

DISCOVERING CONCRETE IN THE 'LAND OF STONE':
A PRE-INVENTORY OF BUILDINGS CONSTRUCTED USING PROPRIETARY
REINFORCED CONCRETE SYSTEMS IN SCOTLAND C. 1900-1920

A dissertation submitted for a

Master of Science (MSc) Degree in Architectural Conservation
University of Edinburgh

by: Allison H. Borden

SCOTTISH CENTRE FOR CONSERVATION STUDIES
SCHOOL OF ARCHITECTURE
EDINBURGH COLLEGE OF ART

2006-2007

Nothing ought to look less secure than it is, and nothing should appear to depend on cement for its security against gravity, a force which never sleeps and is always ready to take the smallest advantage that is offered to it.

Sir Edmund Beckett, *A Book on Building, Civil and Ecclesiastical* (1876).

[C]oncrete was first produced by the hand of Nature in the form of rock...Concrete was next produced by man.

W. Noble Twelvetrees, *Concrete and Reinforced Concrete* (1922).

Reinforced concrete does not grow like wood, is not rolled like steel sections, is not jointed like masonry.

Robert Maillart.

Possibly the most interesting man-made structural material is *reinforced concrete*.

Mario Salvadori, *Why Buildings Stand Up* (1990).

CONTENTS

| | |
|--|----|
| ILLUSTRATIONS | v |
| ACKNOWLEDGEMENTS | vi |
| CHAPTER 1: INTRODUCTION | 1 |
| ABSTRACT | 1 |
| AIM AND OBJECTIVES OF THE RESEARCH | 4 |
| Overall Aim | 4 |
| Specific Objectives | 4 |
| BACKGROUND | 5 |
| JUSTIFICATION FOR THE RESEARCH | 7 |
| RESEARCH METHODOLOGIES | 13 |
| LIMITATIONS OF THE RESEARCH | 15 |
| CHAPTER 2: PROPRIETARY SYSTEMS | 16 |
| REINFORCED CONCRETE SYSTEMS | 16 |
| ‘Other’ Proprietary Systems | 16 |
| Proprietary Reinforced Concrete Systems | 19 |
| Coignet | 22 |
| Considère | 24 |
| Hennebique | 25 |
| Patent Indented Steel Bar Co. (Indented Bar) | 26 |
| Trussed Concrete Steel Co. (Kahn system) | 27 |
| E.P. Wells | 28 |
| CHAPTER 3: A PROBLEM OF PERCEPTION | 31 |
| ATTITUDES TOWARD CONCRETE | 31 |
| The Struggle with Appropriate Form | 31 |
| A Traditional Bias | 33 |
| Engineer v. Architect | 35 |
| By-laws | 36 |
| A Misunderstood Material | 38 |
| Continued Misconceptions | 39 |
| CONSERVATION PRACTICE V. MATERIAL REALITY | 40 |

| | |
|--|----|
| A Question of Integrity | 40 |
| CHAPTER 4: A PRE-INVENTORY | 43 |
| CONSERVATION CHARTERS, CONVENTIONS AND RECOMMENDATIONS | 43 |
| European Precedent | 47 |
| British Precedent | 48 |
| Scottish Legislative Framework | 49 |
| THE DEFINITION OF A PRE-INVENTORY | 51 |
| THE LIST OF BUILDINGS | 52 |
| The Basic Layout | 52 |
| A Statistical Summary | 53 |
| The Statistical Framework | 62 |
| CHAPTER 5: OPPORTUNITIES FOR FUTURE RESEARCH | 64 |
| PHASED RESEARCH | 64 |
| Phase I – Additional Research | 64 |
| Phase II – Inventory | 65 |
| Phase III – Post-Inventory | 66 |
| CONCLUSIONS AND RECOMMENDATIONS | 69 |
| BIBLIOGRAPHY | 71 |

ILLUSTRATIONS

Figures

| | | |
|-------------|---|----|
| Figure 2.1 | Coignet System | 22 |
| Figure 2.2 | Compression and Tension | 23 |
| Figure 2.2 | Shearing Strains | 23 |
| Figure 2.4 | Coignet (a) | 24 |
| Figure 2.5 | Considère Foundation Detail | 24 |
| Figure 2.6 | Hennebique System | 25 |
| Figure 2.7 | Indented Bar Deformed Bar Profiles | 26 |
| Figure 2.8 | Indented Bar Floor Slab and Beam | 26 |
| Figure 2.9 | Kahn System | 27 |
| Figure 2.10 | Wells' Twin Bars | 28 |
| Figure 3.1 | A Selection of Scottish Proprietary Reinforced Concrete Buildings | 34 |

Tables

| | | |
|---------|--|----|
| Table 1 | Descriptions of Proprietary Systems as of 1907 | 21 |
| Table 2 | List of Buildings | 55 |

ACKNOWLEDGEMENTS

Thank you to Jane Robertson for guidance on this project and to B. Lawrance Hurst for the use of his personal library and for his advice and encouragement. I am also indebted to: the staff at Edinburgh College of Art Library, Mike Chrimes and the staff at the Institution of Civil Engineers Library, Robert Thomas and the staff at the Institution of Structural Engineers Library, Peter Elliott at Elliott and Company, Louisa Humm and Mark Watson at Historic Scotland, Margaret Inglis at the Heriot-Watt School of the Built Environment Resource Centre, Jacqueline Lister at Strathclyde University Architecture Library, Diane Watters at the Royal Commission on the Ancient and Historical Monuments of Scotland and the staff at the National Library of Scotland.

I would also like to acknowledge Miles Glendinning, Neil Ross, Stewart Stirling, Michael Bussell, John Hughes at the University of Paisley, and Phil Banfill and Roland Paxton at Heriot-Watt University for their suggestions.

A big thank you goes out to my family and friends, especially to Sara Edmonds, to Aileen, Alexandra, Dave, Nick and Cath (who were willing to take a complete stranger into their London flat) and to Mrs. Sime. I apologise to anyone I may have inadvertently omitted in drawing up this list.

CHAPTER 1: INTRODUCTION

ABSTRACT

Although concrete is not traditionally considered an historic building material, the first example of its use dates from 5600 B.C.¹ Types of concrete developed between that time and the late 19th century varied widely in terms of their individual admixtures, as well as in terms of their strength and durability characteristics.

'Although the Romans experimented with bronze reinforcement'², it wasn't until inventors rediscovered reinforcing techniques in the mid-19th century that the stage was set for the development of what is considered modern 'concrete', or reinforced concrete. In the United Kingdom and on the Continent, developments in reinforced concrete technology remained unchecked until just before the First World War, when the first governmental attempts to regulate use of the material took place.

Reinforced concrete components and construction techniques during this period were all proprietary, or patented, technologies. Although approaches to marketing the technologies differed, companies marketing a product which incorporated their unique reinforcement into building frames and structures of their own design were selling 'monolithic' building systems. These are the subjects of this paper.

¹ John Broomfield, "The Repair of Reinforced Concrete,"
<http://www.buildingconservation.com/articles/concrete/concrete.htm>, 1.

² Broomfield, "The Repair of Reinforced Concrete," 1.

A number of buildings, some of which have been listed, were constructed using these proprietary reinforced concrete systems in Scotland during the period between roughly 1900 and the 1920s. However, outside of the work of Patricia Cusack, which catalogued buildings constructed throughout Britain using the proprietary system of François Hennebique,³ no attempt to identify all of the buildings constructed using proprietary reinforced concrete systems in Scotland has been carried out before the present study.

This study sought to identify early reinforced concrete buildings constructed using proprietary systems in Scotland and resulted in a preliminary list of 71 buildings, including one building complex (see Table 2 in Chapter 4). The list was developed by sifting through books, company catalogues, journals and other documents. As only 12 of these buildings are included on statutory lists, this work identifies an under-researched stock of historic reinforced concrete buildings in Scotland.

Although under-researched, these buildings are not unimportant. The evolution of reinforced concrete design represented by these buildings exemplifies technological innovation in the early 20th century. The buildings document progress in engineering, but also represent an ambivalent period in architectural thinking, when historical revivalism reigned.

Conservation of these buildings presents a dilemma. Although conservation charters and government policies encourage assessment and protection of

³ P. Cusack, "Reinforced Concrete in Britain, 1897-1908" (PhD thesis 32/2/6394, University of Edinburgh, 1982).

buildings representing multiple criteria, there is still a bias to list only those building types considered traditional in terms of both their architectural design and materials. For those agencies brave enough to recognise the importance of 20th century buildings, unfamiliarity with the maintenance requirements of a mass material like concrete often becomes a problem, hampering preventative conservation works that may avert more extensive loss of original fabric.

This dilemma represents only one area of further research related to historic reinforced concrete. The number of other available research avenues highlights the need for interdisciplinary cooperation both in understanding and conserving this fascinating material.

AIM AND OBJECTIVES OF THE RESEARCH

Overall Aim

The overall aim of this paper is to identify buildings in Scotland constructed using proprietary reinforced concrete systems between 1900 and the 1920s, utilising available documentary sources. This study will provide a preliminary, referenced list of these buildings that can be used as the basis for a future comprehensive survey of early reinforced concrete buildings in Scotland.

Specific Objectives

The specific objectives addressed in the text of this paper are:

1. To define proprietary reinforced concrete systems.
2. To conduct a thorough investigation of any published (and limited unpublished) material on this topic through desk study and historical research.
3. To identify those proprietary systems in use in Scotland.
4. To identify buildings in Scotland constructed using proprietary reinforced concrete systems, including listed and unlisted structures.
5. To define and justify use of a pre-inventory as a valid conservation methodology.
6. To provide the basis for a future comprehensive inventory of early reinforced concrete buildings in Scotland.
7. To explore possible biases precluding additional research, looking at both contemporary and present-day debates related to the 'experimental' nature of these buildings.
8. To examine the quality of this study as a basis for future investigation of these buildings in Scotland.

9. To outline areas for future research.

The paper also identifies a class of building under threat, given that twenty of the buildings in Table 2 have already been demolished and seven others converted to new uses. Additionally, at least two of the statutorily listed buildings have recently been proposed for demolition and a total of 31 (possibly as many as 42) other buildings in Table 2 have been deemed worthy of recordation. A wider goal of this work is to disseminate information on a building construction type that has been little-studied in Scotland, particularly from a conservation standpoint. This goal lends professional validity to this work as it ties in with the Royal Commission on the Ancient and Historical Monuments of Scotland's (RCAHMS') 'General Objectives for Survey and Recording'.⁴

BACKGROUND

The period of study includes the Victorian era (1837-1901), and the Edwardian era (1901-1919) of British history. Starting around 1870, intense industrial activity (rapid industrialisation and mechanisation) began in Scotland, with growth in textiles, mining, shipbuilding, train building, bridge building and the development of pig iron, and later, steel. These activities were focused particularly in the west of Scotland. However, specific industries were focused in other geographic areas; for example, Dundee was the centre of the jute manufactory and trade.

⁴ The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS), "Corporate Plan 2004-9 Annex – Survey & Recording Policy Revised April 2004," RCAHMS, <http://www.rcahms.gov.uk/aboutrcahms.html>, 7.

Glasgow, Edinburgh, Dundee and Aberdeen were the largest cities in Scotland at the time and 60% of the population lived in towns of over 5000 persons. Although the majority of the period under consideration is in the Edwardian era, Victorian attitudes persisted.⁵ Even with mechanisation and improved industrial design, there was still the need for products to be fit for use. Early buildings constructed in concrete followed this trend and were modelled on those built using traditional materials.

During the mid- to late 19th century, concrete buildings were typically constructed *in situ* of mass concrete and concrete block, utilising construction methods similar to those used for rammed earth, masonry and brick structures.⁶ Early reinforced concrete construction copied post and beam construction techniques used for iron and steel. This made sense, as concrete had first been used as a subsidiary material to iron and steel for fire-proofing buildings. A 1910 report by the Institution of Civil Engineers Committee on Reinforced Concrete noted that 'reinforced concrete was cheaper for beams and pillars than steel encased in concrete in order to satisfy fire regulations' and was cheaper than traditional materials such as brick for some types of structures.⁷

The cost savings inherent in reinforced concrete construction had a lot to do with the fierce competition for patented reinforced concrete technologies that took

⁵ See Lucien Serrailier, "The Reinforced Concrete Specialist," *Concrete and Constructional Engineering* 7(2) (1912): 93-97.

⁶ Chris Luebke, "On The Development of Structural Form," http://darkwing.uoregon.edu/~struct/resources/essays/influences_on_choice_1.html, 2.

⁷ Marian Bowley, *The British Building Industry: four studies in response and resistance to change* (Cambridge: Cambridge University Press, 1966), 18, 22.

place up to and just after 1910. These technologies were disseminated through treatises published by their inventors; advertisements and articles published by the companies who promoted them; by testing and criticism of the technology by established professional bodies, who saw its 'industrial production' as a direct threat to their aesthetic approach; and, finally, through administrative acceptance of the technology indicated by the adoption of codes of practice.

These proprietary systems flourished until London County Council adopted reinforced concrete regulations in 1915. By this time, information about the technology was public knowledge and it came into more general use.

Construction using proprietary reinforced concrete systems in Scotland followed this trend. Table 2 shows that use of these systems in Scotland occurred roughly between 1900 and 1920.

