.16. The links between the universities' architectural and ceramic departments and industrial manufacturers should be employed to promote innovation through collaboration, utilise innovative ideas, technical and material knowledge of students, while promoting learning through live projects and apprenticeship schemes.

Table 6.1 Recommendations generated in response to the key findings, related to the stakeholders engaged in the design and manufacture of bespoke DFACs.

6.2.2 Ceramic practice contribution

Through my architectural and ceramic practice I address the underdeveloped area that I have identified in ceramic craft making and the industrial manufacturing of bespoke bricks. I have shown that this gap in industrial ceramic practice can be bridged by hybrid manufacturing which combines ceramic craft techniques, digital interventions and industrial manufacturing. My practice outcomes including a collection of 'craft special' bricks and two built case studies, have demonstrated how ceramic craft qualities can be achieved in volume brick manufacturing.

The records of design, prototyping, material experimentations and craft and manufacturing processes used in the course of this research offer an original contribution to the practices of architects, ceramic artists and brick manufacturers. These demonstrate the creative opportunities of decorative bricks, their applications and show how ceramic craft qualities can be achieved in industrial settings.

My research has shown that the high costs of manufacturing inhibit the specification and integration of bespoke DFACs in architectural projects. The time and cost of workmanship, along with energy consumption, were identified to be the key factors contributing to the cost of manufacturing of DFACs. However, my investigation of digital tools for the design, prototyping and fabrication of bespoke DFACs highlighted the potential of these tools to replace the labour-intensive manual processes – thereby reducing the time and cost involved. I have applied digital tools and processes in the creation of bespoke bricks, utilising innovative methods of production that offer economical solutions.

Table 6.2 includes the actions that I undertook in my practice investigation in response to my findings related to the constraints in industrial manufacturing. The constraints were identified through the analysis of the precedents, context analysis and my interviews with expert stakeholders. These actions facilitated the creation of bespoke bricks that demonstrated ceramic craft qualities and included material qualities allowing their structural integration, while offering affordable solutions, as demonstrated in my case studies 1 and 2. I therefore, propose these as recommendations to be followed by others in the creation of bespoke DFACs.

Cost limitations and constraints (c) in industrial manufacturing	**Practice recommendations (p.r.)**
c.1 Tooling and energy consumption for customised solutions contribute to the high cost of bespoke DFACs. (Chapter 3)	p.r.1. Utilise standard clay products and forming, drying and firing industrial processes that exist at the factory to provide cost-effective solutions. p.r.2. Customise existing tools such as brick moulds and extrusion dies to create bespoke pieces. p.r.3. Utilise factory facilities and maker's skills at the factory to customise existing tools.
c.2 Manual workmanship contributes to the high cost of bespoke DFACs. (Chapter 5)	p.r.4. Use digital interventions, tools and processes that can substitute labour-intensive processes, saving costs associated with time and labour.
c.3 Material testing and certification of bespoke DFACs are the key factors that enable or inhibit the integration of these into the public realm. (Chapter 3, Chapter 5)	p.r.5. Utilise factory industrial controlled processes used in the manufacture of products that are tested and certified. p.r.6. Use factory testing facilities to test customised DFACs, whenever possible.

c.4 There is limited material research and development (R&D) taking place at brick factories in the UK. (Chapter 3, Chapter 5)	p.r.7. Utilise flexible factory facilities such as departments that manufacture 'heritage' and 'standard special' products to carry out R&D. p.r.8. Outsource R&D to experimental facilities or institutions. p.r.9. Use collaborations with university schools of architecture and ceramics.
c.5 Repetitive mass-produced ceramic elements and bricks are most economical to manufacture. (Chapter 4)	p.r.10. Design repetitive brick modules that can: • be assembled creating permutations of two-dimensional patterns • be used in varied brick bonds • create multiple three-dimensional geometry when placed in different orientation • be coloured and glazed using diverse ceramic materials and techniques
c.6 Automated industrial manufacturing processes create homogeneous aesthetic results. (Chapter 3)	p.r.11. Use ceramic craft techniques to create variation in texture and colour while retaining the physical and utilitarian properties of DFACs.

Table 6.2 Practice recommendations, responding to the constraints in industrial manufacturing, addressing the ceramic artists, designers, architects and industrial manufacturers engaged in the design and manufacture of bespoke DFACs

6.2.3 Facilitating framework

My investigation into the design, craft making and manufacture of bespoke DFACs through precedent analyses, contextual review and semi-structured interviews highlighted the key role of both collaboration and knowledge exchange between the stakeholders of this research. The creation and integration of 'craft special' bricks in case studies 1 and 2, demonstrated that the collaboration and knowledge exchange between the specialist practices and brick manufacturers was a model for opening up creative and innovative opportunities.

Figures 6.1 and 6.2 demonstrate the existing links, the key relationships and the exchange of specialist knowledge between the stakeholders of this research revealed in the course of this study. Figures 6.3 and 6.4 include the facilitating links established through my practice investigation. Responding to the insights and the key findings of this research, the diagram shown in Figure 6.5 comprises the summary of existing links and shows the proposed connections that can facilitate the creation of bespoke DFACs in the UK, bridging the gap in contemporary practices identified at the outset of this research.

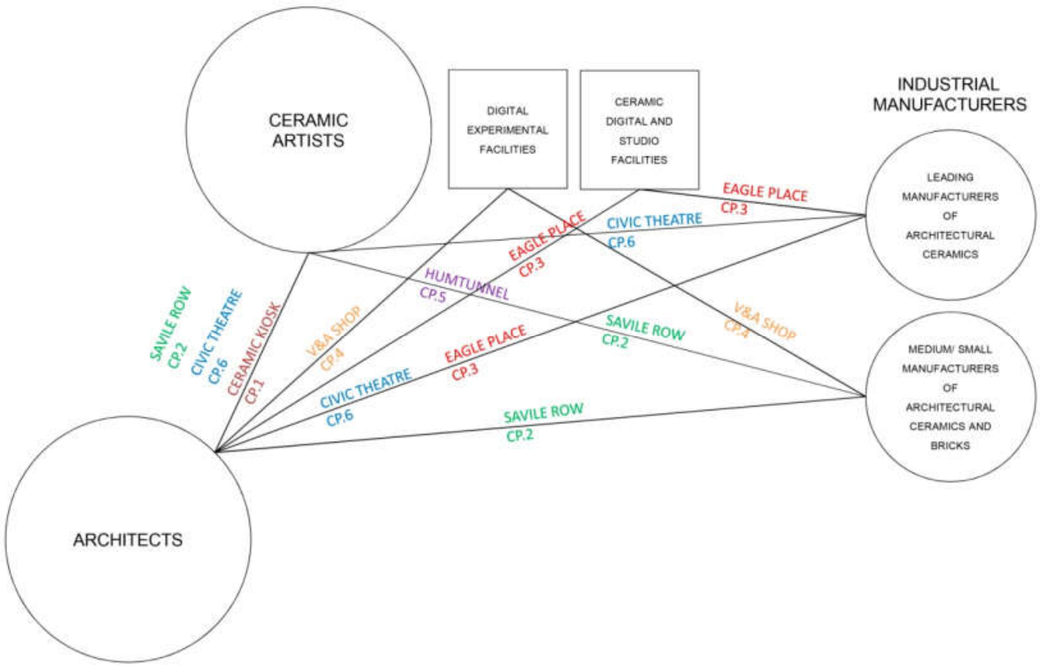

Fig. 6.1 *Knowledge exchange and collaborative links between stakeholders in the contemporary precedents included in Chapter 3 and Appendix A*

Figure 6.2 highlights in blue, the links that came out of the context analysis and the interviews with expert stakeholders. It also includes the links already identified through the analysis of contemporary precedents. The links show the connections between the stakeholders, which enabled the creation of ceramic craft qualities and the development of innovative designs, materials and processes. In this diagram the link, shown by a dotted line, refers to the Brick Project that was organised by

Wienerberger leading to the knowledge exchange between ceramic artists and the manufacturer.[69]

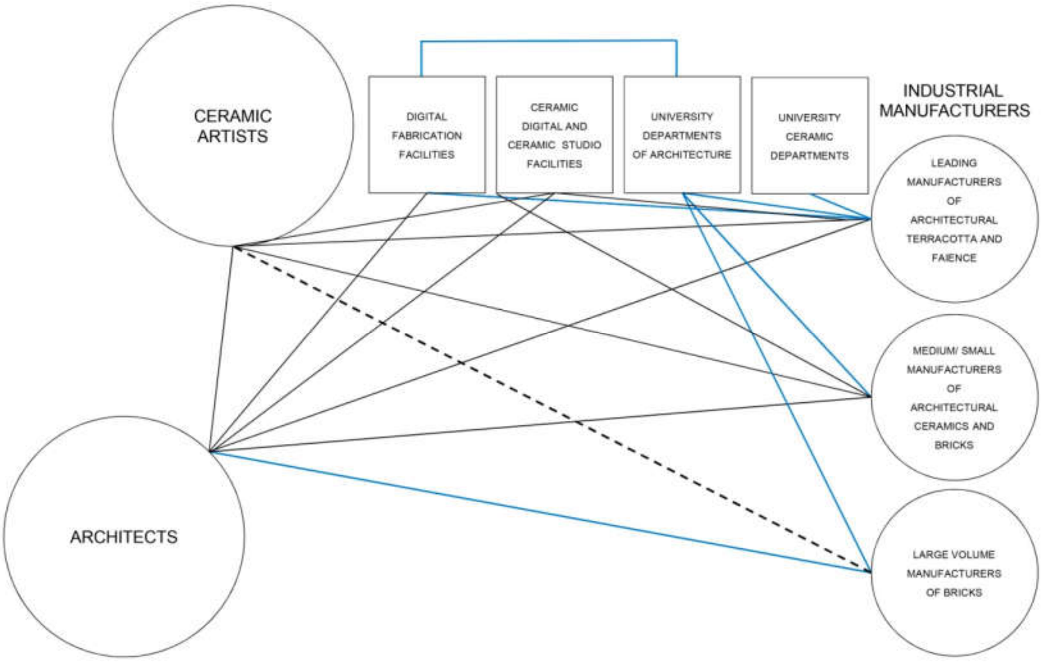

Fig. 6.2. *Knowledge exchange and existing collaborative links between the stakeholders identified through precedent analyses, context analysis and the interviews with expert stakeholders (Chapters 3 and 5, Appendices A and D)*

Having identified, at the early stages of this research, that there is a gap in the industrial manufacturing of bespoke bricks, I used the insights described in the facilitating framework shown in Figure 6.2 to develop my practice within brick manufacturing. Figure 6.3 shows the knowledge exchange that took place during my experimental practice development and my two case studies. My roles as architect and ceramic artist were kept apart in the diagram to demonstrate the presence of the link between the two practices enabling the creation of the DFACs. The links with digital fabrication facilities and ceramic studio facilities enabled prototyping, customisation of tools at the factory, ceramic material testing and glazing of 'craft special' bricks.

[69] The outcomes of the project included a publication and a collection of brick prototypes. These were not put into production by the manufacturer. The details of the Brick Project is included in Chapter 3, section 3.4.3.