JUSTIFICATION FOR THE RESEARCH

A number of articles provide a solid background on the wider history and development of reinforced concrete technology, including deCourcy (1987) and articles in *Rassegna* 49(1) and the *Proceedings of the Institution of Civil Engineers: Structures and Buildings* 116 (1996), updated in Sutherland et al (2001).⁸ Bowley (1960 and 1966) and Powell (1996) discuss possible motivations for use of

⁸ See articles by deCourcy (1987), from *Rassegna* 49(1) and from the *Proceedings of the Institution of Civil Engineer: Structures and Buildings* 116 (1996) updated in James Sutherland, Dawn Humm and Mike Chrimes, eds., *Historic Concrete: Background to Appraisal* (London: Thomas Telford, 2001).

'experimental' construction methods during this period.⁹ Bussell and Frampton, among others, discuss how development of reinforced concrete construction in Britain was due to the 'import' and use of proprietary systems between 1870 and 1900.¹⁰ During this period, 'design was largely undertaken by ... specialist firms.'¹¹

Contemporary publications attempted to document the various systems in use. By 1904, over 50 systems were in use in Britain, including those of Coignet, Considère, Hennebique and Wells.¹² Very few of these buildings have been identified. Of the academic publications available, the most closely related is Patricia Cusack's 1982 PhD thesis for the University of Edinburgh, entitled *Reinforced Concrete in Britain, 1897-1908*, parts of which were subsequently published as a number of journal articles.¹³ Cusack's research focused almost exclusively on buildings constructed by L. G. Mouchel and his licensees using Francois Hennebique's system, although there is passing mention of a Portobello building partially constructed using the Wells system.

9 Marian Bowley, *Innovations in Building Materials: An Economic Study* (London: Gerald Duckworth & Co., Ltd., 1960); Bowley, *The British Building Industry*; Christopher G. Powell, *The British building industry since 1800: an economic history*, 2nd ed (London: E. & F.N. Spon, 1996).

10 Michael N. Bussell, "The Era of Proprietary Reinforcing Systems," *Proceedings of the Institute of Civil Engineers: Structures and Buildings* 116 (1996): 295 and Kenneth Frampton, *Modern Architecture: A Critical History*, 3rd ed. (London: Thames and Hudson, 2006), 37.

11 Charles F. Marsh, *Reinforced Concrete* (London: Archibald Constable and Co., Ltd., 1904), 2 and Bussell, "The era of proprietary reinforcing systems,": 301, quoted in Susan Macdonald, ed., *Concrete: Building Pathology* (Cambridge: Blackwell Science, 2003), 42.

12 Patricia Cusack, "Agents of change: Hennebique, Mouchel and ferro-concrete in Britain 1897-1908," *Construction History: Journal of the Construction History Group* 3 (1987): 61.

13 Patricia Cusack, "François Hennebique: the specialist organisation and the success of ferro-concrete: 1892-1909," *Transactions of the Newcomen Society* 56 (1984-1985): 71-86; Patricia Cusack, "Lion Chambers: A Glasgow Experiment," *Architectural History* 28 (1985): 198-211; Patricia Cusack, "Architects and the Reinforced Concrete Specialist in Britain 1905-1908," *Architectural History* 29 (1986):183-196; and Cusack, "Agents of change,": 61-74.

The Institution of Civil Engineers in London holds parts of the L. G. Mouchel Archive as part of the Concrete Archive. The firm-produced catalogue *Mouchel-Hennebique Ferro-Concrete: List of Works Executed in the UK 1897-1919* (n.d., c. 1920), referenced by Cusack and available at the Institution of Civil Engineers Library, provides a listing of Hennebique works by location. Other sources of information include catalogues for the other building systems, as well as journals reporting on the new technology, like *Concrete and Constructional Engineering* held at the Institution of Civil Engineers Library, the Institution of Structural Engineers Library, the British Library and the National Library of Scotland. A thorough review of Historic Scotland's *Statutory List*, the Royal Commission's (RCAHMS') Canmore database, and the 'Historic Concrete' series published in *Concrete* during the 1980s also provides leads on individual buildings.

A number of case studies have been carried out on particular buildings, including the Hennebique system Lion Chambers.¹⁴ Academic research has been carried out on unreinforced, Victorian-era shuttered concrete buildings in Scotland by Stirling.¹⁵ Lonsdale has carried out sampling and testing on these buildings and Marshall and

14 P. J. M. Bartoss, *Results of Testing Carried out on Lion Chambers Samples* (Paisley: University of Paisley Advanced Concrete and Masonry (ACM) Research Institute, 20 March 1998); McLay Collier and Partners Consulting Civil and Structural Engineers, *Lion Chambers Condition Update Report* (1998); Glasgow Building Preservation Trust, *Lion Chambers: Rediscovering a Lost Cause* (1999); Historic Scotland, *Lion Chambers, 170 Hope Street, Glasgow: Report on Protective Installation* (Edinburgh: Historic Scotland Technical Conservation, Research and Education Group (TCRE), 2000). [All available from: Glasgow City Council Listed Building File #574].

15 S. Stirling, "Early Concrete Buildings in Scotland" (PhD thesis, Heriot-Watt University, 2001).

Hall have examined the conservation and repair of the Lion Chambers in light of conservation philosophy.¹⁶

There is ongoing discussion in the conservation literature regarding the problematic nature of repair strategies for reinforced concrete given the mass nature of the material.¹⁷ Two Category A-listed Hennebique buildings in Glasgow, the Sentinel Works (1903-4) and the Lion Chambers (1904-1907), represent the conflict surrounding conservation of 'experimental' buildings. Today, they seem to suffer from the same negative view applied to reinforced concrete buildings at the turn of the 20th century, that they are ugly and about to fall down.¹⁸ Even though these buildings are considered pre-eminent in the chronology of reinforced concrete structures in Scotland, there have been repeated proposals to demolish them.¹⁹

Literature related to reinforced concrete in Scotland is limited. Buildings have been identified in inventories such as the *Buildings of Scotland* series from an architectural

16 J. Lonsdale, "An examination of historical concrete" (BSc dissertation, Heriot-Watt University, 2002); J. D. Marshall, "Conservation and repair of historic reinforced concrete buildings" (BSc dissertation, Heriot-Watt University, 2001); and, S. J. Hall, "Conservation of Early Reinforced Concrete Structures and the Dilemma of the Lion Chambers" (MSc dissertation, Heriot-Watt University, 2004).

17 Susan Macdonald, ed., *Preserving Post-War Heritage: the care and conservation of mid-twentieth century architecture* (Shaftesbury: Donhead, 2001) and *Concrete*; Bernard M. Feilden, *Conservation of Historic Buildings*, 3rd ed. (Oxford: Elsevier, 2003); Andrew Powter, "History, Deterioration and Repair of Cement and Concrete in Nineteenth Century Fortifications Constructed by the Royal Engineers," *Bulletin for the Association for Preservation Technology* 10(3) (1978): 59-77; John Knight, ed., *The repair of historic buildings in Scotland: Advice on principles and methods* (Edinburgh: Historic Scotland, 1995); Martin F. Weaver, *Conserving buildings: Guide to Techniques and Materials*, revised ed. (New York: John Wiley & Sons, 1997); Dorothy Bell, *The Historic Scotland Guide to International Conservation Charters* (Edinburgh: Historic Scotland, 1997); British Standards Institute, *Guide to the Principles of the Conservation of Historic Buildings, BS7913* (London: British Standards Institute, 1998) among others.

18 James Salmon, "The Decoration of Steel and Reinforced Concrete Structures," *The Builders' Journal and Architectural Engineer* (25 March 1908): 269, 271 and Richard Catt, "A preservation dilemma for the commercially-minded," *Property Week*, 18 May 1995: 29.

19 Glasgow City Council Listed Building Files: Lion Chambers (Listed Building #574) and Sentinel Works.

history perspective. Scottish civil engineering works in concrete have also been identified.²⁰ However, these accounts provide limited information on patented system-built reinforced concrete buildings in Scotland.

Historic concrete repair is not yet specifically included within the suites of technical guidance documents provided by the key heritage agencies such as English Heritage and Historic Scotland. However, publications by Susan Macdonald (formerly of English Heritage) on concrete and a number of case studies have informed their approach and demonstrated the relevance of conservation principles to concrete conservation.²¹

Outside of the United Kingdom, heritage agencies have devoted more attention to the repair of historic concrete. The United States Government Services Administration has instituted a number of initiatives related to Modern architecture²² and the National Park Service published an annotated bibliography in 2003 and online guidance related to historic concrete repair.²³ The Association of Preservation Technology put out an historic concrete investigation and repair

20 Roland Paxton and Jim Shipway, *Civil engineering heritage: Scotland -Highlands and Islands* (London: Thomas Telford, 2007); Roland Paxton and Jim Shipway, *Civil engineering heritage: Scotland -Lowlands and Borders* (London: Thomas Telford, 2007).

21 Macdonald, *Concrete*, 8.

22 "Table of Contents" (ICOMOS Joint International Scientific Committee Meeting, Illinois Institute of Technology Campus, Chicago, Illinois, 21-23 June 2007), 115.

23 Adrienne Beaudet Cowden, *Historic Concrete: an annotated bibliography* (Washington, D.C.: United States Department of the Interior, National Park Service, Preservation Assistance Division, 1993); William B. Coney, "Preservation Brief 15: Preservation of Historic Concrete: Problems and General Approaches," <http://www.nps.gov/history/hps/tps/briefs/brief15.htm>.

training course manual in 1989.²⁴ The New Zealand Department of Conservation produced a handbook for historic concrete structures in 2000.²⁵ The New South Wales Heritage Office in Australia published *Investigation and repair of historic concrete* in 2003, authored by Susan Macdonald.²⁶

Engineering organisations, including the Institution of Civil Engineers and the Institution of Structural Engineers, have ongoing interest in historic concrete.²⁷ Torraca produced the seminal materials text, which included a discussion of concrete.²⁸ Research into building materials, including reinforced concrete, is ongoing both in the European Union (EU) and in Scotland. Mallinson's and Davies' (1986) work lays out testing and analytic procedures for historic concrete based on historic papers [Skempton, Pasley, etc].²⁹ They also analysed samples from a few structures built using the Hennebique system, although none in Scotland: Weaver's Mill (1897-8), Woolston Quay (1899) and the Ralli Building in Salford (1914). Jull and Lees (1990) have conducted sampling and testing in the United Kingdom on mostly ancient (Roman) concrete samples.³⁰ The Advanced Concrete and Masonry

24 APT (Association for Preservation Technology), "Historic Concrete: Investigation and Repair" (APT Pre-conference training course, APT Annual Meeting, Chicago, Illinois, 4-6 September 1989).

25 Department of Conservation Te Papa Atawhai, *Historic concrete structures: a maintenance & management handbook for New Zealand: draft* (Auckland, New Zealand: Salmond Architects, 2000).

26 New South Wales Heritage Office, "Investigation and Repair of Historic Concrete," http://www.heritage.nsw.gov.au/docs/Concrete_Part_1.pdf and http://www.heritage.nsw.gov.au/docs/Concrete_Part_2.pdf

27 see Sutherland et al, *Historic Concrete*, the Concrete Archive at the Institution of Civil Engineers and holdings in the Institution of Structural Engineers Library.

28 Giorgio Torraca, *Porous Building Materials: Materials Science for Architectural Conservation*, 3rd ed. (Rome: ICCROM, 1988).

29 L.G. Mallinson and I.L. Davies, *A historical examination of concrete*, EUR 10937EN (Luxembourg: Commission of the European Communities Directorate-General Telecommunications, Information Industries and Innovation, 1987).

30 S.P. Jull and T.P. Lees, *Studies of historic concrete*, EUR 12972EN (Luxembourg: Commission of the European Communities Directorate-General Telecommunications, Information Industries and Innovation, 1990).

Centre at the University of Paisley and firms such as Heath and Hardie in Dundee have conducted limited petrographic analysis of Scottish historic concrete samples.

There are numerous publications related to conservation of mass materials produced both in the UK and Scotland.³¹ Collins considers mass concrete construction to have evolved from *pisé*.³² 'Several types of tempered earth or clay walled structures are known to have existed in Scotland', including *pisé* and claywall (clay and boole work).³³ Mass concrete building in 19th century Scotland has been considered 'an extension of shuttered clay walling'.³⁴ These publications can be important resources for conservation practice when dealing with reinforced concrete, also a mass material.

RESEARCH METHODOLOGIES

The research underpinning this paper began during evaluation of two early reinforced concrete buildings for the Conservation Technology module at Edinburgh College of Art. Research was conducted between January and August

31 These publications include: John Warren, *Conservation of Earth Structures* (London: Architectural Press, 1999); John and Nicola Ashurst, "The Repair and Maintenance of Cob, Chalk, Mud..." in *Practical Building Conservation: English Heritage Technical Handbook #2, Brick, Terracotta and Earth* (Aldershot: Gower Technical, 1988); Clough Williams-Ellis, *Buildings in Cob, Pisé and Stabilised Earth* (Shaftesbury: Donhead, 1999; reprint Cambridge University Press, 1916); Becky Little and Tom Morton, "Building with Earth in Scotland: Innovative Design and Sustainability," (Edinburgh: Scottish Executive Central Research Unit, 2001), <http://www.scotland.gov.uk/Resource/Doc/156686/0042109.pdf>; Sarah Pearson and Bob Meeson, eds. "CBA Research Report 126. Vernacular Buildings in a Changing World: understanding, recording and conservation," (Conference Proceedings, Oxford, 1998; York: Council for British Archaeology 2001); Richard Oxley, *Survey and Repair of Traditional Buildings: a sustainable approach* (Shaftesbury: Donhead, 2003); Knight, *The repair of historic buildings in Scotland*, 69-70; Scottish Vernacular Buildings Working Group, various publications; John F. Smith, *A critical bibliography of building conservation: historic towns, buildings, their furnishings and fittings* (London: Mansell Information Publishing, 1978).

32 Peter Collins, *Concrete: the Vision of a New Architecture* (London: Faber & Faber, 1959), 20.

33 Bruce Walker, Christopher McGregor and Rebecca Little, *Earth Structures and construction in Scotland: A guide to the Recognition and Conservation of Earth Technology in Scotland (TAN 6)* (Edinburgh: Historic Scotland, 1996), quoted in Stirling, "Early Concrete Buildings in Scotland," 112, 114.

34 Stirling, "Early Concrete Buildings in Scotland," 115.

2007. The methodology chosen for this dissertation was modelled on European and British precedents, including Belgium's process of bibliographical inventory, and procedures requiring review of documentary sources as preparation for an inventory carried out in Denmark, France, Ireland and England (see Chapter 4). The method is a thematic pre-inventory, consisting of preparatory documentary research conducted in libraries and archives. Thematic study of documentation is validated by Scottish policy.

The first step was a desk study utilising online library catalogues, electronic indexes and search engines to locate additional sources of information. Research was then carried out at Edinburgh College of Art Library, University of Edinburgh Library and specialist libraries, such as the National Library of Scotland (NLS), the British Library (BL), the Institution of Civil Engineers Library and the Institution of Structural Engineers Library. Systematic review of each document included recording where it was available, its shelfmark, bibliographic information, and notes and comments on the material.

Additional work included historical research and desktop review of the conservation literature to outline the background and history of reinforced concrete technology, to describe attitudes toward it during the period the buildings were constructed and to determine current attitudes toward conservation of these buildings.

LIMITATIONS OF THE RESEARCH

The boundaries of this pre-inventory work are tightly prescribed. It does not pretend to be a history of engineering design, nor does it include civil engineering works, such as bridges, reservoirs, quays, jetties, groynes, piers, viaducts, culverts and war defences.³⁵ The buildings identified are constructed using patented reinforced concrete systems. Structures built using non-monolithic systems, including fireproof flooring systems, are not included.

Sources consulted were limited to those available in the United Kingdom and those available online, particularly in terms of government publications; therefore, the historical, theoretical and philosophical approach to conservation of reinforced concrete laid out in this paper has a distinctly Western bias. Identification of buildings was through reportage by existing published material and review of a limited amount of unpublished material referenced therein.

³⁵ See both Sutherland et al, *Historic Concrete*, 211 and "Characteristics of the Chief Systems of Reinforced Concrete Applied to Buildings in Great Britain," *Concrete & Constructional Engineering* 2 (6) (January 1908): 429 for precedent.

CHAPTER 2: PROPRIETARY SYSTEMS

This chapter begins with an overview of the development of reinforced concrete systems. It then goes on to describe the characteristics of the proprietary reinforced concrete systems under investigation in this paper. It defines what made them 'systems' and the limits of the general period of their use in Scotland. A brief description of each system represented in Table 2 (Chapter 4) is then given.

REINFORCED CONCRETE SYSTEMS

'[T]he invention of reinforced concrete ... was ... made ... at least three times between 1854 and 1867 [Patents were issued to Wilkinson (1854), Matthew Allen (1862) and HYB Scott (1867)]. [I]t was not until the last two decades of the nineteenth century that it was really developed for either walls or frames.'³⁶ 'The period of most intense development in reinforced concrete design occurred between 1870 and 1900, with pioneering work being carried out simultaneously in Germany, America, England and France.'³⁷

'Other' Proprietary Systems

The development of reinforced concrete building systems in Britain depended on the foreign innovators, who began patenting their systems in the United Kingdom just before the turn of the 20th century. The proprietary nature of the technology meant that publications detailing the properties of the systems were not produced. Even the 'experts' at the time found defining these proprietary systems difficult, particularly since the companies marketing them introduced a number of unique

³⁶ Bowley, *Innovations*, 54.

³⁷ Frampton, *Modern Architecture*, 37.

terms to describe their versions of the French *béton armé*. Collins summarised the terms used, including 'Armoured concrete' and its rough English translation 'Armed concrete' [Francois Monier, later G.A. Wayss and Wayss & Freytag], 'Ferro – Concrete' [Hennebique], 'Hooped concrete', 'Sidero-concrete', 'Steel-concrete', 'Concrete-steel'³⁸, 'Concrete-metal', and finally 'Reinforced concrete'³⁹. The Institution of Civil Engineers formed a standing committee that first met in 1909 with a charge to define the 'systems of reinforced concrete construction now in use.'⁴⁰

This proved difficult. The Committee had trouble coming to a 'decision as to what should be included under the heading of 'Reinforced Concrete Systems' of construction ... primarily ... when attempting to describe the various forms of floor construction. It was all too easy to consider as reinforced concrete work some of the excellent forms of steel frame floor construction, in which concrete play[ed] an important part, and equally easy on the other hand to omit from [the] Reinforced Concrete series floors in which the reinforcement [was] either in the form of joists, or comprise[d] steel sections very like joists.'⁴¹

The steel-frame floors referred to by the engineers were a type of fireproof flooring system using iron and, later, rolled steel joists encased in concrete or supporting a

38 W. Noble Twelvetrees, *Concrete-steel. A treatise on the theory and practice of reinforced concrete construction* (London: Sir Isaac Pitman and Sons, Ltd., 1905), 4.

39 The term 'reinforced concrete' was invented in 1898, it was not associated with particular system and became 'generally accepted by 1906' per Thomas C. Jester, ed., *Twentieth-century Building Materials: History and Conservation* (New York: McGraw-Hill, 1995), 96; Collins, *Concrete*, 77.

40 "The Institution of Civil Engineers and Reinforced Concrete: Preliminary and Interim Report of the Committee on Reinforced Concrete," *Concrete & Constructional Engineering* 5(10) (October 1910): 707.

41 "Characteristics of the Chief Systems of Reinforced Concrete Applied to Buildings in Great Britain": 427-8.

layer of concrete breeze, sometimes reinforced.⁴² There were a number of fireproof flooring systems in use in the United Kingdom in the mid- to late 1800s, including Fox's and Barrett's, Dennett's, Allen's, Brannon's and Stuart's Granolithic of Edinburgh. Another type of fireproof floor, which remained in use until the Second World War, consisted of hollow clay tubes or lintels finished with concrete that spanned between steel joists.⁴³ These floors were used in a number of buildings where they might not be expected today, including Balmoral Castle [Fox & Barrett], the Duke of Fife's Mar Lodge (1895), near Braemar, and White's Hotel and the 'Scotsman' Office (1901), North Bridge, Edinburgh [Stuart's Granolithic].

These fireproof flooring systems differed from the proprietary reinforced concrete systems which are the subject of this paper because they were used in conjunction with steel frames and load-bearing walls.⁴⁴ The fireproof flooring systems were not monolithic systems used for whole building frames and structures.

By 1904, there were over 50 proprietary reinforced concrete construction systems in use in the United Kingdom.⁴⁵ This number included some of the fireproof flooring systems, as well as reinforced concrete components (most often reinforcing bars) sold off separately rather than as part of a packaged building system. Companies selling off components to be incorporated into others' structural designs often referred to them as systems. Lucien Serrailier divided the firms marketing these

42 Sutherland et al, *Historic Concrete*, 57.

43 Collins, *Concrete*, 37.

44 B. Lawrance Hurst. Pers. comm. 26 July 2007, 21 August 2007 and e-mail message to author on 4 September 2007.

45 Marsh, *Reinforced Concrete*, 2, paraphrased in Cusack, "Agents," 61.

proprietary reinforced concrete building systems into two camps, those that sold patent systems and those that sold 'patent bars or reinforcing material', but he did not identify them by name.⁴⁶ Contemporaries, such as Jones (1913), Marsh and Marsh and Dunn (multiple dates/editions), as well as organisations' publications, such as those of the Institution of Civil Engineers (1910) and the Association of Municipal and County Engineers (1905) and journals like *Concrete & Constructional Engineering* (1908) attempted to provide comprehensive lists of the systems available during the period, but are often criticised for missing one or another. Although some of the systems may have been neglected in these lists and the different types of structural systems were not indexed separately, it was difficult to accurately represent those available, as the number of patented systems and components in use at any one time was always changing.

Proprietary Reinforced Concrete Systems

Systems where a company's unique reinforcement was incorporated into a building frame or structure of its own design are considered proprietary reinforced concrete system (monolithic) buildings in the context of this paper. A number of buildings constructed using the various systems were identified through consultation of statutory lists, company catalogues, journals and prior academic studies. The list was then narrowed to buildings constructed in Scotland from approximately 1900 to 1920. These buildings are identified in Table 2 (see Chapter 4) and are examples of the following systems:

- Coignet

⁴⁶ Serrailier, "The Reinforced Concrete Specialist," 95.

- Considère
- Hennebique
- Patent Indented Steel Bar Co. (Indented Bar)
- Trussed Concrete Steel Co. (Kahn system)
- E.P. Wells

Three buildings where B.R.C. (British Reinforced Concrete Engineering Co.) and Expanded Metal and Corrugated Bar Co. (Expamet) products were in use in addition to a monolithic system have been included on the list. Although B.R.C. does have one floor type that appears monolithic – a reinforced concrete floor supported on reinforced concrete beams – the other two floor types marketed by B.R.C. and Expamet cannot be considered monolithic, as B.R.C.'s flooring was most commonly supported by steel beams and Expanded Metal's was applied in sheets supported by steel joists.

Table 1 and the following paragraphs give brief descriptions of each of the monolithic systems. Each reinforced concrete system had a unique means to address the forces of compression and tension acting upon it. These forces are described in the text box entitled 'Proprietary Systems and the Forces of Compression and Tension'.

Table 1. Descriptions of Proprietary Systems as of 1907

| | Form of principal (tension) bars | Form of secondary (compression) bars | Form of shear reinforcement | Method of fixing shear reinforcement | Orientation of shear reinforcement | Column cross-section | Column Construction |
|--------------------------------------|--|--------------------------------------|--|---|------------------------------------|--------------------------------|--|
| Colignet | Round straight bars | Round straight bars | Round bars bent to U-shape | Looped under tension bars and twisted above compression bars | Vertical | Cylindrical or square | Round straight bars (longitudinal reinforcement); round rods in spiral coils fixed at ends by wire (transverse reinforcement) |
| Colignet (a) | Round straight bars and round bars bent up near supports | Round straight bars | Bent-up ends of extra tension bars | Continuous with extra tension bars | Diagonal | | |
| Considère | Round straight bars and round bars bent up near supports | Round straight bars | (a) bent up ends of extra tension bars (b) round rods lapped around the main tension and compression bars | (a) continuous with extra tension bars (b) bent round tension and compression bars | (a) Diagonal (b) Vertical | Circular, octagonal, or square | Round straight bars (longitudinal reinforcement); round rods in spiral coils with ends of coils bent inwards (transverse reinforcement) |
| Hennebique | Round straight bars and round bars bent up near supports | Round straight bars | Steel strip bent to U-shape and made with spring clip | Spring on to tension bars and bent over for anchorage in concrete | Vertical | Square or oblong | Round straight bars (longitudinal reinforcement); wire links looped over longitudinal bars, ends twisted, and anchored into concrete – horizontal (transverse reinforcement) |
| Indented Bar | Corrugated square (deformed) bar, bent up near supports | Corrugated square straight bars | Bent-up ends of tension bars | Continuous with tension bars | Diagonal | Cylindrical, square or oblong | Corrugated square straight bars (longitudinal reinforcement); wire lateral ties wrapped around longitudinal bars horizontally (transverse reinforcement) |
| Trussed Concrete Steel (Kahn) | Square bars, generally straight, sometimes bent up towards supports (diamond section with projecting flat wings) | Square straight bars | Wings attached to main part of tension and compression bars | Continuous with tension and compression bars (rigidly connected) | Diagonal | Not specified | Square straight bars (longitudinal reinforcement); wings attached to main part of longitudinal bars, continuous with them on a 45 degree diagonal, extend across column (transverse reinforcement); plain bars sometimes used in addition; some pillars have helical hooping |
| Wells | Twin round bars connected by a short web (in floor slabs, twin round steel bars and straight compression bars) | Round straight bars | Steel strip hangers (connect upper and lower reinforcements) and holders (bonders run from compression bars to neutral axis) | Bent round tension bars | Vertical | Rectangular | Round straight bars (longitudinal reinforcement); round rods passing entirely around longitudinal bars and ends formed with hook-and-eye joint (transverse) |

Sources: The majority of the table (describing system components) is identical to that of Buser's "The use of proprietary reinforcing systems," 216, with the addition of the fourth column by the author. This, along with Buser's table, is a reproduction of the tables in "Chronicle of the Chief Systems of Reinforced Concrete Applied to Buildings in Great Britain," Concrete & Constructional Engineering 2 (1) (January 1906): 433, 434, 438 and some of the explanatory text accompanying them, supplemented by language from James C. Case's Reinforced Concrete, 223, 228.