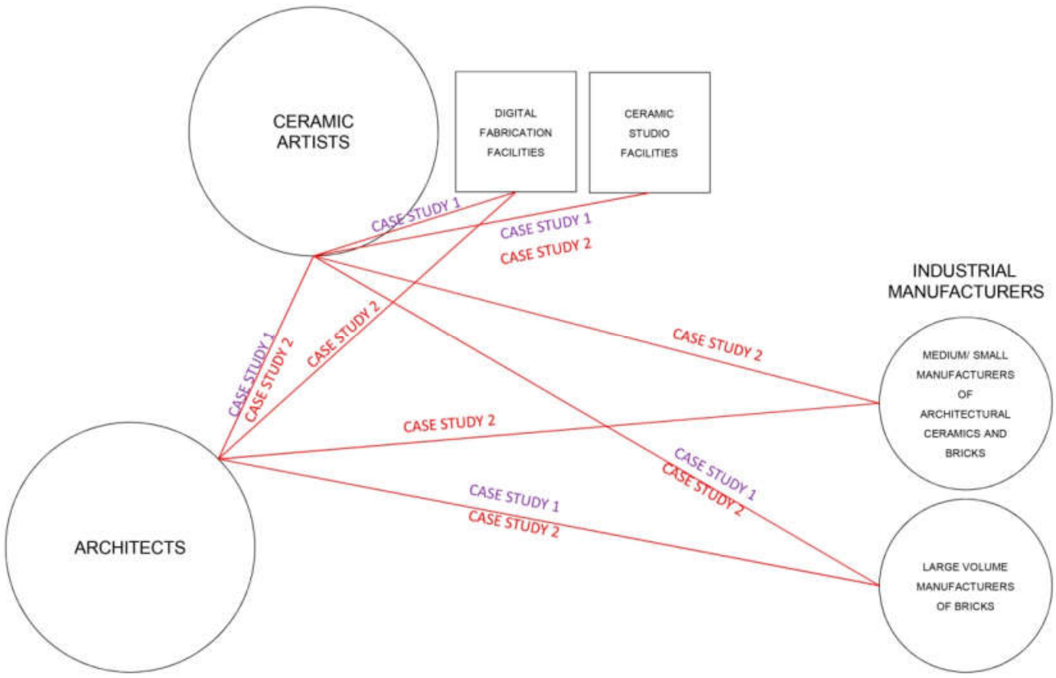

Fig. 6.3. *Knowledge exchange and the collaborative links established between the stakeholders during my practice investigation in the two case studies (Chapter 4)*

Figure 6.4 demonstrates the contribution of the findings from my practice investigation, shown by the red lines, to the existing collaborative context of design and manufacture of DFACs established through this research. The collaborative link between ceramic artist and the large volume brick manufacturer established through my practice, enabled the manufacturing of bespoke bricks, which were integrated into structures.

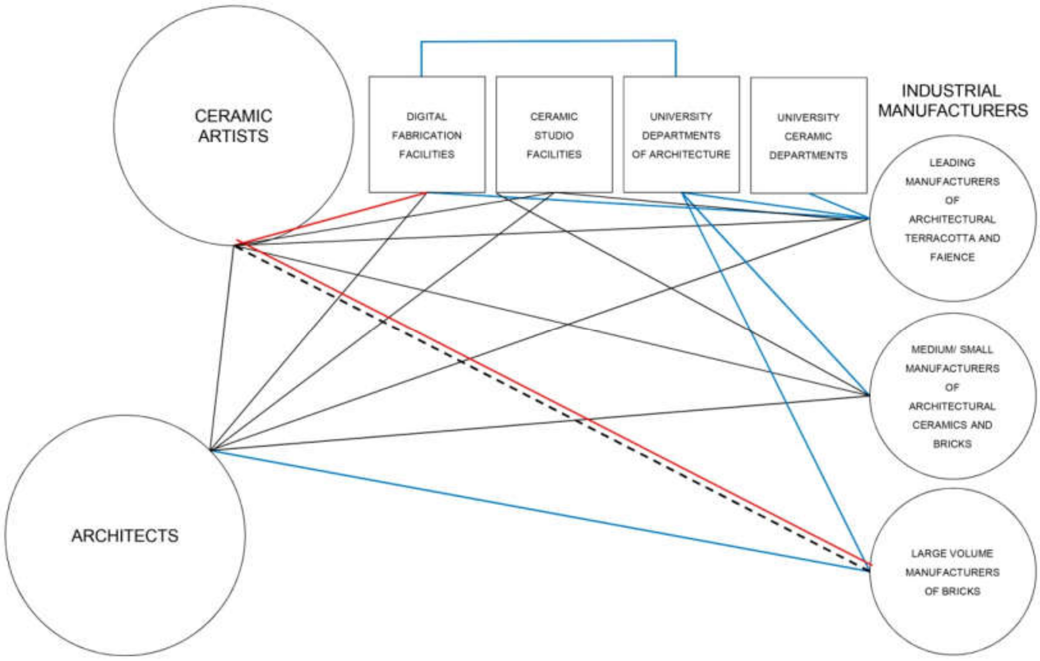

Fig. 6.4. *Contribution of findings from my practice to the existing facilitating framework established through precedents, context analysis and engagement with expert stakeholders*

Figure 6.5 shows a proposed facilitating framework for the creation of DFACs based on the

findings of this research. My research demonstrates that existing collaborative links between large manufacturers of architectural terracotta and faience, medium and small manufacturers of architectural ceramics and the stakeholders included in the diagram, enable the creation of bespoke DFACs. However, some links do not exist between large brick manufacturers and other stakeholders. I therefore propose that there should be collaborative relationships developed between the large brick manufacturers and i) ceramic artists, ii) university ceramic departments, iii) digital fabrication facilities and iv) the links with architectural departments should be reinforced.

My practice investigation shows that collaboration with the staff at digital fabrication facilities can facilitate innovative designs, making and manufacturing processes. The link proposing collaboration between ceramic artists and digital fabrication facilities is included in the diagram.

It was demonstrated that ceramic material knowledge gained through collaboration with ceramic artists aided architects through the design process and facilitated architectural projects. Following this, I propose that the collaborative links between architects, university ceramic departments and their ceramic studio facilities take place. Moreover, the links between the ceramic and architectural departments within and between universities could contribute to the education of both ceramic artists and architects enabling the creation of bespoke DFACs.

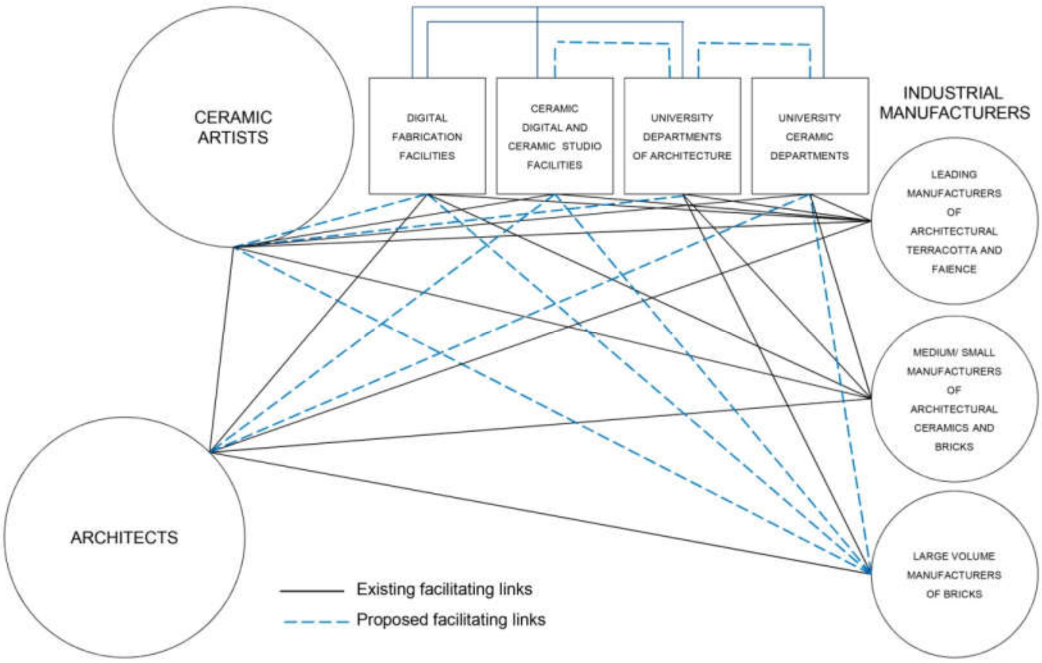

Fig. 6.5. *Facilitating framework: proposed links between the stakeholders to enable knowledge exchange and collaboration in the creation of bespoke DFACs*

6.3 Facilitating agency and professional engagement

This practice-based research was underpinned by engaging with multiple stakeholders through exhibitions, seminars and symposia. These engagements were used to gather insights from various audiences in order to gain a nuanced understanding of the complex factors connected with the creation of bespoke DFACs and the relationships between the stakeholders. Through these engagements my professional agency developed, which facilitated this research and established the direction for the future dissemination of my findings.

Developing my professional network allowed me to connect with the manufacturers of DFACs in Europe and the USA. By attending multidisciplinary workshops organised by these manufacturers I gained insights which contributed to the key findings of this research.

In order to engage with architects in the UK, I have presented continuous professional development (CPD) seminars related to this research to both large and small-scale architectural companies. Question and answer (Q&A) sessions during my presentations provided insights into the factors that inhibit the design and specification of bespoke DFACs addressing the gap in knowledge, misconceptions on the sourcing, cost, craft making and manufacturing of bespoke bricks. My presentation and the exhibition at the Materials for Architecture symposia in London in 2018 provided more insights through informal discussions with representatives of the construction industry in the UK.

Having won the "Future Lights in Ceramics" competition organised by the Ceramics and its Dimension European Society in 2018, I was able to both engage with a wider audience of ceramic artists in the UK and Europe and to gain the knowledge of European historic and contemporary manufacturing of DFACs. My participation in the European Ceramic Society (ECerS) XVI symposium in Turin in 2019 allowed me to gain insights into the context of European architectural ceramics and the collaborations between Italian designers and tile manufacturers.

My collaboration with the Brick Development Association (BDA) highlighted the gaps in the manufacturing of bespoke decorative bricks in the UK and led to my production of 'Technical Notes on Decorative Brickworks and Brick Artwork' document for the BDA website.[70]

Through working with EH Smith, a leading supplier of bricks and architectural rain screen facades, I have contributed an article to the company's online guest blog. The article discussed ceramic craft qualities of industrially produced bricks and addressed ceramic artists, architects and brick manufacturers. The publication subsequently led to my factory visits and discussions with brick manufacturers on the potential of digital interventions in manufacturing processes.[71]

[70] The document awaits approval by the BDA technical panel

[71] List of publications that includes exhibitions, published papers and public presentations is included on pp.10-11

Figure 6.6 shows the development of my agency and practice during this study.

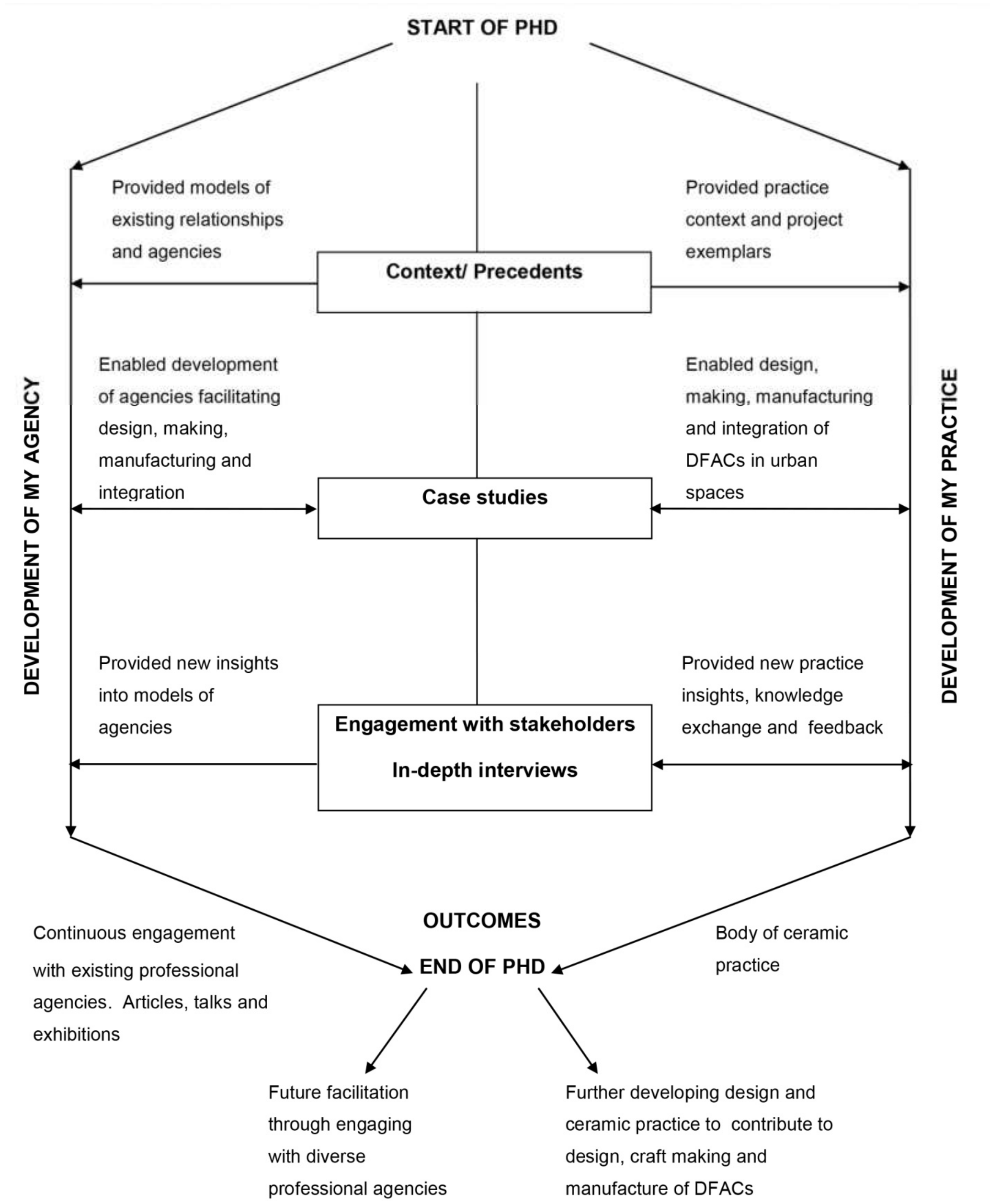

Fig. 6.6. *Development of my agency and practice in the course of this research and future dissemination of my findings*

My research that revealed a disjunction in the practices of ceramic artists, architects and industrial manufacturers highlighted the continuing need for practices, such as mine, to engage with all stakeholders and thereby bring about a growth of knowledge and application of architectural ceramics and bespoke bricks.