Coignet

In 1855, Francois Coignet obtained patents in both France and the United Kingdom.⁴⁷ In 1904, G. C. Workman opened a branch office in London that was run by Francois' son Edmund.⁴⁸ In 1908, the company introduced a variant of the system (identified here as 'Coignet (a)') where bars of different 'length[s] ...with their ends bent upwards at an angle of 45 degrees' were grouped 'together in the lower part of the beam.'⁴⁹ Figure 2.1 (1) & (2) are diagrams of the system and its variant as originally introduced in Britain.

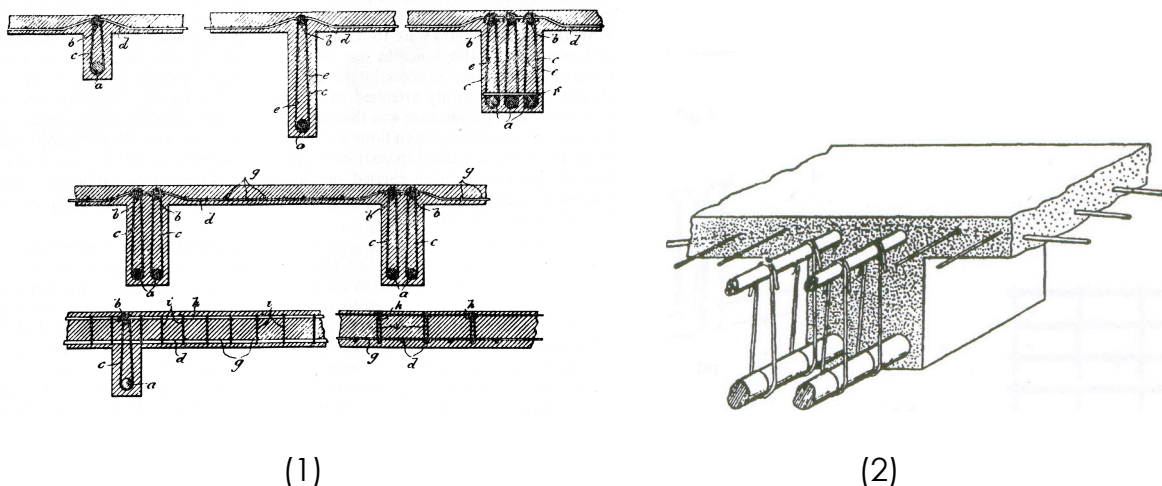


Figure 2.1 Coignet System

Sources: "Figure 6: Coignet's British Patent No. 24371 of 1904" from S. B. Hamilton. Department of Scientific and Industrial Research (Building Research Station). *A Note on the History of Reinforced Concrete in Buildings NBS (National Building Studies) Special Report No. 24.* (London: Her Majesty's Stationary Office (HMSO), 1956), 12; axonometric from Bussell, "The Era of Proprietary Reinforcing Systems," 298. [Not to scale].

⁴⁷ Jones, *Cassell's Reinforced Concrete*, 6.

⁴⁸ Collins, *Concrete*, 77.

⁴⁹ "Characteristics of the Chief Systems of Reinforced Concrete Applied to Buildings in Great Britain": 430.

Proprietary Systems and the Forces of Compression and Tension

'[T]here are no perfectly rigid structural materials.'¹ The patented reinforced concrete system designers were working with the placement of reinforcement to manage the forces that act on structural components, such as beams, columns, and slabs. When a structure is under load, or weight, two main forces and two 'secondary' forces are at work.

Loads, or weight distributed over a structure, come in different forms. There is the dead load, or weight of the structural components themselves, and the live load, or people and furnishings in the structure. There are also dynamic loads, sudden 'shocks' to the structural system, such as earthquakes, wind gusts or impacts when heavy objects are dropped, and hidden loads, changes in temperature and soil settlement under a building.²

Figure 2.2 Compression and Tension

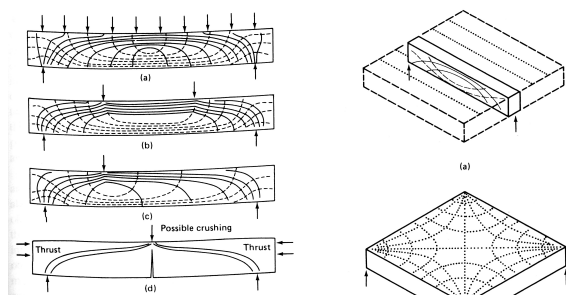


Figure 2.7 Isostatics of a beam
(Courtesy: R.J. Mainstone)
Isostatics are contour lines of tension (shown dotted) and compression (shown solid). The closeness of the contours indicates the intensity of stress. Where lines cross, shear occurs. It can be seen that tension is greatest in the bottom and compression in the top of the beam at mid-span. Shear is greatest at the ends.
(a) Uniformly distributed loading
(b) Two-point loads
(c) One-point load
(d) One-point load with crack
The occurrence of the cracks causes the beam to become an arch, only dealing with compressive stresses. Lateral thrusts are now required to retain it in position. Local crushing may occur

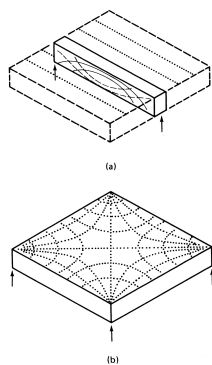


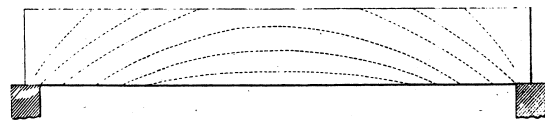
Figure 2.8 Isostatics of a slab
(Courtesy: R.J. Mainstone)
(a) A slab reinforced in one direction may be considered as a series of parallel beams
(b) A slab reinforced in two directions set on four supports. For simplicity, only tensile stresses are shown, but compressive stresses are equal and opposite. The stress pattern is remarkably like the pattern made by the ribs of a Gothic vault which, by using arched forms, removes the need for positive joints having tensile resistance but which generates outward thrusts

Source: Bernard Feilden, *Conservation of Historic Buildings*. 3rd ed. (Oxford: Elsevier, 2003), 29. [Not to scale].

Compression describes what happens when a component of the structure is pushed by a load and shortens. Tension describes the action when a component is pulled by a load, and stretches or lengthens.³ The forces of compression and tension are described in Figure 2.2.

When covering a wide span, a beam or floor slab is being pushed down by the load, so supports 'must exert an upward reaction equal to the load', or shear action, and the beam or slab must resist being bent downwards by the load.⁴ A simple illustration of the effect of shearing strains on a beam is illustrated in Figure 2.3.

Figure 2.3 Shearing Strains



Source: T.J. Gueritte, "Ferro-Concrete Construction," *Edinburgh Architectural Association Transactions* 5 (1905-6, publ. 1910): 17. [Not to scale].

Concrete has compressive strength, whilst steel has tensile strength. Reinforced concrete unites the two to create a more resilient material than either on its own.

1 Mario Salvadori, *Why Buildings Stand Up: The Strength of Architecture* (New York: W.W. Norton & Co., 1990), 43-58.

2 Salvadori, *Why Buildings Stand Up*, 59-60.

3 Salvadori, *Why Buildings Stand Up*, 84.

4 Salvadori, *Why Buildings Stand Up*, 146.

Figure 2.4 shows the variant system identified as Coignet (a) in Table 1. The upward bend in the reinforcing bars near the supports was meant to counteract tension due to shear.

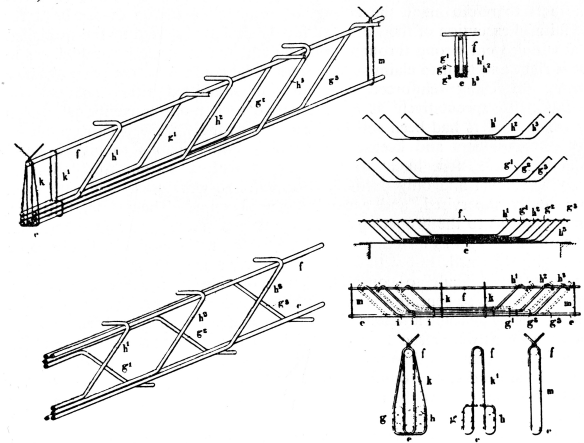


Figure 2.4 Coignet (a)

Source: "Figure 7: Coignet's British Patent No. 14693 of 1906" from Hamilton, A Note, 13. [Not to scale].

Considère

Armand-Gabriel Considère obtained a British patent in 1902. By 1906, he 'headed the national committee that established the French code for reinforced concrete practice.'⁵⁰ Considère opened London offices in 1909⁵¹ and still has offices throughout Britain today.

Considère was known primarily for his spirally reinforced piles. The spiral arrangement of his reinforcement is shown in Figure 2.5, a detail drawing for the Port Dundas Distillery. Considère utilised both bent-up bars near supports and round rods wrapped around the tension and compression bars for shear reinforcement in beams and slabs.

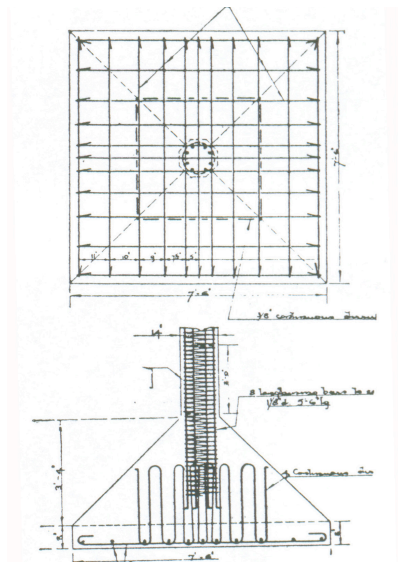


Figure 2.5 Foundation Detail for Port Dundas Distillery

Source: "Figure 1. Foundation Details" from Albert Lakeman, "Port Dundas Distillery," *Concrete and Constructional Engineering* 10(8) (Aug. 1915): 381. [Not to scale].

⁵⁰ Frampton, *Modern Architecture*, 38.

⁵¹ Collins, *Concrete*, 81.

Hennebique

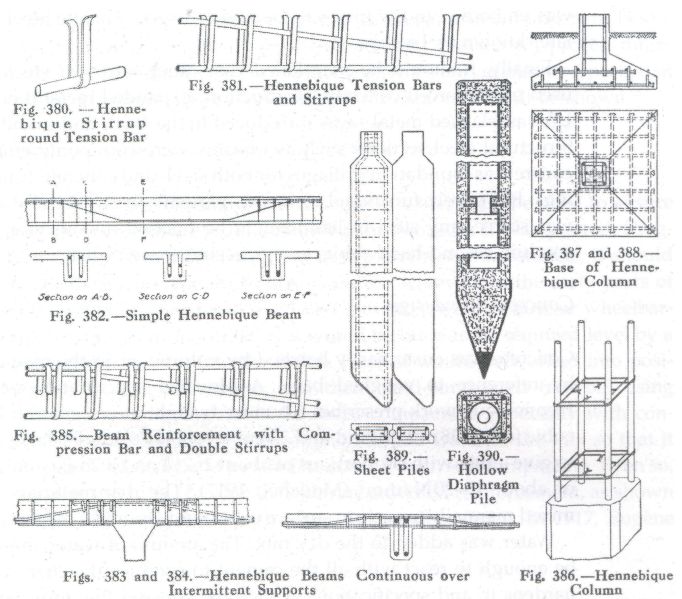
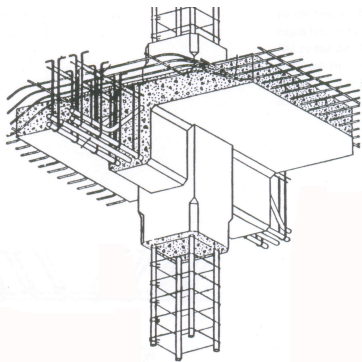
In 1897, the Hennebique system was introduced in Britain by his agent, L.G.

Mouchel. Hennebique obtained a number of patents, which expired in 1907.⁵²

Illustrations of Hennebique's system are provided in Figure 2.6.

Figure 2.6 Hennebique System

Sources: diagrams at right, 'The Hennebique Reinforcing System' from Jones (1920), reprinted in Macdonald, *Concrete*, 37; axonometric drawing (below) from Bussell, "The era of proprietary reinforcing systems": 306. [Not to scale].



Hennebique and his licensees out-competed the other firms active in the British market for proprietary reinforced concrete systems, as evidenced by the number of projects built. Table 2 (Chapter 4) shows that this was true in Scotland, as well. '1908 probably marks the end of the Mouchel-Hennebique dominance in British reinforced-concrete construction and although the combination had an influence on concrete building in this country for many years, examples of other designers'

⁵² Collins, *Concrete*, 74.

work were now beginning to appear.⁵³ However, the Hennebique system remained in use and the company is still in existence in West Byfleet, Surrey.

Patent Indented Steel Bar Co. (Indented Bar)

The deformed bar used in the Patent Indented Steel Bar Company's system was sometimes round in section (see Figure 2.7).⁵⁴ For each application, the company or independent engineers would prepare a design to meet the needs of the client.



Figure 2.7 Indented Bar Deformed Bar Profiles

Source: Fig. 10 (a) and (b) from Bussell, "The era of proprietary reinforcing systems": 298. [Not to scale].

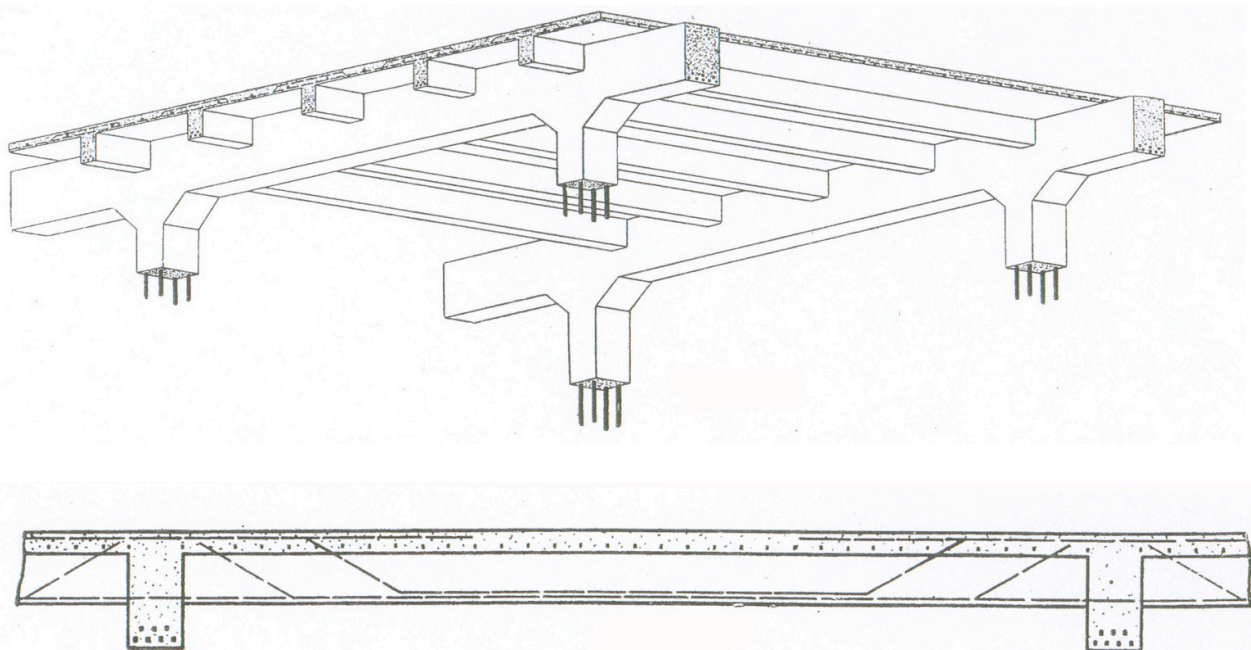


Figure 2.8 Indented Bar Floor Slab and Beam

Source: Figs. 4 and 5 from *Indented Steel Bars*, 1907, 18. [Not to scale].

⁵³ Roy Day, "Ferro-Concrete: The Construction Industry enters the 20th Century," *Bristol Industrial Archaeological Society Journal* 13 (1980): 28.

⁵⁴ Jones, *Cassell's Reinforced Concrete*, 221.

Reinforced floor slabs produced by Indented Bar were supported on concrete beams, as illustrated in Figure 2.8. Shear reinforcement is visible in the transverse section through the slab, which was taken through the locations of supports.

Trussed Concrete Steel Co. (Kahn system)

The Trussed Concrete Steel Co. (Kahn system) was established in England in 1907.⁵⁵

'The main component of the system was the Trussed Bar, rolled with wide flanges, which were later sheared and the sections bent up at an angle of 45 degrees.'⁵⁶

The trussed bar is illustrated in Figure 2.9. The Kahn trussed bars were originally in pairs (see (a)) and later staggered (b). Typical profiles of the reinforcing bars are shown in (c) and (d). Drawing (e) shows a later bar profile.

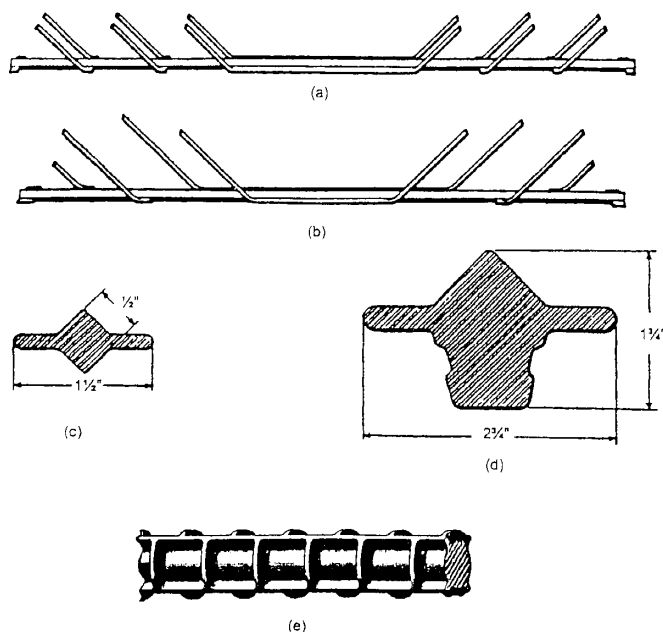


Figure 2.9 Kahn System

Source: 'Fig. 13', Newby, *Early Reinforced Concrete*, 154. [Not to scale].

⁵⁵ Bowley, *The British Building Industry*, 18 and *Truscon*, 8.

⁵⁶ *Truscon*, 7.

By comparing (a) and (b) with Figures 2.2 and 2.3, it is clear that the diagonals were designed to resist shear stresses. The Trussed Concrete Steel Company also sold reinforcement to other designers.

E.P. Wells

'At first sight the sections of a beam on this system may appear to be identical with those of a Hennebique beam'. However, '[t]he tension reinforcement consists of specially rolled twin bars.'⁵⁷

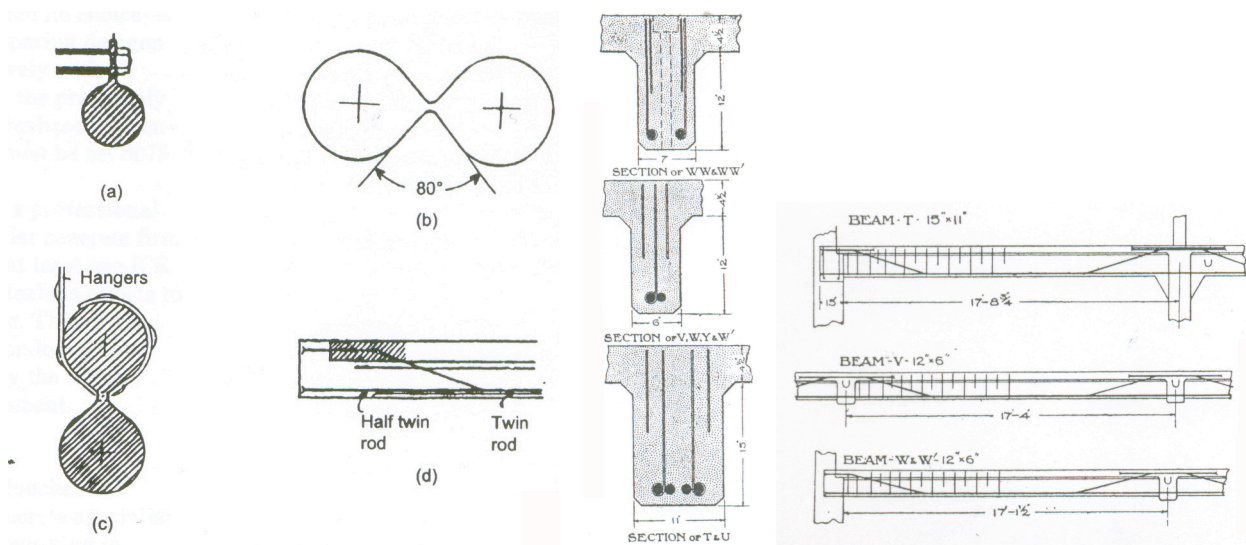


Figure 2.10 Wells' Twin Bars

Source: 'Fig. 24 Wells' in Bussell, "The era of proprietary reinforcing systems": 300; 'Fig. 3 Reinforced Concrete Factory (Working Details), Beams in Section' and 'Fig. 4 Reinforced Concrete Factory (Working Details), Beams in Elevation' from "Reinforced Concrete Factory" [Ramsay Tech], *Concrete & Construction Engineering*, 462. [Not to scale].

Wells' original design was a single round bar with a flat continuous fin that could be perforated to accommodate transverse bars (see (a), above). He later joined twin bars in an hourglass profile (see (b), above). This design, with the addition of a perforation, accommodated hangers (see (c) and the lower two beam sections).

⁵⁷ "Characteristics of the Chief Systems of Reinforced Concrete Applied to Buildings in Great Britain": 432.

By slitting the twinned bars longitudinally, one bar could be cranked up over the supports (see (d) and the three beam elevation drawings).⁵⁸

The systems developed by Coignet, Hennebique, Patent Indented Steel Bar and Wells all include '[m]ain and secondary beams combined with slabs to form a monolithic floor system.'⁵⁹ In the Kahn system, 'where beams and slabs are used in conjunction, compression bars are employed in a reversed position at suitable distances apart over each beam, so as to provide for negative bending moments in both longitudinal and transverse directions and to bond the slabs with the beams.'⁶⁰ In all five systems - Coignet, Hennebique, Patent Indented Steel Bar, Trussed Concrete Steel (Kahn) and Wells - '[w]alls of buildings are usually formed of columns, beams, and panels, all of reinforced concrete, or with brickwork panels.'⁶¹ Coignet, Hennebique and Indented Bar all specify mild steel reinforcement. The other companies rely on specification of tensile strength of the reinforcement and other performance characteristics.⁶²

More detailed information and additional images are available from Cassell's *Reinforced Concrete* (1913), 'Characteristics of the Chief Systems of Reinforced Concrete applied to Buildings in Great Britain,' *Concrete & Constructional*

58 Bussell, "The Era of Proprietary Reinforcing Systems" : 295.

59 "Characteristics of the Chief Systems of Reinforced Concrete Applied to Buildings in Great Britain": 434, 435, 436, 437.

60 "Characteristics of the Chief Systems of Reinforced Concrete Applied to Buildings in Great Britain": 432.

61 "Characteristics of the Chief Systems of Reinforced Concrete Applied to Buildings in Great Britain": 439, 440, 441.

62 "The Institution of Civil Engineers," *Concrete & Constructional Engineering* 5(10) (October 1910): 719 and Indented Bar per Bernard E. Jones, *Cassell's Reinforced Concrete: A Complete Treatise on the Practice and Theory of Modern Construction in Concrete-Steel* (London: Cassell and Co., Ltd., 1913), 222.

Engineering vol. 2 no. 6 (January 1908) and 'The Institution of Civil Engineers and Reinforced Concrete,' *Concrete & Constructional Engineering* vol. 5, no. 10 (1910). As mentioned earlier, examples of Scottish buildings constructed using the systems described above are included in Table 2 (Chapter 4).

CHAPTER 3: A PROBLEM OF PERCEPTION

Chapter 3 takes a look at attitudes toward reinforced concrete. First, the hidden nature of reinforced concrete is examined. Contemporary arguments regarding the appropriate architectural form for the new material are then laid out. Finally, the fact that concrete is a misunderstood material and the impact this combination of factors has on its conservation are explored.

ATTITUDES TOWARD CONCRETE

John Berger begins *Ways of Seeing* with the quote: 'The relation between what we see and what we know is never settled', 'the knowledge, the explanation, never quite fits the sight.'⁶³ Never has this been truer than with reinforced concrete. Even the material's word associations inspire confidence – solid and substantial. Although the epitome of solidity, concrete is deceptive; it may appear massive, but it is capable of plastic form and long spans with little actual material. Proprietary system-built structures in particular appear very similar to earlier timber, iron and steel-framed structures and are often clad in masonry (stone) or brick.

The Struggle with Appropriate Form

One of the debates of the time revolved around the fact that '[t]o the untrained eye, most of these early reinforced concrete buildings could be mistaken for concrete cased steel-framed buildings of the period.'⁶⁴ From the 1860s and 1870s, in the context of architectural revivalism and eclecticism, Viollet-le-Duc had been arguing for 'forms 'appropriate' to the new social, economic and technical

⁶³ John Berger, *Ways of Seeing* (New York: Penguin Books, 1977), 7.