6.4 Perspective organisations for the further dissemination

The following organisations will be approached to disseminate my findings and include:

- Brick Development Association (BDA)
- Craft Potters Association (CPA)
- Royal Institute of British Architects (RIBA)
- Tile and Architectural Ceramics Association (TACS)
- UK Craft Council
- UK Design Council
- Winston Churchill Memorial Trust

6.5 Further research

Given the lack of literature on architectural ceramics and, specifically on decorative bricks, there is scope for future explorations of both historic and contemporary applications of DFACs and the processes that facilitate the creation of these. This study highlights the need for systematic research that can lead to publications on architectural ceramics aiming to address architects, designers, ceramic artists, planners and developers to facilitate creative opportunities and enable wider application of DFACs.

The practice aspect of this research can be used as a basis for future research into the processes of design, craft making and industrial manufacture of bespoke decorative bricks. My case studies serve as examples of the structural integration of bespoke DFACs, which highlighted that there is extensive scope for research into innovative brick designs and brick artwork.

Manufacturers in the UK might better facilitate research into innovative customisation, in particular, by applying digital processes to the industrial fabrication of bespoke bricks. University ceramics and architecture departments can both carry out research into innovative technical solutions and ceramic material and aesthetic qualities, to support the manufacture of bespoke DFACs.

Research into the application of craft processes in industrial manufacturing, carried out by ceramic artists and ceramic university departments, can facilitate the creation of ceramic craft qualities in industrially-produced DFACs. Further research into decorative glazes carried out by ceramic artists, craft specialists and manufacturers can support manufacturing processes and the creation of glazed bricks in the UK.

The decline of craft skills in brick manufacturing, as highlighted in this research, can be addressed by further investigation, opening opportunities for their revival. Valuable research can be carried out into initiatives and models of localised production of decorative DFACs, use of local craft skills, and policies that can facilitate these.

6.6 Closing remarks

This research addresses the existing gap in design, craft making and manufacturing practices, informing the fields of architecture, ceramic art and the industrial manufacturers involved in the creation of bespoke DFACs. The facilitating framework and key findings that I have identified and described in the process of my research aim to enable knowledge exchange and collaboration leading to both innovation and production of bespoke DFACs, contributing to the creation of diverse urban spaces.

The development of design guidelines and practice-specific recommendations for architects, ceramic artists and industrial manufacturers, planners and developers which my research sets out, will facilitate design, craft making, industrial manufacturing, specification and structural integration of bespoke DFACs. The dissemination of the key findings demonstrated through my ceramic practice outcomes, evidence how bespoke DFACs can be manufactured by the utilisation of innovative methods that combine digital, ceramic craft and industrial processes.

This practice-based research establishes the opportunities for further research and development in the field.

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APPENDICES

Appendix A

Stakeholders engaged with during this research: ceramic artists, architects, industrial manufacturers

Ceramic artists	
Andy Brayman, USA	Andy Brayman is a ceramic artist and the founder of The Matter Factory experimental ceramic facility based in Kansas City, USA. Brayman's practice combines traditional ceramic art practice and designs that use digital fabrication. From 2018 the Matter Factory became the Research & Development department for the Boston Valley Terra Cotta factory in Buffalo, New York. Brayman develops prototypes and new products for the manufacturers and supports the annual Architectural Ceramics Assemblies Workshop (ACAW) multidisciplinary workshop.
Lubna Chowdhary, UK	Lubna Chowdhary is a London based ceramic artist known for her colourful site-specific artwork. She has completed an artist in residency at the Victoria & Albert museum in 2017 and was shortlisted for the Jerwood Applied Arts Prize 2001. Chowdhary collaborated with Makespace Architects in creating glazed ceramic inserts for the facade of the Al Hikmah mosque in Aberdeen.
Babs Haenen, The Netherlands	Babs Haenen is a ceramic artist based in Amsterdam. Known for her expressive sculptural porcelain vessels she worked with Royal Tichelaar in Makkum manufacturer to produce site-specific artwork. Haenen collaborated with the architect Erick van Egeraat and Royal Tichelaar in the creation of porcelain sculptural cladding for the Civic Theatre in Haarlem, the Netherlands.
Duncan Hooson, UK	Duncan Hooson is a ceramic artist, author and educator. He is Stage 1 Leader, BA Ceramic Design at Central Saint Martins, Reader in Knowledge Exchange and co-founder of Clayground Collective, a UK

	independent arts organisation. Hooson’s practice is rooted in public engagement and includes private and public art commissions and collaborations with architects.
Christine Jetten, The Netherlands	Christine Jetten is a ceramic artist and glaze specialist based in the Netherlands. As a part of her practice, Christine collaborates internationally with architects and manufacturers to create bespoke glazes for ceramic facades. She engages with architects from the early stages of projects to develop glazes in response to their brief and often supports manufacturers in the development of glazes in industrial settings to achieve ceramic craft qualities. Christine collaborated on a number of projects with manufacturers in Europe, the USA and China.
Lydia Johnson, UK	Architect and ceramic artist Lydia Johnson is the founder of Fettle Studio, that focuses on design and making between architecture and ceramics. Johnson was one of the curators of the *Hand Held to Super Scale: Building with Ceramics* exhibition at the Building Centre in 2019. She collaborated with Penoyre & Prasad Architects on the Learning & Teaching Centre for Brunel University in London project, developing coloured glazes and prototypes for the ceramic cladding. Johnson is an architect at Citizens Design Bureau, a co-operative company of architects.
Kate Malone, UK	Kate Malone OBE is British ceramic artist who is renowned for her decorative, figurative vases and polychromatic sculptural pieces inspired by plants and nature. Her studio artwork is formed and decorated by hand. Crystalline glazes, that became Malone's trademark, were used for the facade of the retail and

	office building at 24 Savile Row, London.
Marta Nagy, Hungary	Prof. Marta Nagy is a ceramic artist and academic. She is the head of Masters in Ceramic Design program at the University of Pecs, Hungary. She collaborated with the architects and the Zsolnay Porcelain ceramic manufacturer in the creation of the ceramic polychromatic dome for the Pecs library foyer. Decorative brickwork for the Humtunnel pedestrian underpass in Delft was designed and produced by Nagy in collaboration with a brick manufacturer.
Matthew Raw, UK	Matthew Raw is a ceramic artist, former V&A artist in residence and co-founder of the Manifold collective. A Jerwood Prize winner, Raw uses tiles and letterforms to create narrative artworks in clay. As a part of his practice he runs public workshops in ceramics. Raw was involved in co-creation of a ceramic kiosk at Seven Sisters underground station in London.
Loraine Rutt, UK	Ceramic artist and cartographer, Loraine Rutt completed a Winston Churchill Travelling Fellowship in ceramic art in architecture visiting Mexico, Spain and the USA in 1996. Inspired by maps and travel, she founded The Little Globe Co; her ceramic practice focuses on making of maps and miniature globes in clay. Rutt collaborated with Metropolitan Workshop Architects and developed glazing to enable the manufacture of the ceramic facade for the Mapleton Crescent development in London.

Architectural practices	
Assemble, UK	Assemble is a Turner prize winning architects' collective which is engaged in art and architectural projects. Their

	practice includes self-built and publically engaged projects. The practice was engaged in the design and making of a ceramic kiosk at Seven Sisters underground station in London in collaboration with the ceramic artist Matthew Raw.
Bureau de Change Architects, UK	Bureau de Change is an award winning architectural practice based in London. Their designs are produced through prototyping, testing and extensive material research. The architects collaborate regularly with various fabricators to develop bespoke detailing for their projects. The practice was responsible for The Interlock building, which featured bespoke bricks produced for the facade by a volume brick manufacturer.
EPR Architects Ltd, UK	EPR Architects is a multidisciplinary practice which works across architecture, master planning and interiors, designing for workspace, hospitality and leisure sectors. EPR Architects collaborated with ceramic artist Kate Malone and craft manufacturer Froyle Tiles on the creation of a bespoke glazed facade at 24 Savile Row in London.
Eric Parry Architects, UK	Eric Parry Architects are involved in commercial, education, leisure and master planning projects. The architects are responsible for projects in London and Bath that feature glazed ceramic cladding. The practice collaborated with manufacturer Darwen Terracotta on the 1 Eagle Place project in Piccadilly, London.
Erick van Egeraat Architects, The Netherlands	Erick van Egeraat Architects is a multidisciplinary Rotterdam-based architectural practice involved in a range of international projects. The company collaborated with ceramic artist Babs Haenen and industrial manufacturer Royal Tichelaar to create a porcelain facade for the restoration of the Municipal Theatre in Haarlem, the Netherlands.

Makespace Architects, UK	Makespace Architects is a small London-based company which specialises in religious and community buildings, with a special focus on designs for mosques in the UK. The company collaborated with ceramic artist Lubna Chowdhary on the Al Hikmah Mosque in Aberdeen.
Metropolitan Workshop, UK	Metropolitan Workshop is a large multidisciplinary London-based practice which is involved in master planning and architectural projects on various scales. The company's Mapleton Crescent development features ceramic cladding created in collaboration with ceramic artist Loraine Rutt.
Penoyre and Prasad, UK	Penoyre and Prasad is a large UK-based company which specialises in education and healthcare buildings. The company designed The Learning and Teaching Centre for Brunel University that included a glazed facade developed in collaboration with ceramic artist Lydia Johnson.

Industrial Manufacturers	
Darwen Terracotta, UK	Based in Blackburn, Lancashire, Darwen Terracotta is the UK's only industrial manufacturer producing glazed architectural ceramic elements for building facades. Utilising both traditional ceramic craft and digital manufacturing techniques, the company is involved in restoration and new build projects. The projects include the restoration of the Royal Albert Hall and the new build House for Essex created in collaboration with ceramic artist Grayson Perry. The company manufactured the bespoke ceramic facade and artwork for 1 Eagle Place in London in collaboration with Erick Parry Architects and artist Richard Deacon.