⁶⁴ Clive Richardson, "Dating buildings: concrete," *The Architect's Journal* (6 April 2000): 36.

conditions' of the time.⁶⁵ Thomas Potter's 1877 book focused on this 'question of 'Aesthetics', also discouraging imitation of historic forms.⁶⁶

At the same time that appropriate forms for the new material were being encouraged, the flexibility of reinforced concrete didn't dictate a vocabulary.⁶⁷ Architects looked to earlier building typologies and historical styles. In some cases, this was successful. In his design for the Lion Chambers (a Hennebique system building in Glasgow listed in Table 2), 'Salmon ... looked to earlier 'vernacular styles'; specifically '[t]he Scottish style, ... the old rough-cast castle, ... the plain rough-cast surfaces, extending to the window-sashes, the simple corbelling, the small cornices, the straight lines, the rarity of arches, and other details'. Although traditionally constructed 'in other materials [these] constructional features ... seemed appropriate for the new material.'⁶⁸

In other cases, ideas were not so successful. In an 1876 lecture at the Royal Institute of British Architects (RIBA), Alexander Payne 'conceded on all hands that concrete buildings are durable, strong, dry, and not expensive; but the general outcry is, that they are ugly.' He went on to suggest half timbering with cast iron and concrete.⁶⁹

⁶⁵ William J. R. Curtis, *Modern architecture since 1900*, 2nd ed., (Englewood Cliffs, New Jersey: Prentice-Hall, 1987), 16.

⁶⁶ Collins, *Concrete*, 98.

⁶⁷ Curtis, *Modern architecture*, 39.

⁶⁸ James Salmon, "The Decoration of Steel and Reinforced Concrete Structures," *Builders' Journal* 27 (25 March 1908): 269-273, quoted in Cusack, "Lion Chambers," 200.

⁶⁹ Alexander Payne, "Concrete as a Building Material," *Transactions of the Institute of British Architects* (1875) [sic]: 180.

A Traditional Bias

The argument that concrete was inherently unattractive persisted. It has suffered because it has 'always been regarded as a cheap material.'⁷⁰ Collins argues that between Roman times and the end of the French Revolution, concrete was little used due 'mainly to an ingrained conviction that ashlar was the only respectable material for better class building.'⁷¹ '[A]s far as buildings of any architectural pretension [were] concerned, [concrete was] almost entirely used in hidden situations... except in the case perhaps of commercial or industrial architecture.'⁷²

This was where the material came into its own. The grid-like plan and simple, rectilinear forms of commercial buildings worked well with industry's need for long spans with little floor area taken up by vertical supports and for lots of natural light. These 'structural skeletons' followed a rationalist aesthetic. The concrete frame dictated an almost Classical order, with proportion and symmetry. Exterior walls no longer needed to be load-bearing. Infill panels could be made of concrete or other non-weight-bearing material. 'Thus the design of interesting reinforced concrete structures tended to be regarded more and more as the domain of the leading civil engineers.'⁷³ A representative selection of Scottish buildings is shown in Figure 3.1.

70 Maxwell Ayrton, *Architects' Journal* (24 Nov 1926): 661, quoted in Collins, *Concrete*, 133.

71 Collins, *Concrete*, 19.

72 Jones, *Cassell's Reinforced Concrete*, 229.

73 Collins, *Concrete*, 93.



[3 and 4] Kinlochleven Aluminium Works Power House (view from the NW) [Coignet System]

Source: RCAHMS, SC716966, 2005.



[69] The Wallace-Scott Tailoring Institute [Considère]

Source: Concrete and Constructional Engineering 9(12), 710.



[35] Lion Chambers [Hennebique]

Source: the Author.

Figure 3.1 A Selection of Scottish Proprietary Reinforced Concrete Buildings

The photographs on this page represent all but one [Patent Indented Steel Bar Co. (Indented Bar)] of the six proprietary reinforced concrete systems in use in Scotland between 1900 and 1920. They are arranged alphabetically by system name. Each building's line item number/s [from Table 2 (Chapter 4)] is/are included in brackets under its image.



[29] Heathall Uniroyal Factory [Trussed Concrete Steel Co. (Kahn system)]

Source: photo 89/13/MW 32courtesy of Mark Watson



[72] William Ramsay Technical Institute (Portobello Chocolate Factory) [E.P. Wells]

Source: the Author.

Engineer v. Architect

There was a rift of sorts between the architectural and engineering professions during this period.⁷⁴ There were no statutory regulations in place for concrete design until 1915, when the London County Council introduced reinforced concrete regulations. Before 1915, design was mostly the province of specialist firms who developed their methods using French and German work published outside Britain.

The foreign origins of reinforced concrete building systems, along with the patented secrecy and seeming self-promotion of the entrepreneurs involved were seen as 'distasteful' to the British professional audience.⁷⁵ 'The secrecy surrounding the techniques of reinforced concrete obviously restricted opportunities for criticism and correction.'⁷⁶ 'The specialist...[was]... regarded by many as an intruder' and a threat to the position of both architects and engineers.⁷⁷ However, some argued that just as in the past both architects and engineers had relied 'upon the structural steel specialist' for assistance with specifications, architects now relied 'upon the [proprietary reinforced concrete system] specialist for the structural portion of [the]

⁷⁴ Curtis, *Modern architecture*, 14.

⁷⁵ "The Progress of Reinforced Concrete in Great Britain during 1906," *Concrete and Constructional Engineering* 2(1) (March 1907): 5-12 quoted in P. Cusack, "Reinforced Concrete": 233; Editorial notes, *Concrete and Constructional Engineering* 5(10) (Oct. 1910): 703, quoted in Cusack, "Reinforced Concrete": 374-375; Frank Jay, "Pioneers of the Concrete Industry: Notes on the Work of William Wilkinson and Peter Stuart," *Building Industries* 17 (16.5.1906): 17, quoted in Cusack, "Reinforced Concrete: 381; reference to 'pretentious foreigners', E.O. Sachs quoted in Ed. Notes, *Concrete and Constructional Engineering* 3(4) (Sept. 1908): 262, quoted in Cusack, "Reinforced concrete": 387; Cusack, "Architects," 190.

⁷⁶ Cusack, "Agents," 73.

⁷⁷ Serraillier, "The Reinforced Concrete Specialist," 94.

work.¹⁷⁸ This is in evidence in Table 2, where two-thirds of the buildings on the list involved the work of both an architect and an engineer.

'In 1906, three important events took place in Britain which marked an advance in the direction of raising the status of the design and construction of works in reinforced concrete from that of a proprietary mystery into that of a regular branch of engineering construction.' First, 'the appearance in March 1906 of *Concrete and Constructional Engineering*'; second, 'the convening, by the Royal Institute of British Architects, of a Reinforced Concrete Committee' [its report, issued in 1909, led to the first revision of the London County Council Act since 1894]; and, finally, 'the appointment in December 1906 by the British Fire Prevention Committee of a Special Commission on Concrete Aggregates.'¹⁷⁹ 'The RIBA Committee and similar initiatives were attempts to open up the subject for study and debate.'¹⁸⁰

By-laws

Although it is argued that by-laws in place at the time hampered adoption of reinforced concrete construction⁸¹, others maintain that they had little effect on innovation. '[E]nthusiastic promoters of reinforced concrete construction were able to get round some, if not all, of the regulations outside the area of London County Council control; or at least to get reinforced concrete accepted in place of steel

⁷⁸ Serrailier, "The Reinforced Concrete Specialist," 93.

⁷⁹ Department of Scientific and Industrial Research (Building Research Station) and Hamilton. *A Note on the History of Reinforced Concrete in Buildings*, 14-15.

⁸⁰ Cusack, "Agents," 73.

⁸¹ British Reinforced Concrete Engineering Company, *BRC Reinforcements*, 8th ed. (Stafford: The British Reinforced Concrete Engineering Co., Ltd., 1924), 9.

even before there was any provision in by-laws for it.⁸² The 1894 London Building Act did not apply to docks, railway companies, or any property in Britain outside of London.⁸³ 'It thus happened that the only privately-owned buildings which could legally be constructed in reinforced concrete were either industrial buildings (for which special rules applied) and railway buildings (which were removed from the control of local by-laws altogether).'⁸⁴

In spite of the regulations, concrete 'became attractive to engineers and architects alike, for its freedom of form, fire resistance and high tensile strength.'⁸⁵ The problem was that the building regulations were stated in terms of materials, which did not include reinforced concrete, and detailed rules (wall thicknesses, etc.) for construction instead of performance requirements.⁸⁶ March and Dunn argued that '[a] better practice exists in Scotland, where, in cities, towns and burghs, the permission of the local Dean of Guild Court must be procured. Taking Edinburgh Dean of Guild Court as a type, there are no regulations fixing either the size or material of which walls are to be built.'⁸⁷

By default, local governments required the use of more reinforced concrete than structurally necessary. At the same time, they actively refused to authorise loans for concrete on the same terms as masonry or timber construction until after the First

82 Bowley, *The British Building Industry*, 13.

83 Bowley, *The British Building Industry*, 26.

84 Collins, *Concrete*, 78.

85 Richardson, "Dating buildings: concrete": 36.

86 Bowley, *The British Building Industry*, 24.

87 Charles F. Marsh and William Dunn, *Reinforced Concrete*, 3rd ed. (London: Archibald Constable and Co., Ltd., 1909), 3.

World War.⁸⁸ In the end, '[i]t was [the] argument for sanitary worker dwellings and fireproof public buildings, rather than any structural or aesthetic potentialities of the material, which prompted architects and their clients to allow the material to prove itself in increasingly important projects.'⁸⁹

A Misunderstood Material

'During the second half of the 19th century, a number of people had set down and published and patented the principles of reinforced concrete [design], but the forms of construction in general use inducted that no real understanding of the behaviour of reinforcement in conjunction with concrete existed in general practice.'⁹⁰ 'The misconception that there [were] permanent finishes to concrete which need[ed] no maintenance [was] only matched by the misunderstanding over the durability of reinforced concrete as a structural material.' Marsh first propagated this idea in 1904.⁹¹

Although reinforced concrete was fire-resistant, durable and resistant to loading stress and sound and vibration impacts in industrial applications, there were misconceptions that it was impermeable, 'practically indestructible, and require[d] no maintenance.'⁹² The benefits of reinforced concrete construction included the

88 Serrailier, "The Reinforced Concrete Specialist," 97; "Reinforced Concrete and the Local Government Board [Editorial notes]," *Concrete and Constructional Engineering* 11(4) (Sept. 1907): 257 [see note in article's bibliography]; Bowley, *The British Building Industry*, 20; British Reinforced Concrete Engineering Company, *BRC Reinforcements*, 20.

89 Collins, *Concrete*, 43.

90 Sutherland et al, *Historic Concrete*, 62.

91 Sutherland et al, *Historic Concrete*, 6.

92 Marsh, *Reinforced Concrete*, 7-27; Stuart's Granolithic advertisement, *Edinburgh Architectural Association Transactions* 8 (1905-7): 66; Edmund Coignet Ltd., *Reinforced Concrete Constructions – Coignet System* (Westminster, London: Wightman & Co, Ltd, 1910), 7.

'rapidity with which works [could] be executed' and, often, the local availability of components, its monolithicism, and its lightness and slenderness, which resulted in a 'saving of material', and therefore a 'gain of interior space' and reduced cost.⁹³ Although there was a general understanding of the importance of certain quality issues, such as the proper placement of the reinforcement, the appropriateness of materials selected as aggregate, the percentage of water needed in the mix and the necessity for ramming of the concrete, some of this information was not fully correct. This lack of detailed knowledge about the chemistry of reinforced concrete would later result in material decay and conservation issues.

Continued Misconceptions

Concrete is so captivating because it 'is still a little understood – even misunderstood – material.' '[P]eople thought concrete would last forever. It doesn't.'⁹⁴ The continuing need for honesty in the use of material, or use of concrete in its 'natural' state has reduced its aesthetic potential 'due to poor and uneven weathering'⁹⁵, particularly in a northern climate.⁹⁶ 'A weather patina may be acceptable on masonry but not on concrete.'⁹⁷

The use of concrete in publicly-funded housing schemes from the 1940s onward added a social stigma, permanently associating the material with the tower block

93 W. Noble Twelvetrees, *Treatise on reinforced concrete: including the new standard notation of the Concrete Institute* (London: Sir Isaac Pitman and Sons, Ltd., 1920), 9-10.

94 David Littlefield, "Grey matters," *Building Design* 1533 (17 May 2002): 16.

95 Sutherland et al, *Historic Concrete*, 6.

96 Charles McKean, "The way forward for urban concrete – a personal view ["Urban Concrete Is concrete's urban image irredeemably tarnished? How can we ensure it more than a supporting role in the future?]," *The Architect's Journal* 9(204) (12 September 1996). Suppl. *Concrete Quarterly* 180 (Autumn 1996): 21.

97 Charles McKean, "The way forward for urban concrete," *The Architect's Journal* 9(204) (12 September 1996): 22.

rather than with the sweeping forms seen in the work of the likes of Le Corbusier, Pier Luigi Nervi and Eero Saarinen.

The fact that concrete is also a material in such widespread current use and that it is 'constantly evolving'⁹⁸ means that it is 'often ignored as being of little 'historic' significance.'⁹⁹ This is reflected in the small number of reinforced concrete buildings included on Historic Scotland's *Statutory List* (see *The Statutory Framework*, Chapter 4).

CONSERVATION PRACTICE V. MATERIAL REALITY

Even now, guidance for treatment of deteriorating or damaged reinforced concrete is limited. It wasn't until the 1960s that the restoration and maintenance of reinforced concrete structures was on anyone's radar.¹⁰⁰ It follows that '[t]he repair methods used for concrete have ... developed ... particularly in the last 30 years.'¹⁰¹ 'The privilege of using only proven repair techniques can be difficult to observe when many of the repair systems ... are fairly new, and there is no information on their long-term performance or any negative side effects.'¹⁰²

A Question of Integrity

The *Burra Charter* (1998, Articles 3 and 27.1) and the *New Zealand Charter* (1992, Article 4iii), support the least possible physical intervention and minimal loss of fabric when undertaking building conservation works. Even more recent charter language

98 Littlefield, "Grey matters," *Building Design* 1533 (17 May 2002): 16.

99 Stirling, "Early Concrete," 2.

100 Luciana Ravanel and Maurice Culot, "Introduction," *Rassegna* 49(1) (March 1992): 50.

101 Macdonald, *Concrete*, 6; Macdonald, *Preserving*, 39.

102 Knight, *The repair of historic buildings in Scotland*, 6.

suggests that '[t]he value of architectural heritage is not only in its appearance, but also in the integrity of all its components as a unique product of the specific building technology of its time. In particular the removal of the inner structures maintaining only the façades does not fit the conservation criteria.'¹⁰³ The often destructive nature of repair and sometimes irreversible techniques necessary to conserve reinforced concrete call into question the basic tenets of 'minimal intervention, maximum retention of original fabric, conserve as found and reversibility.'¹⁰⁴ The degree of deterioration may require that reconstruction be brought into play.¹⁰⁵ The repair options available for reinforced concrete point out the difficulty with its conservation in an ethical framework.

In 1978, Andrew Powter clearly laid out three difficulties faced by conservators approaching an early concrete building:

- 'unfamiliarity ... with concrete as a material and with [the] long-term effects of conservation media and methods' on that material;
- preoccupation 'with materials which are constructed with unit [materials] rather than in monolithic form'; and
- trepidation, given that '19th and early 20th century concrete structures were often poorly built without a proper knowledge of the properties and characteristics of the materials and systems [used]. Consequently deterioration may be extremely severe and

103 ICOMOS 14th General Assembly, "ICOMOS Charter- Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage (2003)," ICOMOS, http://www.international.icomos.org/charters/structures_e.htm (see 1.3).

104 Australia ICOMOS, "The Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (The Burra Charter) (1998)," <http://www.icomos.org/australia/burra.html> [see Articles 15.3 and 20.1]; Knight, *The repair of historic buildings in Scotland*, 44-45; Susan Macdonald, ed. *Modern Matters: Principles and Practice in Conserving Recent Architecture* (Shaftesbury: Donhead, 1996), 88; and Weaver, *Conserving Buildings*, 147.

105 ICOMOS, "International Charter for the Conservation and Restoration of Monuments and Sites (The Venice Charter)," ICOMOS, http://www.international.icomos.org/charters/venice_e.htm (see Venice 1962, Article 10); Australia ICOMOS, "The Burra Charter," [see Articles 15.2/note and 18-20].

the degree of intervention required from the conservator may be considered extensive.¹⁰⁶

It can be argued that conservators still face these dilemmas today.

¹⁰⁶ Powter, "History, Deterioration, and Repair," 59-77, quoted in Weaver, *Conserving Buildings*, 147.

CHAPTER 4: A PRE-INVENTORY

This chapter begins with a discussion of the conservation charters and how, beginning in the mid- to late 20th century, they influenced government policy related to historic building inventory and assessment, including protection of 20th century architectural heritage and technical and civil engineering heritage (represented by the buildings included in Table 2 later in this chapter). The chapter continues by defining a pre-inventory. European and British precedent, including Scottish precedent, for this approach is discussed. Scottish planning guidance and policies related to building inventory are laid out and considered. Then, a more specific definition of a pre-inventory is given based on the context of this paper. It includes a discussion of the framework utilised to develop the format for the list of buildings (Table 2).

CONSERVATION CHARTERS, CONVENTIONS AND RECOMMENDATIONS

Interest in conservation of cultural heritage has gone through a progression beginning in the 17th century.¹⁰⁷ At that time, conservation activities were primarily related to individual buildings, usually churches. This work grew through the 18th and 19th centuries to include 'the restoration of works of art, ancient monuments and historic buildings; this was reflected in several countries in the creation of state organisations for their protection.'¹⁰⁸

107 Jukka Jokilehto, *A History of Architectural Conservation* (London: Elsevier, 1999), 252.

108 Jukka Jokilehto, "Conservation Ethics 'The Seven Lamps'" (reader, AC10 History and Theory of Conservation, Edinburgh College of Art, Fall 2006; reprint, lecture, Edinburgh, 24 March 1994): 2.

By the mid-19th century the first mention is made of inventories.¹⁰⁹ It wasn't until the mass destruction of the built environment during the First World War that consciousness focused on the importance of taking stock of cultural heritage. This shift is illustrated by a series of cultural heritage policy documents, which provide guides to 'good' conservation practice. The majority of these documents have been produced by ICOMOS, the International Council on Monuments and Sites, the CE, or Council of Europe, and UNESCO, the United Nations Educational, Scientific and Cultural Organisation. The philosophy outlined in the UNESCO documents is applicable to sites of international significance. The ICOMOS Charters examine conservation ethics in practice, whilst the CE documents explore the societal benefits of European conservation.

Beginning with the *Athens Charter* in 1931, the charters emphasise the importance of documentation. 'The Conference expresses the wish that: 1. Each country, or the institutions created or recognised competent for this purpose, publish an inventory of ancient monuments, with photographs and explanatory notes...'¹¹⁰

There have been multiple recommendations on documentation methods drafted by the Council of Europe. *Resolution criteria and methods of cataloguing ancient buildings and historical or artistic sites (66/19)*, adopted in 1966, states '[t]hat it is impossible to safeguard such a heritage effectively before having identified the assets of which it is comprised; [t]hat it is therefore essential first of all to compile a

109 Jokilehto, *A History*, 245-6.

110 ICOMOS First International Congress of Architects and Technicians of Historic Monuments, "The Athens Charter for the Restoration of Historic Monuments (1931)," ICOMOS, http://www.icomos.org/athens_charter.html

protective inventory...'¹¹¹ The Council of Europe re-iterated the importance of Inventory of the European Cultural Heritage (IECH) in the booklet *Protective Inventory* published in 1968 and in the *Resolution on the compilation of national inventories of monuments, groups of buildings and sites of historical or artistic interest (72/21)*, adopted in 1972.¹¹²

Article 2 of *The Convention for the Protection of the Architectural Heritage of Europe* (1985) records the importance 'identification of properties to be protected' and notes that inventories should be maintained.¹¹³ The language of Article 2 was repeated in *Recommendation No. R (95) 3 on Co-ordinating Documentation Methods and Systems Related to Historic Buildings and Monuments of the Architectural Heritage*, adopted in 1995, which emphasised 'the need to maintain inventories or prepare appropriate documentation as prerequisites for a conservation policy.'¹¹⁴

111 Council of Europe, "Resolution criteria and methods of cataloguing ancient buildings and historical or artistic sites (66/19) (1966)," [http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res\(66\)19.asp#TopOfPage](http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res(66)19.asp#TopOfPage)

112 Council of Europe, "Resolution on the compilation of national inventories of monuments, groups of buildings and sites of historical or artistic interest (72/21) (1972)," [http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res\(72\)21.asp#TopOfPage](http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res(72)21.asp#TopOfPage)

113 Council of Europe, "The Convention for the Protection of the Architectural Heritage of Europe (1985)," <http://conventions.coe.int/treaty/en/Treaties/Html/121.htm>

114 Council of Europe, "Recommendation No. R (95) 3 on Co-ordinating Documentation Methods and Systems Related to Historic Buildings and Monuments of the Architectural Heritage (1995)," <https://wcd.coe.int/ViewDoc.jsp?id=528215>

Item 17 in the ICOMOS *Guidelines for Education and Training* (1993) states that 'conservation depends upon documentation'. ICOMOS has also published *Principles for the Recording of Monuments, Groups of Buildings and Sites* (1996).¹¹⁵ UNESCO *Recommendations*, issued in 1962 and 1968, paralleled the thinking of the other heritage bodies. They went a bit further, putting into words the previous assumption that 'protection of the environment [should be] an integrated part of urban and regional planning', calling this 'integrated conservation'.¹¹⁶ Article 4 of the UNESCO *Convention Concerning the Protection of the World Cultural and Natural Heritage* (1972) again indicates that it is the state's responsibility to identify, protect, and conserve.¹¹⁷

Documents produced by the three organisations all have relevance to preservation of 20th century architecture. Most relevant to proprietary reinforced concrete buildings are *Council of Europe Recommendation R(91)13* (1991), which discusses the 'protection of twentieth-century architectural heritage'¹¹⁸ and *Recommendation R(90)20* (1999), where both 'protection and conservation of the industrial, technical and civil engineering heritage in Europe' and 'the protection of the twentieth-century architectural heritage' are goals.¹¹⁹

115 ICOMOS, "Principles for the Recording of Monuments, Groups of Buildings and Sites (1996)," http://www.international.icomos.org/charters/recording_e.htm

116 Bell, *The Historic Scotland Guide*, 53.

117 UNESCO, "UNESCO Convention Concerning the Protection of the World Cultural and Natural Heritage (1972)," <http://whc.unesco.org/archive/convention-en.pdf>

118 Bell, *The Historic Scotland Guide*, 73.

119 Council of Europe, "Recommendation R(91)13(1991)," quoted in Bell, *The Historic Scotland Guide*, 13, 72-73.

European Precedent

The Royal Commission on the Historical Monuments of England hosted a colloquium entitled *Inventories of Monuments and Historic Buildings in Europe* in 1988. The introduction to the published proceedings states that '[t]he compilation of inventories of archaeological monuments and historic buildings has a history of over a century in Europe, and has been acknowledged as a prerequisite of management policy if that policy is to be informed and sensitive; to take account of the full range of sites and monuments that survive; and to understand the regional differences that mark the various cultures present.'¹²⁰ During the colloquium, representatives of a number of national heritage bodies presented papers describing approaches to building inventories.

Belgium described its process of bibliographical inventory, a partial inventory consisting of basic bibliographic research, an overview of history and evolution and comprehension of development of the building type.¹²¹ The Danish representative noted that dating back to production of *Danmarks Kirker* in the 19th century, there has been a history of use of documentary sources to identify built heritage in Denmark and that, in that country, the resources were 'often inter-related through the use of the same type of building material.'¹²² He went on to say that '[t]he preparatory work that precedes the writing and publication of the inventory can be divided into two phases: studies in archives, museum collections and libraries on

¹²⁰ Royal Commission on the Historical Monuments of England, *Inventories of Monuments and Historic Buildings in Europe*. Proceedings of a Colloquium Held in Oxford, England in 1988. (London: Royal Commission on the Historical Monuments of England (RCHME), 1992), viii.

¹²¹ RCHME, *Inventories*, 45.

¹²² RCHME, *Inventories*, 59.

one hand ('indoor work'), and field research on the other.¹²³ The French region of Rhône-Alps noted that time constraints necessitated compilation of a pre-inventory, consisting of analysis and organisation of existing documentation.¹²⁴ Ireland's *Architectural Heritage Protection Guidelines* (2000) include perusal of documentary sources as a valid means to identify potential structures.¹²⁵

British Precedent

In discussing the 'Monuments Protection Programme (MPP), initiated by English Heritage in 1986', Stratton notes that the first step was to 'identify archaeological and historic sites ...by reviewing established information about them.'¹²⁶ It is understood that often this data may be incomplete and often of variable quality.¹²⁷ Since the 1960s in England (in Wales since around 1970), the 'idea of making thematic surveys within geographical areas ... has ... become the ... standard method of approach for our surveys.'¹²⁸ [Thematic surveys], similar to the one undertaken here, 'aim to achieve comprehensive coverage of selected classes of building at summary level', a broad-brush approach to be followed up later.¹²⁹

123 RCHME, *Inventories*, 61.

124 RCHME, *Inventories*, 91.

125 Government of Ireland, "Architectural Heritage Protection: Guidelines for Planning Authorities. Guidance on part IV of the Planning and Development Act 2000," *Series: Department of the Environment Planning Guidelines, no. 9*, Dublin: The Stationary Office 2004, 23, 39.

126 Michael Stratton, "Industrial Monuments: A Protection Programme," *Industrial Archaeology Review* 13(1) (Autumn 1990): 37.

127 Timothy Darvill, Andrew Saunders and Bill Startin, "A question of national importance: approaches to the evaluation of ancient monuments for the Monuments Protection Programme in England," *Antiquity* 61(231) (March 1987): 393, 402.