Froyle Tiles, UK	Froyle Tiles is a small-scale craft manufacturer specialising in tiles for domestic applications. The company produces hand-crafted tiled for commercial projects, small-scale domestic and restoration commissions. Froyle Tiles company was instrumental in the creation of bespoke ceramic glazed tiles for 24 Savile Row and floor tiles for the Victoria and Albert Museum shop.
Forterra, UK	Forterra is a large high-volume UK manufacturer of clay bricks. Forterra's factory in Cradley, West Midlands, specialises in the manufacture of 'special' brick shapes. The company was responsible for the manufacture of bespoke bricks that formed the facade for 'The Interlock' building in London.
H.G. Matthews, UK	H.G. Matthews is a family run medium-sized brick factory located in Buckinghamshire. The factory specialises in wood fired bricks and is the only one of its kind in the UK. The factory includes a small glazing department that allows for small batch production of bespoke glazed bricks. Bespoke glazes produced at the factory are applied to both imported and locally fired bricks and to unfired bricks produced at their own factory. Bricks for the 'Ornamental Wall', case study 2, were glazed at the factory.
Ibstock Plc, UK	Ibstock Plc is the UK's largest manufacturer of clay bricks. Ibstock factories located at various sites in the UK manufacture both mass-produced standard bricks and hand-crafted brick specials.
Wienerberger, UK	Wienerberger is the world's largest manufacturer of clay roof tiles and bricks. Wienerberger UK factories include

	high-volume manufacturing and medium-sized facilities that produce brick 'specials' and clay products for restoration projects. 'Ceramic City Bench', case study 1, and 'Ornamental Wall', case study 2, were manufactured at the Wienerberger factory in Ewhurst, Surrey.
NBK Terracotta, Germany	NBK Terracotta is a large-scale German manufacturer of extruded glazed and unglazed ceramics. Following their production of RAL colour-matched ceramic facades for the St. Giles development in London, the company is engaging with ceramic artists to achieve ceramic craft qualities in their production. NBK Terracotta produced ceramic facades for the Mapleton Crescent development and the Learning & Teaching Centre, Brunel University, both in London.
Royal Tichelaar, The Netherlands	Established in the 16th century, Royal Tichelaar in Makkum is the oldest ceramic manufacturer in the Netherlands. Run by the Tichelaar family for 400 years until 2015, it originally produced bricks, followed by the manufacture of tiles and tableware. From late 1990s, the company transferred most of its production to architectural ceramics. Collaboration with architects and artists led to the manufacture of the porcelain pavement for the courtyard at the Victoria and Albert Museum in London and the creation of the ceramic facade for the Civic Theatre in Haarlem, created in collaboration with ceramic artist Babs Haenen.
Boston Valley Terra Cotta (BVTC), USA	BVTC is a large family-run manufacturer of glazed and unglazed ceramics for building facades based in Buffalo, New York State. The company utilises digital fabrication in manufacturing bespoke ceramic facades. Traditional

	ceramic craft techniques are combined with mechanised and digital processes. The annual Architectural Ceramics Assemblies Workshop (ACAW) multidisciplinary workshop organised by the manufacturer aims to provide knowledge exchange and facilitate innovation. BVTC's ongoing collaboration with the department of architecture at the University of Buffalo includes a student apprenticeship which facilitates the development of digital tools and processes.

Appendix B

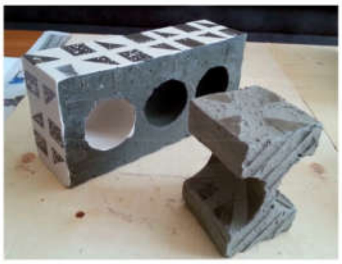
Documentation of practice

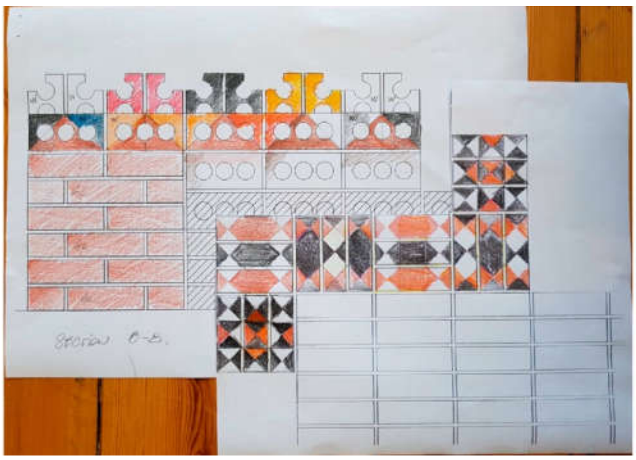
B.1: Case study 1: Record of design, making, construction and observation of Ceramic City Bench

Design of the bench
March 2018

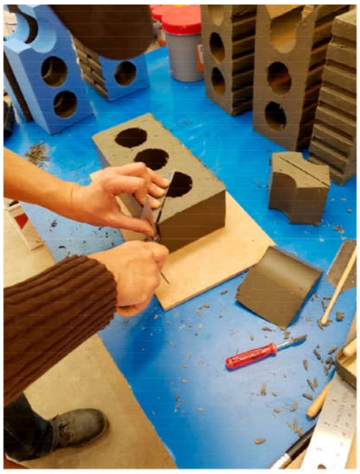
Inspirations, experimentations

Preliminary experimentations:
Carving, scoring, use of underglazes.





Making the bench at
Ewhurst, Wienerberger factory
8-10 April 2018

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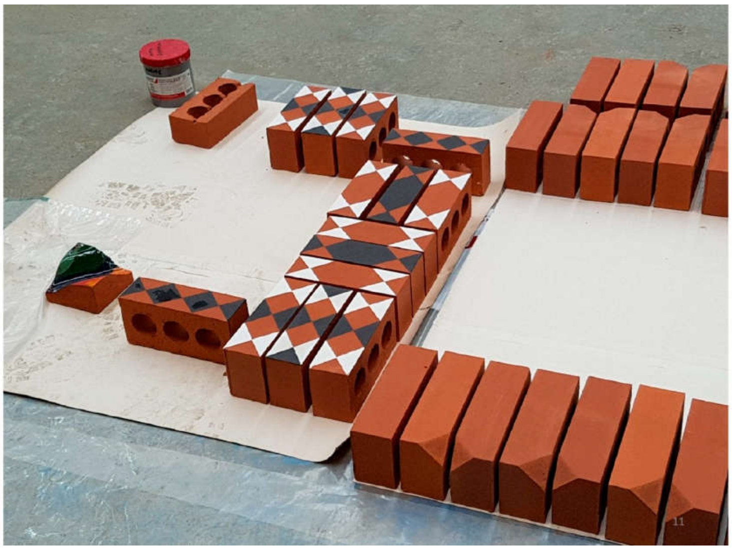
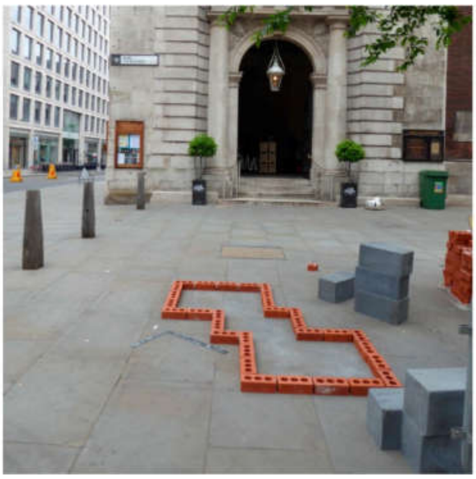
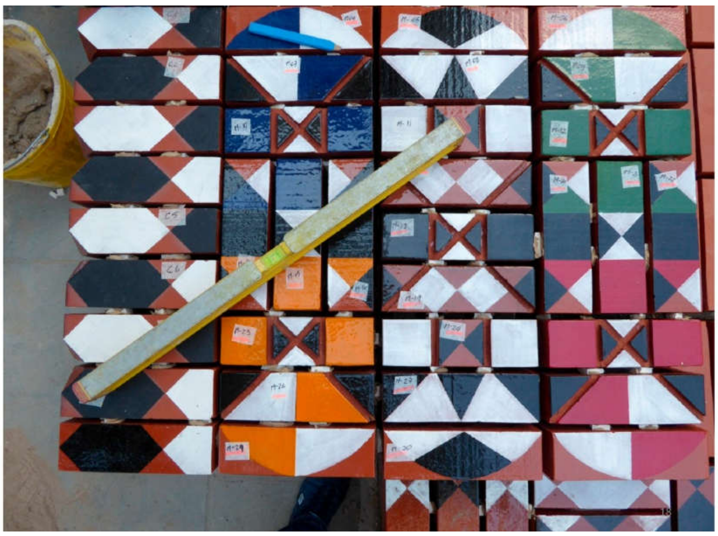
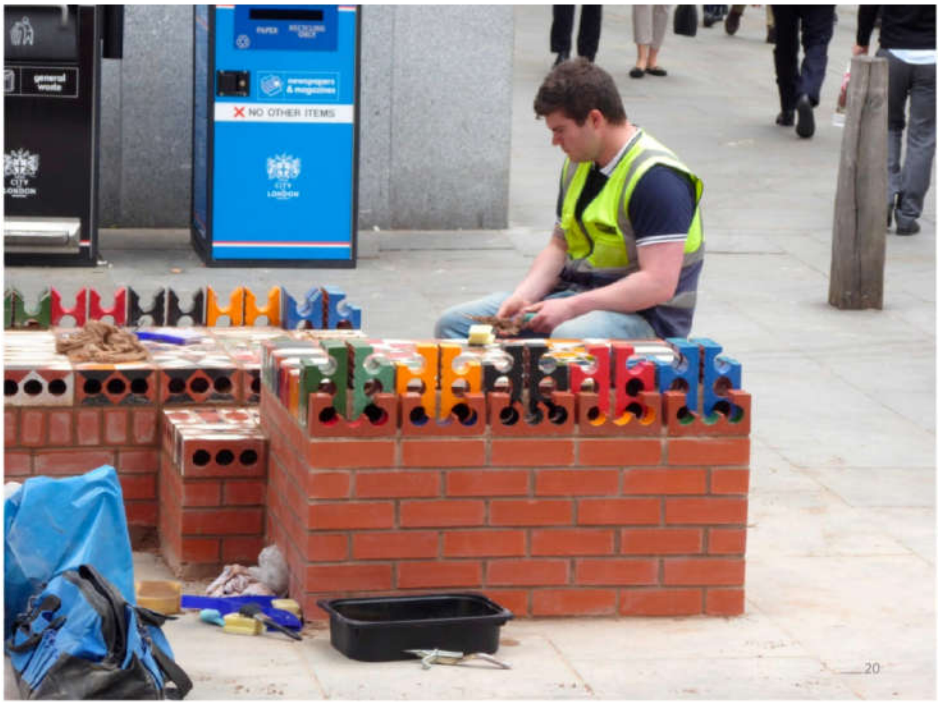


Construction of the bench
In the City of London
June 2018





Observations of the bench
In the City of London
June 2018



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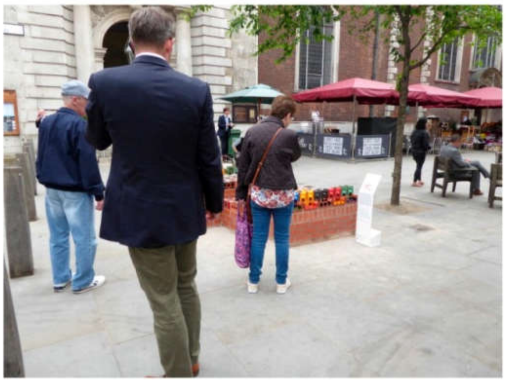

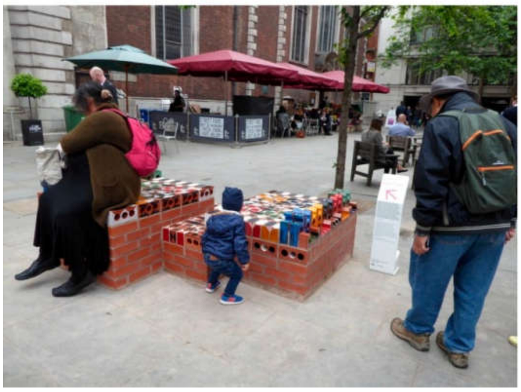

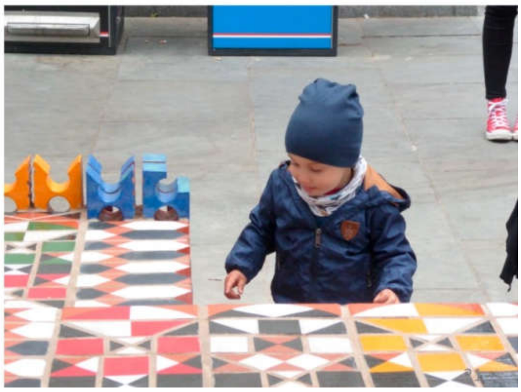

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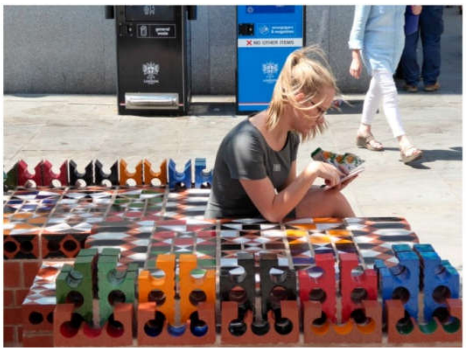
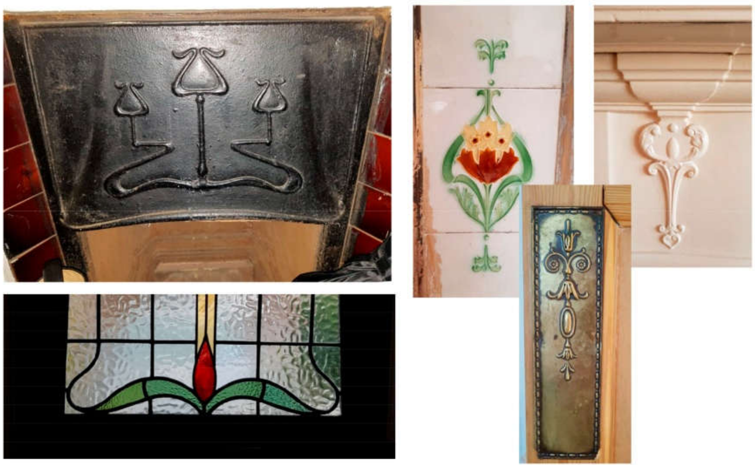


B.2. Case study 2: Record of design, making, construction and observation of Ornamental Wall

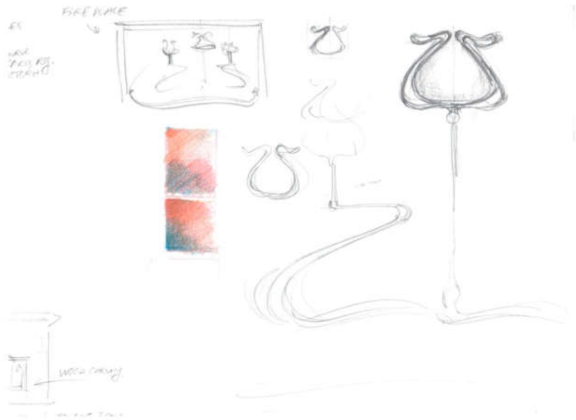
Local context:
Edwardian houses on the street developed circa 1910

Local context:
Details of front garden walls along the street

Local context:
Original detailing of the house



Local context:
Original detailing of the house



Laser cut elements based on the original detailing of the house and used for the creation of the relief in the brickwork

Preliminary design development and experimentation at Ewhurst, Wienerberger factory

Making ornamental bricks and cappings at Ewhurst factory.
Glazing at H.G. Matthews factory

Mould-made brick copings stamped with laser-cut ornamental motifs

Mould-made brick copings rolled with plaster profile made on the lathe

Test glazing of cappings, partially glazed bullnose corners

Construction of the wall

Demolition works, 12.05.20

The wall is deconstructed manually using hand tools and a pneumatic breaker

Foundation, 15.05.20

Ready-mixed concrete delivered on site and poured into the 600mm x 700mm trench.
Concrete was levelled manually.

Bricks setting out, 23.05.20

Blue engineering bricks set in hydraulic lime mortar are used above the ground level to form the base of the wall.

Wall construction, 23.05.20

Damp proof course (DPC) laid over engineering bricks to provide a barrier for water raising from the ground to protect porous decorative bricks above.

Wall construction, 23.05.20

Decorative bricks were made at Wienerberger Keymer factory, fired and transported to HG Matthews factory where these were glazed and fired a second time. HG Matthews standard machine-made red bricks were used for the blue-glazed headers and salt-glazed headers . Standard red bricks were used for the back of the wall.

Wall construction, 23.05.20

Textured bricks were hand-made by a brick maker in the moulds made by Maria Gasparian (MG). The bricks were fired at Wienerberger Keymer factory and delivered to the site.

Wall construction, 23.05.20

Decorative bricks set in moderate hydraulic lime mortar above the DPC.

Wall construction, 23.05.20

Laing decorative bullnose corners and blue glazed and salt glazed headers

Wall construction, 23.05.20

Wall construction, 24.05.20

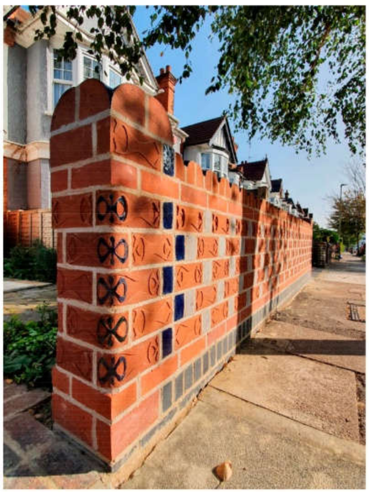
Wall construction, 24.05.20

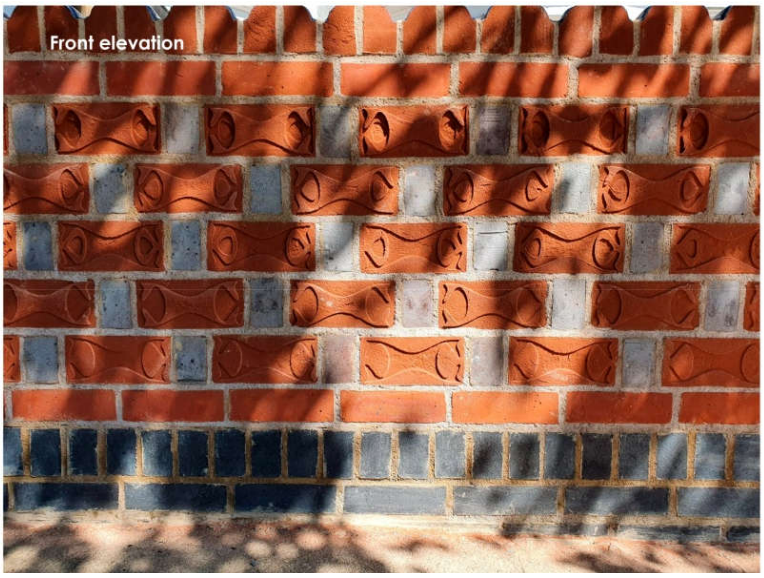
Installation of glazed brick cappings. Pointing with well-compacted moderate hydraulic lime mortar to encourage water run off.

The bricklayers by the completed wall, 24.05.20

Standard pier copings modified

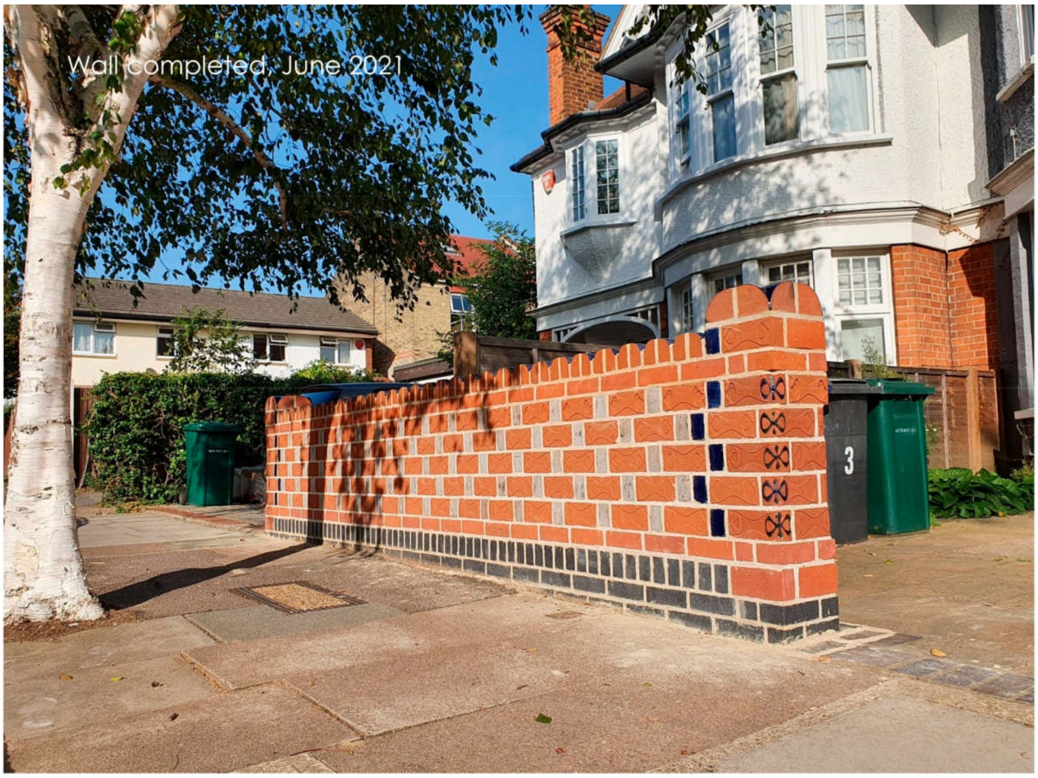
Standard copings adapted to the piers of the wall





The wall in the street context

Observation of the wall in the street context


Wall completed, June 2021
3

Appendix C

Analyses of historical and contemporary precedents

C.1. Brick artwork, Het Schip social housing complex, Amsterdam, The Netherlands (HP.1)

This scheme features sculptural brick detailing integrated into the facades of the social housing complex that was built in response to the housing shortage in the Netherlands. Within a limited budget the inventive use of essential building materials such as bricks and clay roof tiles provided decorative elements that aided individuality to the buildings.

The housing shortage triggered an increase in the number of housing schemes in the interwar period in the Netherlands. However the limited budget made it challenging to create architecture that aspired to improve the living environment. This precedent was selected to examine the factors that facilitated the structural integration of brick artwork into buildings and the relationships between the stakeholders involved in the project.

Key project Information

Location	Amsterdam, The Netherlands
Construction dates	1920-1921
Project participants	
Client	Social housing cooperative Eigen Haard (Own Heart)
Architect	Michele de Klerk
Sculptor	Hildo Krop
Bricklayers and ceramic makers	unknown
Ceramic materials used	Exterior: unglazed carved bricks, vitrified roof tiles. Interior:glazed factory-made tiles, hand-made decorative tiles

Project context

Het Schip housing complex was built as a part of the government-supported housing reform that was a response to the poor housing conditions in the Netherlands in the nineteenth century. In response to the housing shortage, the

1901 Housing Act attempted to improve the situation and enabled housing associations to build good homes in great numbers. Government loans financed the efforts of these self-organising cooperatives (Van Diemen et al., 2018).

The importance of individual touches was highlighted in the development and at the same time, austerity measures connected with interwar economic and political crises imposed constraints that dictated the aesthetic and material solutions.

The design intent

Designed by Michel de Klerk, one of the founders of the Amsterdam School movement, the housing complex demonstrated the guiding principles of the group. Architects of the Amsterdam School propagated art that was democratic and accessible to people by integrating "communal art" into the buildings and creating Gesamtkunstwerk- the unity of art, crafts and architecture (Van Diemen et al., 2018, p.18; Het Schip, 2016).

Design, craft and manufacturing processes; Ceramic craft and material qualities

Stylised birds, animals and plant motifs carved out of bricks were included into the facades, creating accents on the corners of the buildings, flat entrances and archways.

The relationships and knowledge exchange

The architect produced the sketches for the sculptures and architectural drawings indicating the position of the brick artwork in the buildings. The sculptures were executed by Hildo Krop, Amsterdam's chief municipal sculptor (Figure B.1). The structural integration of the artwork into facades evidences the coordination and staging of the building works and the creation of the artwork.

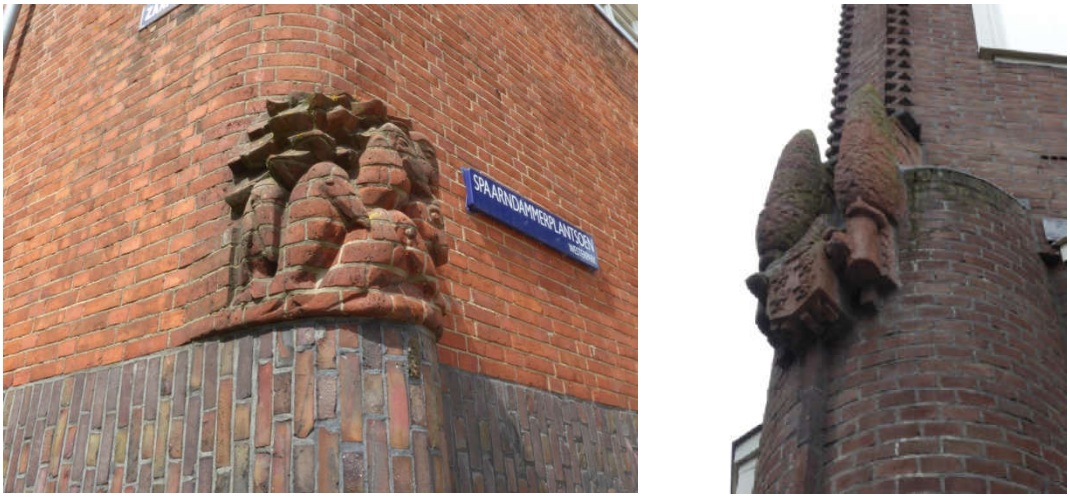


Fig. C.1. *Sculpted corner details of Het Schip apartment blocks* (2016)

Insights from HP.1

- Government policies and loans facilitated the creation of housing that created an improved environment.
- The guiding principles of the Amsterdam School movement, that advocated the integration of art into buildings, facilitated the structural integration of sculptures into the facades with the view to improve the environment for residents.
- Collaboration between the architect and sculptor facilitated the design and structural integration of the brick artwork.
- This included the involvement of the sculptor who worked in a variety of media, including clay, which enabled the creation of brick sculptures.
- The sculptor's collaboration with the architect who produced the sketches for the sculptures and designed the locations of the artwork enabled the integration of the pieces into the buildings.

C.2. Ceramic mosaic bench, Park Güell, Barcelona, Spain (HP.3)

This precedent was chosen to examine the factors and relationships between the architects, artists and makers that allowed the execution of the undulating crafted ceramic bench.
The precedent illustrated how form, human scale, colour and ceramic craft qualities contributed to a varied ceramic environment.

Fig. C.2. *Park Güell, details of the ceramic bench* (2016)

Key Project Information

Construction Dates	1900-1914
Project Participants	
Client	Eusebe Güell
Architects	Antoni **Gaudí** and Josep Maria Jujol Gibert.
Sculptors, specialist craft makers	unknown
Ceramic materials used	Original pieces for the bench: recycled low fired ceramic tableware and tiles. Renovation: stoneware clay, coloured engobes, high-fired glazes.

Project Context

From the Middle Ages the Iberian Peninsula was a meeting place of Islamic and Christian architectural traditions. The 'Modernista' movement in Spain prevailing at the end of the 19th century and the beginning of the 20th century, was heavily influenced by Arts and Crafts aesthetics. The architecture of this period demonstrated the interest toward the use of traditional materials and combined traditional and innovative building techniques.

The social context in Spain at the beginning of the 20th century, similar to other European countries and Britain in particular, led a desire to escape from the cramped conditions of industrialised cities and look toward nature. This tendency led to several projects in the suburbs of European cities and in the case of Britain to the Garden City movement. Social ideas, utilised in Britain by the architects of the Arts and Crafts and Garden Cities developments such as Bourneville and Port Sunlight were brought to the attention of Spanish industrialists and architects (*The history of Park Güel*, 2016).

Local architectural traditions and aesthetics, such as the use of ceramics, colours and motifs linked to the traditional Moorish architecture, combined with the innovation in building techniques brought to the innovative architecture and detailing. Supported by the rich clients - industrialists the best examples of Modernista architecture, including Park Güel, were created in the new neighbourhoods of Barcelona.

Design intent

The park was conceived to surround luxury houses for upper class residents, and was inspired by the English Garden City movement, responding to public health in the industrialised city. However, the commercial project was unsuccessful and the park was converted to a public park in 1926.

Design, craft and manufacturing processes/ Ceramic craft and material qualities

The aesthetic language developed by Gaudi and Jujol, was influenced by Moorish architecture and the use of coloured ceramics to cover the surfaces of walls and decorative elements. The iconography of the park was inspired by natural motifs, the implementation being enabled by the close co-creation between the architects, sculptors and craftsmen working on site. The "sea serpent" curved bench was designed with enclaves to create social interaction.

The surface of the undulating public bench was clad by broken glazed ceramic pieces to create a mosaic 'trencadis', which the complex three-dimensional geometry to be covered.

The ceramic waste materials such as broken tableware and tiles were delivered daily and were laid by hand on site by sculptors and craftsmen without preliminary drawings resulting in highly expressive and unrepeated patterns and motifs (Torres, 2018). The surface patterns on the bench are individual, showing that a certain degree of artistic freedom was allowed to the artists and craftsmen. Both Gaudi and Jujol were heavily involved in the works on site, supervising and collaborating which allowed for the creative freedom to take place in a collaborative process. Ornaments evoking sea creatures, organic motifs and colour combinations form the bench (Bergos Masso and Llimarag, 1999).

The original bright colours and textures were achieved through the use of low-fired ceramic tableware and tiles provided by local ceramic factories. These factories have deteriorated throughout the 20th century and were restored by the Ceramica Cumella ceramic manufacturer in 2005. The replica pieces were produced using stoneware clay, painted with the coloured ceramic slips and engobes to match the colours of the originals and fired at a higher temperature to provide longevity (Cumella, 2016).

The relationships and knowledge exchange

Collaborative working relationships between the architect, artists and craftsmen enabled the creation of this highly crafted intervention. The client's long working relationship with the architect and his commitment to the project enabled the creation of the park and the inclusion of the artwork. The involvement of several sculptors and craftsmen during the execution of the mosaic bench and the artistic freedom allowed by the architects provided a variability of aesthetic language.

Insights from HP.3

- The client's commitment and relationship with the architect enabled freedom of expression and an idiosyncratic result.

- Enabling budget and timescale of the project allowed the creation of the artwork.
- Artistic freedom during the execution of the mosaic provided variability of aesthetic language.
- Information and knowledge exchange through prototyping and three-dimensional modelling by the architects, on-site collaboration and co-creation enabled the construction of the complex configuration.
- The original use of local ceramic products created site-specific aesthetics and expressed the local cultural context.
- The original ceramics replaced during the restoration works by Ceramica Cumella manufacturer, were substituted by high-fired stoneware to add to the longevity of the bench.

C.3 Terracotta ornamental facade, Guaranty Building, Buffalo, New York, the USA (HP.4)

The Guaranty Insurance building features both low and high relief repetitive decorative facade detailing. The cladding was made in unglazed terracotta that served as fireproofing cladding and expressed the high profile of a successful insurance company building in Buffalo.

The implementation of a large-scale building that features repetitive elements that combine the large scale and intricacy of the detailing was focus of this investigation. The relationships between the designers, makers and industrial manufacturer that allowed for the design and production of the ceramic elements were also addressed.

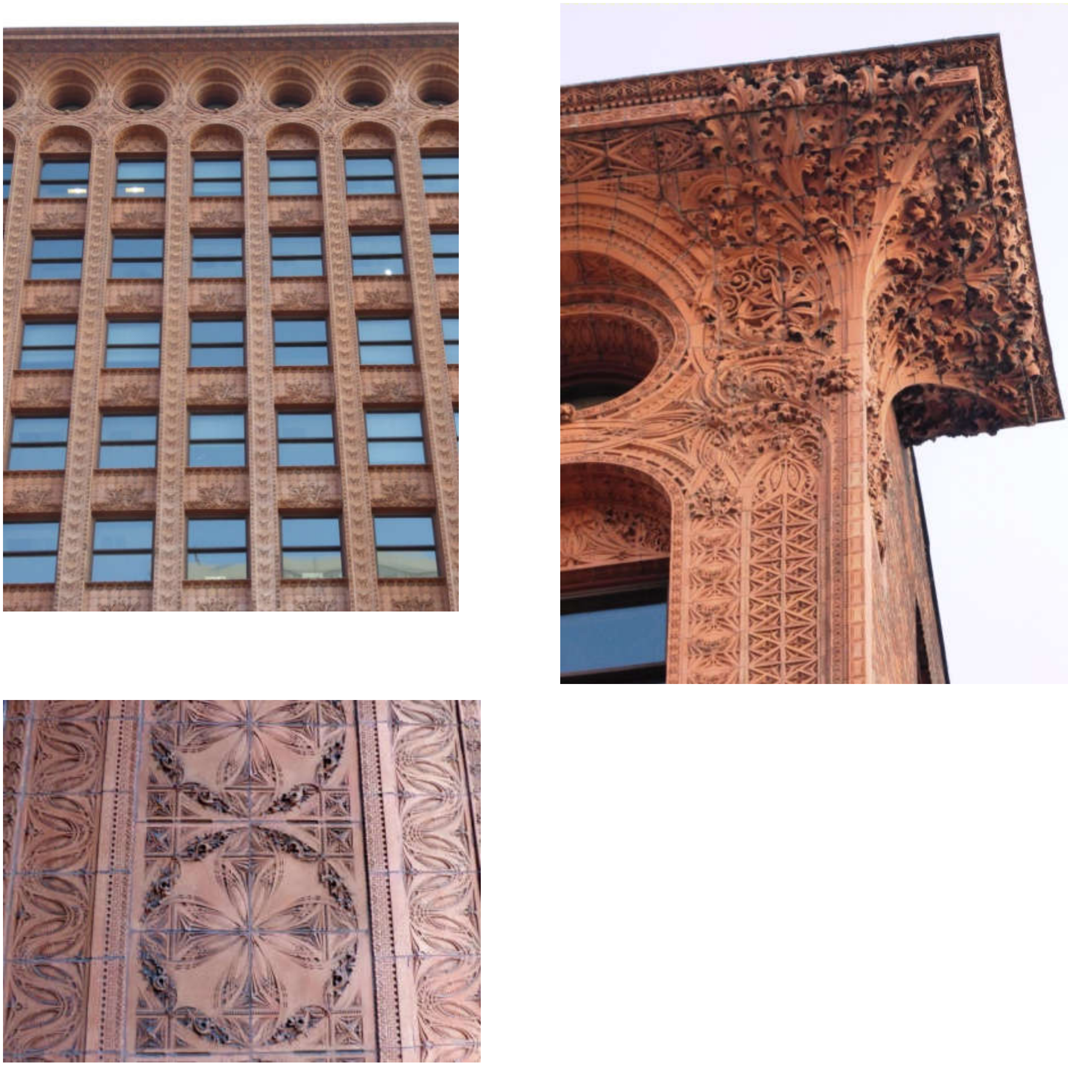


Fig. C.3. *Guaranty Building, details of the elevation and ornamental cornice* (2018).

Key project Information

Construction dates	Completed in 1896
Project participants	
Client	Hascal T. Taylor
Architects	Louis Sullivan, Dankmar Adler
Architectural draftsmen	unknown
Sculptors, specialist craft makers	unknown
Ceramic materials used	High and low- relief unglazed terracotta panels

Project Context

The use of architectural ceramics for high-rise buildings was in high demands in the USA following the Great Chicago Fire in 1871. Following the fire, the architects have been faced with the urgent demand to fireproof the exterior of their buildings. Terracotta detailing was brought to the USA from Britain, where the Arts and Crafts style was prevalent at the time. The ornamentation of the early skyscrapers in the USA and particularly the Guaranty building was highly influenced by the aesthetics of Arts and Crafts movement.

Design Intent

The multi-purpose office building with the first three storeys serving as a lobby, was created to express the status of the client's company. The public areas for street-facing shops, public entrances and lobbies all included terracotta elements connecting the interior and exterior spaces.

Design, craft and manufacturing processes; Ceramic craft and material qualities

Terracotta ornamental elements cover the entire front elevation of the building and are integral to the structure. While detailed sketches produced by the architects were developed by draftsmen, the three dimensional elements were produced at the factory and finished by hand (*Guaranty Building,* 2018).

Unglazed terracotta ornamentation accentuated the vertical movement of the façade and culminates in the cornice of the building. The abstract floral motifs that cover the entirety of the facade including the pilasters, spandrels, heavy columns at the entrance lobby and protruding capitels at the ground floor added to the outstanding presence of the building in the street. While low relief repetitive detailing was achieved in press moulds, high relief capitels and cornices of the building were finished by hand after being released from the mould to introduce complex three-dimensional elements.

Boston Valley Terra Cotta manufacturer, who were responsible for the restoration of the building, utilised contemporary digital techniques including 3D scanning and CNC milling combined with traditional ceramic craft techniques for the reproduction and manufacturing of the decorative elements.

The relationships and knowledge exchange

Collaboration between the designers, sculptors and makers enabled the creation of terracotta elements on a large scale. Sketches created by the architect were made into working drawings by the draftsmen in the architects' offices. These were made into plaster prototypes and enabled the mould-making and industrial manufacture of elaborate ornamentation (*Guaranty Building*, 2018).

Insights from HP.4

- Collaboration between architects draftsmen, sculptors and makers at the factory enabled the development of intricate detailing.
- Information exchange through sketches, prototyping and modelling by architects, enabled the construction of elaborate ornamentation.
- Ceramic manufacturer's support that included ceramic craft methods within large volume production enabled the large-scale project.
- Contemporary manufacturing methods allow the reproduction of elaborate detailing using digital technology.
- Digital 3D scanning technology enabled the reproduction of existing architectural detailing at a great speed, precision and at a lower cost compared to the hand-made sculpted originals.

- A combination of hand-made and digital processes were used in the reproduction of high relief that includes the creation of undercuts and required hand-made finishing.

C.4 Ceramic floor tiles, Victoria and Albert Museum shop (CP.4)

This precedent was chosen to investigate the creation of bespoke ceramic floor tiles that were created with the aid of digital tools. 3D printing with clay created inconsistent material qualities but provided 'digital' aesthetics that were reproduced by traditional hand-made techniques to ensure the material qualities required. The precedent highlighted the importance of early involvement of a ceramic material specialist to achieve the material qualities required for the structural integration of bespoke DFACs.

Key project Information

Location	Victoria & Albert Museum shop, London
Construction dates	Completed in 2017
Project participants	
Client	Victoria & Albert Museum
Architect	Friend & Company
Architect/ Digital fabrication	Guan Lee, Grymsdyke Farm
Ceramic manufacturer	Froyle Tiles
Ceramic materials used	3D printed clay and hand press-mould stoneware floor tiles. Clear and blue-grey glazes.

Project context

The ceramic floor tiles were part of the overall shop fitting out and remodelling of museum retail space. Friend & Company architect's aim was to "express Victoria and Albert Museum's historic association with craft and design" (McLaughlin, 2017).

Design intent

The design of the shop aspired to relate to the original (1863) museum shop which aimed to "showcase new crafts" and to connect visitors with the museum's collections. The design of the tiles for the museum floor was created using digital craft while relating to the historic collection of the museum.

Design, craft and manufacturing processes; Ceramic craft and material qualities

The tile design was originated by the architects responsible for the shop design and was further developed by the architect Guan Lee, who produced 3D printed clay tiles. The design was based on reference to a floral ornament on a ceramic piece in the museum collection.

Originally the tiles were 3D printed in clay at the Grymsdyke Farm experimental facilities. The soft clay was squeezed through the nozzle using a robotic arm, over the hand-rolled stoneware tiles. The difference in the moisture content in the liquid clay and the slab base caused the tiles to warp and delaminate (Lee, 2017 and Miller, 2017). The tiles were fired at the Froyle Tiles craft manufacturing facilities and were installed on the perimeter of the shop and under the cabinets.

However, within a year of installation the tiles were remade and substituted. Figure B.4 shows on the left the original 3D printed tiles and tiles that were remade by Froyle Tiles on the right. The 3D printed tiles were re-made using a traditional press-mould technique. To recreate the aesthetics of a 3D printed tile, plaster moulds were made from the 3D printed model at Froyle Tiles. The moulds were finished by hand to eliminate the undercuts created by the printed coils. The clay was hand-pressed in the plaster moulds, fired and glazed with the blue-gray glaze to highlight the depth of the relief (Miller, 2018). The tiles that had a consistent surface were installed in the central parts of the shop.

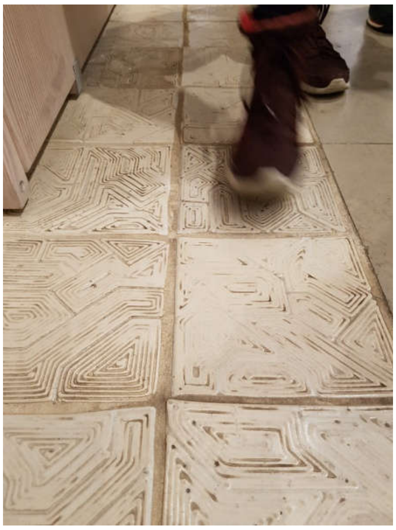
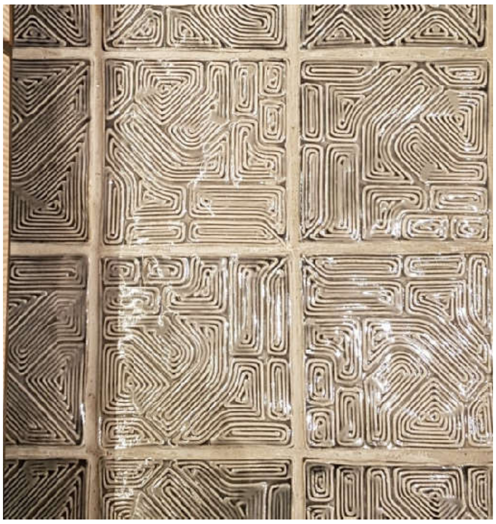
 

Fig. C.4. *Left: Tiles 3D printed in clay at Grymsdyke Farm experimental facilities. Right: tiles remade by Froyle Tiles using a traditional press-mould technique* (2018)

Relationships and knowledge exchange

The diagram included in Figure B.4 shows how the collaboration between the ceramic craft manufacturer and digital fabricator at the second stage of the project created improved aesthetics and material results that aided the structural integration of the tiles into the floor.

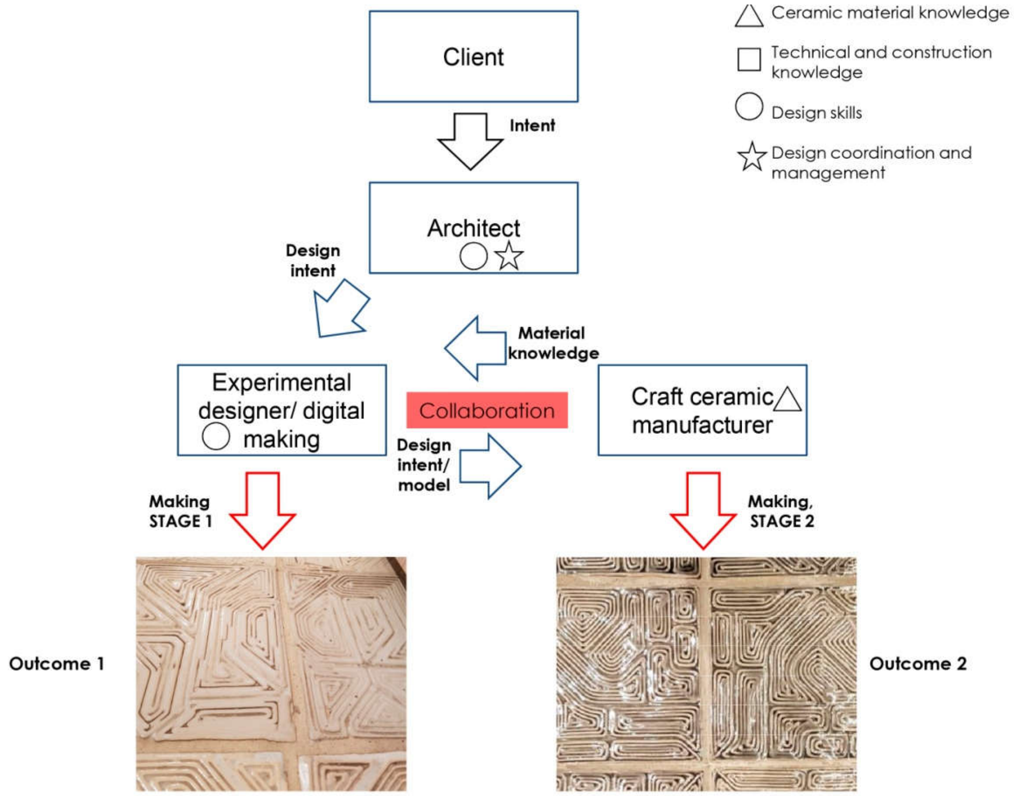


Fig. C.5. *Relationships of project participants, information and knowledge exchange*

Insights from CP.4

- Knowledge exchange and collaboration between the craft ceramic tile manufacturer and experimental maker enabled the creation of material qualities necessary for the integration of the tiles .
- A lack of ceramic material knowledge on behalf of the architect caused material failures.
- A lack of preliminary material testing and experimentation caused inconsistent material qualities.
- The involvement of a small-scale craft manufacturer facilitated the manufacture of floor tiles that combined material and ceramic craft qualities.
- While 3D printing in clay presents opportunities and provides distinct aesthetics, it has limitations in the production of DFACs.

C.5 Decorative brick cladding, Humtunnel bicycle and pedestrian underpass, Delft, the Netherlands (CP.5)

The decorative brick cladding for the underpass was designed by Hungarian ceramic artist Marta Nagy in response to the brief by the Delft City Council aiming to improve the environment of this city-centre location. The processes of design and manufacture of the bricks by the artist in collaboration with a small-scale brick manufacturer were investigated in this precedent.

Key project Information

Location	Delft, the Netherlands
Construction dates	Completed in 2013
Project participants	
Client	Municipality of Delft
Architect	N/A
Ceramic artist	Marta Nagy
Ceramic manufacturer	Hungarian small-scale brick manufacturer
Installer	Local bricklayer
Ceramic materials used	Undulating customised bricks. Silver and gold paint.

Project context

The project was a part of the "Delft Ceramic Route" initiative introduced by the city authorities to celebrate the heritage of the city of Delft that has produced ceramics since 1653.

Design intent

Before the renovation the walls of the underpass which is located on the route from the railway station to the city centre were covered with graffiti and advertising leaflets.

The City Council’s brief aspired the new intervention to improve the environment in the tunnel, eliminate graffiti, advertising and littering.

Design, craft and manufacturing processes; Ceramic craft and material qualities

Marta Nagy has created a brick artwork called ‘Garden’, the patterns of which were inspired by a map of Delft dated 1652 that shows canals and gardens. Both aesthetic and utilitarian considerations drove the design of the decorative cladding for the tunnel. Undulating bricks form a strong geometrical pattern that was devised by Nagy to discourage spraying graffiti. The undulation of the bricks was developed to prevent attachment of advertising leaflets.

The bricks were hand-made in moulds in the factory and were individually cut by the factory staff, fired to 1050˚C and painted with golden and silver paint by the artist.

Unglazed terracotta coloured bricks were used to contrast with the traditional "Delft Blue" ceramics and to create a robust surface for the walls of the tunnel. The composition of the ‘Garden’ comprised silver and golden highlights making abstract patterns referencing flowers (Nagy, 2016). Figure B.6 shows the tunnel before the renovation and Figure B.7- three years after the artwork was installed, demonstrating the long lasting effect of the ceramic intervention.

Fig.C.6. *Humtunnel, Delft. The tunnel before renovation* (Photo: Nagy, 2013)

Fig. C.7. *Humtunnel, Delft. Brick artwork three years after completion* (2016)

Relationships and knowledge exchange

The project was enabled by the flexibility of a small-scale Hungarian brick manufacturer who undertook the production of the special shaped bricks, which were made in customised moulds and then cut by hand (Nagy, 2016). The ceramic artist worked alongside the manufacturer at their facility, iterating the designs to create repetitive elements that would create a varied pattern across the walls of the tunnel. Nagy's previous experience and architectural knowledge facilitated the design, manufacture and integration of the bespoke brickwork.

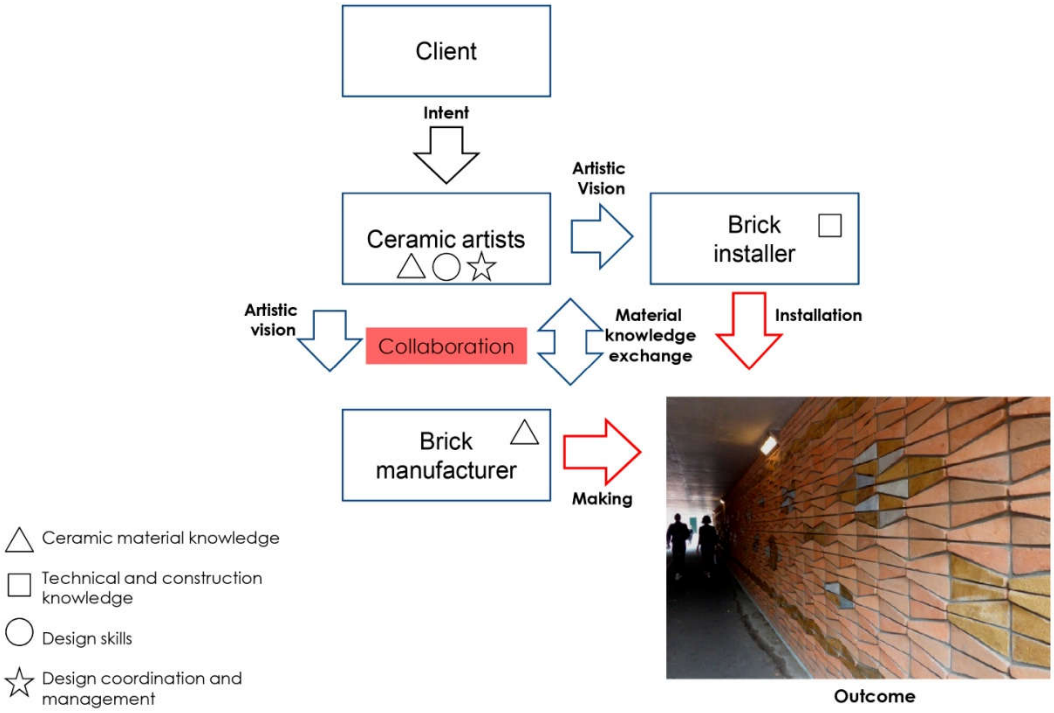


Fig. C.8. *Relationships of project participants, information and knowledge exchange.*

Insights from CP.5

- Commissioning by the local authority facilitated the project.
- Ceramic material knowledge, design and management skills performed by the ceramic artist enabled the creation and structural integration of the artwork.
- The flexible small-scale manufacturer facilitated the craft making of bespoke bricks.
- Collaboration between the ceramic artist and manufacturer enabled the making of bespoke bricks.
- Site-specific narrative was achieved through the artwork made out of bespoke bricks.
- The artwork resulted in an improved environment of the underpass aided by the application of undulating bricks.

C.6 Civic Theatre, Haarlem, the Netherlands (CP.6)

The creation of sculptural porcelain cladding for the extension to the Civic Theatre building was investigated in this precedent. The collaboration between the ceramic artist and Royal Tichelaar manufacturer, the working relationships with the architect and her contribution to the aesthetics of the building were examined to gain insights into the factors that facilitated the manufacture and integration of the bespoke ceramic elements.

Key project Information

Location	Haarlem, the Netherlands
Construction dates	Completed 2009
Project participants	
Client	Municipality of Haarlem
Architect	Erick van Egeraat Architects
Ceramic artist	Babs Haenen
Ceramic manufacturer	Royal Tichelaar, Makkum
Installer	unknown
Ceramic materials used	Porcelain slip-cast and glazed cladding elements

Project context

Built in 1918, the Theatre building was designed by the Dutch architect J.A.G. van der Steur and included ceramic elements created by the Dutch ceramic artist Leon Senf. Erick Van Egeraat Associated Architects were commissioned to design the extension to the building which included a new fly tower.

Erick Van Egeraat has collaborated with the Dutch ceramic artist Babs Haenen since the late 1990s after visiting her solo show ‘ the Turbulent Vessel’ at the Stedelijk Museum in Amsterdam in 1998 (Haenen, 2020). In order to develop porcelain elements for the Civic Theatre he approached Haenen at the early stages of the project. Ceramic elements, designed by the artist in collaboration with the architect were part of the composition of the facade which comprised bricks, ceramic tiles and glass panels visually connecting the historic building to the new extension.

Design, craft and manufacturing processes; Ceramic craft and material qualities

Folded fabric, rocks and mosses provided inspiration for the repetitive relief tiles and ornaments**.** Sculptural elements introduced within the tiles cast shadows reminiscent of a Greek palmette pattern. The colours of the tiles that graduate from dark blue and green becoming lighter at the higher level were derived from the dark-green ceramic tiles from the original building that were created by ceramic designer Leon Senf for the original building (Cfile, 2021b). The collaboration between the artist and the ceramic manufacturer led to the development and production of porcelain elements making the Civic Theatre the first porcelain facade in the Netherlands. The building is situated in the vicinity of the Sint Bavo cathedral which also features ceramic elements which were described as 'Modern Baroque" by the architect.

The aesthetic language and ceramic craft techniques developed in the artist's own studio artwork were utilised to develop ceramic elements for the facade of the Civic Theatre. The translation of the ceramic craft aesthetics into the industrial process was facilitated by the close involvement of the artist working with the manufacturer. There were three reproducible designs which were created through a series of iterations at Royal Tichelaar in Makkum (Haenen, 2020).

Fig. C.9 *Left: elements of porcelain cladding. Right: fragment of the Theatre rear elevation* (2021)

Relationships and knowledge exchange

The collaborative links and knowledge exchange that enabled the design, craft making and manufacture of the ceramic cladding for the Theatre are described in Figure B.10.

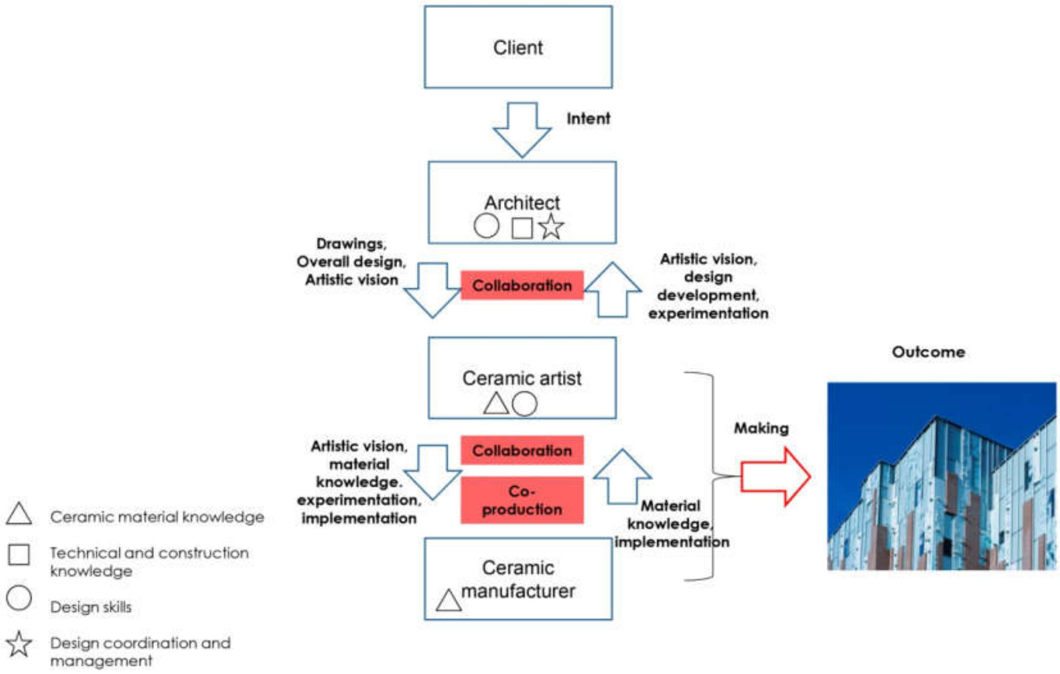


Fig. C.10. *Relationships of project participants, information and knowledge exchange.*

Insights from CP.6

- Collaborative relationship between the architect and the ceramic artist prior to the project facilitated her early involvement in the design process.
- Ceramic artist's at the early stage of the project facilitated the design development and collaboration with the manufacturer.
- Artist's engagement with the manufacturer and her work at the factory facilitated the iterative design and manufacturing processes.
- Artist's personal artistic language provided distinct ceramic aesthetics.
- Bespoke ceramic elements provided site-specificity and a link to the architectural context through the use of sculptural motifs and the colour of the glaze.

Appendix E

Factory visits (2016-2021): Summary of products and processes

Manufacturing methods of clay products made in brick factories in the UK and Europe

Factory	Visit dates	Location	Product	Forming Methods						Achieving Texture			Achieving Colour					
				Extru-sion	Hand-pressed in the mould	Machine-pressed in the mould	Hand-Cut	Sculpted / Rubbed	RAM - pressed	Applying sand	Stam-ping and rolling textures	Carving	Sands coloured by metal oxides	Decora-ting clay slips/ engobes	Under-glazes	Glazes	Metal oxides/ soluble salts	Firing atmosphere (oxidised/ reduced)
Ewhurst, Keymer, Wienerber-ger	2017 2019	Ewhurst, Surrey, UK	Extruded standard hollow bricks	*						*			*	*				Oxidised
			Hand-made standard solid bricks		*					*			*					Oxidised
			Hand-made solid "standard special" brick		*					*	*		*					Oxidised
			Hand-made roof tiles	*			*			*			*					Oxidised
			Roof detailing	*			*											Oxidised
Cradley, Forterra factory	2019, 2021		Extruded solid standard bricks and paviours	*														Oxidised and reduced
			Extruded ‘standard special’ bricks	*				*										Oxidised and reduced
			Extruded ‘non-standard special’ bricks	*			*											Oxidised and reduced
			Special detailing	*					*									Oxidised and reduced

H.G. Matthews	2018-2021		Hand-made standard solid bricks		*	*	*	*		*						*		Oxidised
			Hand-made solid brick "standard specials"		*	*	*	*		*						*		Oxidised
Ibstock Plc				*		*												Oxidised
Ibstock Plc, Eclipse factory	December 2020	Leicester		*		*												Oxidised
Ketley factory	March 2019	Dudley, West-Midlands, UK	Extruded solid standard bricks	*														Oxidised and reduced
			Extruded solid standard paviours	*							*							Oxidised and reduced
			Extruded quarry tiles	*														Oxidised and reduced
			Roof finials	*			*	*										Oxidised
			Roof detailing	*			*											Oxidised
St. Joris	July 2016	Roremont, Netherlands	Extruded standard hollow bricks	*		*					*			*		*		Oxidised
			Extruded "standard special" brick	*												*		Oxidised
			Extruded window sills	*												*		Oxidised
			Bespoke designs	*					*							*		

Terracotta and faience products in the UK, Europe and USA

Factory	Visit dates	Location	Product	Forming Methods						Achieving Texture			Achieving Colour					
				Extru-sion	Hand-pressed in the mould	Slip-cast	Hand-Cut	Sculpted / Rubbed	RAM - pressed	Applying sand	Stam-ping and rolling textures	Carving	Sands coloured by metal oxides	Decora-ting clay slips/ engobes	Use of ceramic decals	Glazes	Metal oxides/ soluble salts	Firing atmosphere (oxidised/ reduced)
Darwen Terracotta	2017	Blackburn Lanca-shire, UK	Bespoke facade cladding		*	*									*	*		Oxidised
			Bespoke sculptural elements		*	*		*	*		*	*		*	*	*		Oxidised
			Standard hand-basins			*			*							*		Oxidised
Royal Tichelaar, Maakkum	2016	Makkum, Netherlan ds	Bespoke ceramic cladding and paving		*	*		*	*		*	*		*		*	*	Oxidised
			Bespoke sculptural elements		*	*		*	*		*	*		*		*	*	Oxidised
Ceramica Cumella	2016	Granolles Spain	Bespoke facade cladding	*	*	*		*	*		*	*		*		*	*	Oxidised
			Bespoke sculptural elements		*	*		*	*		*	*		*		*	*	Oxidised
			Bespoke tiles												*			