128 RCHME, *Inventories*, 3.

129 RCHME, *Inventories*, 39.

Scottish Legislative Framework

Historic Scotland is the government agency charged with conservation of the historic environment in Scotland. The process for listing buildings, outlined in the *Planning (Listed Buildings and Conservation Areas) (Scotland) Act of 1997*, and that for scheduling, under the terms of the *Ancient Monuments and Archaeological Areas Act 1979*, are administered by Historic Scotland on behalf of the Scottish Ministers.¹³⁰

NPPG 18 Planning and the Historic Environment 'sets out the Government's planning policies in relation to the historic environment with a view to its protection, conservation and enhancement. ...The primary source of guidance on the Secretary of State's interests and responsibilities in relation to listed buildings and conservation areas is provided in the *Memorandum of Guidance on Listed Buildings and Conservation Areas* (revised 1998) (the Memorandum).'¹³¹ Scottish policy was drafted with the intention of protecting pre-20th century heritage first, as laid out in the principles for listing.¹³² 'The list is constantly under review and buildings can be added to the list by three main methods: [b]y comprehensive re-survey of geographic areas; [b]y thematic study looking at one particular building type (e.g.

¹³⁰ Historic Scotland, "Scottish Historic Environment Policy (SHEP) on Listing," 27 March 2007 and Historic Scotland, "Listing: the identification of Scotland's special buildings," 2007, <http://www.historic-scotland.gov.uk/pastconsultations> and http://www.historic-scotland.gov.uk/sheps_listing.pdf; Historic Scotland, "Scottish Historic Environment Policy (SHEP) on Scheduling," 2006, <http://www.historic-scotland.gov.uk/index/policyandguidance/policypublications/ministerialpolicies.htm>

¹³¹ Scottish Office – Planning and Building, "NPPG 18: Planning and the Historic Environment," <http://www.scotland.gov.uk/publications/1999/04/nppg18> and Historic Scotland, "1998 Memorandum of Guidance on listed buildings and conservation areas," 29 April 1999, http://www.historic-scotland.gov.uk/memorandumofguidance_1998.pdf

¹³² *Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997*, section 74(1)(a).

hospitals) [or in the case of this paper, proprietary reinforced concrete buildings]; [and b]y individual proposals for buildings to be added to the list.'¹³³

'The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) is responsible for recording, interpreting and collecting information about the built environment.'¹³⁴ This charge includes 'identify[ing], survey[ing] and interpret[ing] the built environment of Scotland.'¹³⁵ The RCAHMS recording policy describes how these activities have 'a long history in Scotland, beginning with Alexander Gordon's *Itinerarium Septentrionale* in 1726, ... Major-General William Roy's *Military Antiquities of the Romans in North Britain*, ... published in 1793' and 'the *Ordnance Survey of Great Britain*.'¹³⁶

Gazetteers (geographic indexes that 'list places or geographical features by theme'), including *The Ordnance Gazetteer of Scotland* by Francis Groome and the *Gazetteer of Scotland* by Rev J.M. Wilson, 'became popular in Britain in the 19th century.'¹³⁷ This work established a country-wide precedent. These activities continued with '[t]he recording of castellated, domestic and ecclesiastical architecture by David MacGibbon and Thomas Ross in the last decades of the 19th

133 Historic Scotland, "How do we list buildings?," <http://www.historic-scotland.gov.uk/index/historicbuildings/howarebuildingslisted.htm>.

134 The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS), "About us: RCAHMS," <http://www.rcahms.gov.uk/aboutrcahms.html> (updated 31 May 2007).

135 RCAHMS, "About us: RCAHMS".

136 RCAHMS, "Corporate Plan 2004-9," 5.

137 Gazetteer, in Wikipedia, the online encyclopedia, <http://en.wikipedia.org/wiki/Gazetteer> (last modified 6 Sept. 2007).

century, the work of the National Art Survey of Scotland and Romilly Allen's study of Early Christian sculptured stones.¹³⁸

Current RCAHMS recording procedure starts at a general level (Level 0) and works toward the collection of more detailed information (Level 4 (5, 6)). Level 0 is '[p]reliminary, desk-based survey and record' and is 'seen as preparatory to the creation of a basic field record (Level 1).'¹³⁹ The pre-inventory work within this paper followed a Level 0 RCAHMS recording procedure.

THE DEFINITION OF A PRE-INVENTORY

Feilden lists inventories under 'Preparatory procedures for conservation.'¹⁴⁰

The *Oxford English Dictionary* (1989) defines an inventory as: '1. A detailed list of articles, such as goods and chattels, or parcels of land, found to have been in the possession of a person at his decease or conviction, sometimes with a statement of the nature and value of each; hence any such detailed statement of the property of a person, of the goods or furniture in a house or messuage, or the like; 2. a. *gen.* or *fig.* from 1. A list, catalogue; a detailed account.' It also gives a more concise definition, as follows: '1. *Trans.* To make an inventory or descriptive list of; to enter in an inventory, to catalogue: a. goods, etc.'¹⁴¹

The dictionary defines 'pre-' as 'repr. adv. and prep. (of place, rank and time) before, in front, in advance' and under the examples explains it as 'occurring

138 RCAHMS, "Corporate Plan 2004-9," 5.

139 RCAHMS, "Corporate Plan 2004-9," 11-12.

140 Bernard M. Feilden, *Conservation of Historic Buildings*, 7.

141 The Oxford English Dictionary, 2nd ed., p. 41, s.v. "inventory."

before some other process.¹⁴² The list of buildings included as Table 2 is not descriptive, additional work would be required to make it so. It is not meant to be a formal inventory per current policy guidance, but a pre-cursor to this work or a pre-inventory.

THE LIST OF BUILDINGS

The Basic Layout

The headings in Table 2 are: Building Name, Alternate/Historic Name, Year Built, Location, Street Address, Client, Architect, Engineer or Consulting Engineer, Contractor, System, Whole Building?, Portion of Building?, References 1-5, Listed? (Y or N), Graphic? and Extant?. The format and headings for the table were developed after review of the Council of Europe *Recommendation No. R (95)3 on Co-ordinating of Documentation Methods and Systems Related to Historic Buildings and Monuments of the Architectural Heritage*, RCAHMS *Survey and Recording policy* and the Canmore database, Historic Scotland's *Statutory List* and the DOCOMOMO fiche format.¹⁴³ The content in the table is intended to direct future researchers on this topic to additional sources of information; for example, the company archives of contracting or engineering firms.

¹⁴² The Oxford English Dictionary, 2nd ed., p. 294, 296, s.v. "pre-."

¹⁴³ Council of Europe, "Resolution (72/21) (1972)," [http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res\(72\)21.asp#TopOfPage](http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res(72)21.asp#TopOfPage); RCAHMS, "Corporate Plan 2004-9"; RCAHMS Canmore database, http://www.rcahms.gov.uk/pls/portal/PORTAL.wwa_app_module.show?p_sessionid=483188&p_header=true; Historic Scotland, *Historic Buildings Statutory List*; DOCOMOMO Georgia Register, <http://www.docomomoga.org/pages/register.html>

A Statistical Summary

The buildings included in the table are either wholly reinforced concrete, including their infill wall panels, or reinforced concrete frame (the entire building structure is reinforced concrete, except for the infill wall panels, which are often masonry or glazing). The company catalogues and lists used as primary source material often did not identify whether a particular building was wholly constructed using reinforced concrete. Where this was the case, and additional source material was available, the additional source was included as a reference. Out of the 71 buildings on the list, 62 (including the two entries for Kinlochleven Aluminium Works) have more than one source and 9 have one. If the name of the project in the source suggested only partial construction in reinforced concrete (i.e. 'warehouse floors'), that building was not included in the table.

The table includes 71 buildings, including two line items representing one building complex, Kinlochleven Aluminium Works. Of the total number of buildings, three (the Kinlochleven complex, Broadford Mills and Usher Hall) were constructed using multiple systems. The remaining buildings used the following systems: Considère [9], Hennebique [51], Indented Bar [1], Trussed Concrete Steel (Kahn System) [3], and Wells [1]. There are three additional buildings included on the list that do not have a system identified.

The buildings are listed in alphabetical order by the project title given in the source literature. This means that projects completed for the same client do not necessarily follow each other in the table. For example, see line items 19 and 42, both projects

for Herdman's. An attempt was made to eliminate duplicate entries; however, the examination of Dean of Guild records required for further clarification was beyond the scope of this study.

Construction dates for the buildings have been included where given. In many cases, these differed between sources. Where that was the case, it is duly noted. Confirmation of the completion date for each building would need to be verified, where possible, through consultation of Dean of Guild records. The buildings with a given date range from 1903 to 1921.

A number of the buildings were already included in Historic Scotland's *Statutory List* (12, including the two entries for Kinlochleven) or in the Royal Commission's Canmore database (31, including one NMRS Number covering the two line items for Kinlochleven and three NMRS Numbers covering the six line items (two each) for Albion Motor Car Company, Broadford Works and Herdman's Granary). Wherever this was the case, the identification number used by Historic Scotland (HB Number) or the NMRS (National Monuments Record of Scotland) number was included in the table.

Table 2. List of Buildings

| Item | Building Name | Alternate/Historic Name | Year Built | Location | Street Address | Client | Architect | Engineer or Consulting Engineer | Contractor | System | Whole Building? | Portion of Building? | Reference 1 | Reference 2 | Reference 3 | Reference 4 | Reference 5 | Listed? Y or N | Graphic? | Extant? | |
|------------|------------------------------|--|--------------------------|--------------------|-------------------------|---|---|-------------------------------------|--|--|-------------------------------------|---|---|--|---|--|--|-------------------------|---------------------------|---|---|
| 1 | The Administration Building | Weir Group Admin. Building; Weir Pumps Ltd.; Holm Foundry Cathcart Works; G. And J. Weir; Inverlair Ave. | (?)1915 (1912) | Cathcart, Glasgow | 149 (147) Newlands Road | Messrs. G. & J. Weir, Ltd. Pump manufacturers | Albert Kahn | | | Trussed Concrete Steel Co. (Kahn) | | | Concrete & Constructional Engineering (C&CE) vol. 10, no. 9 Sept. 1915, pp. 433-440 | Thompson, p. 80, 89-93 | RCAHMS - NMRS Number: NS56SE 161 | | | | | Y - see xeroxes from Thompson; Canmore | Y |
| 2 (see 44) | Albion Motor Car Company | Albion Motor Works | 1913 (1st block) (?)1912 | Scotstoun, Glasgow | 1272 South Street | Albion Motor Car Company, Ltd., Glasgow | | | Gray's Ferro-Concrete Contracting Co., Glasgow | Trussed Concrete Steel Co. (Kahn) | | my note - main block, turbine house have brick infill panels; boiler house, all r.c.? | C & CE vol. 15 no. 5- May 1920, p. 366-367 | Mouchel-Hennebique (MH) List 1920, p. 39 (1912) | Thompson, p. 81, 84 | RCAHMS - NMRS Number: NS56NW 83 | | | | Y - C&CE; Ltd. Canmore | N |
| 3 | Aluminium Works | Kinlochleven Aluminium Works; Kinlochleven Aluminium Smelter | | Kinlochleven | | | A. E. Bell, local rep. for DESIGNER A. Alban H. Scott, M.S.A. of Scott & Fraser, London | | McLaughlin & Harvey of Belfast and London | Coignet (Power House), Hennebique, Expanded Metal | | power house, village, staff houses, and no. 4 culvert | Reinforced Concrete Constructions - Coignet System (1910) | Historic Scotland (HS) e-mail list: silos, bridge and power house 1904-9 | C&CE 5(8) 1910, p. 586 [does not specify which structure on which system] | RCAHMS - NN16SE 3.00 | | Y (HB 12926; HB 49944) | Y - Canmore | N - mostly demo'd. 1989 | |
| 4 | Aluminium Works | Carbon Factory And Silos, Loch Leven; Aluminium Factory ('The Ice Factor') | | Kinlochleven | | | | | McAlpine and Sons | See above | | Carbon Factory | Reinforced Concrete Constructions - Coignet System (1910) | | See above | See above | | | Y - Canmore | Y - converted to 'The Ice Factor' indoor climbing centre c. 1999 per Mark Watson (MW) | |
| 5 | Ashley Rd. School | | 1912 | Aberdeen | | The Aberdeen Education Board | J.A.O. Allan | | | Hennebique | | | MH List 1920, p. 59 (1912) | (?)RCAHMS primary school and ancillary bldgs. dated 1887 | | | | | | | |
| 6 | Bakery | Kidd's Bakery; Andrew G Kidd's Bakery (Site Of) | 1908 (1907) | Dundee | Lytton Street | A.G. Kidd & Son Ltd | Johnson & Baxter | | | Hennebique | | clad | Hennebique Ferro-Concrete: Theory and Practice, 1909, p. 229 | MH List 1920, p. 33 (1907) | RCAHMS - NMRS Number: NO32NE 2005 | | | | | N - demo'd | |
| 7 | Biscuit Factory | | 1907 | Leith, Edinburgh | (?) 19 Elbe Street | William Crawford & Son, Ltd. | A. Hunter Crawford, FRIBA | | | Hennebique | Y | | Hennebique Ferro-Concrete: Theory and Practice, 1909, p. 222 | MH List 1920, p. 33 (1907) | also 'strong room' - see Twelvetees (1907), p. 390 | | | | Y | | |
| 8 | Bonded Whisky Warehouse | Watson's Bond (Seagate Block, North Bond) | 1909 (1907 per HS) | Dundee | 99 Seagate (North Bond) | Messrs. James Watson & Co., Ltd. | Johnson & Baxter | details: L.G. Mouchel/T.J. Gueritte | Messrs. Thorburn & Son, Edinburgh | Hennebique | | reinforced concrete frame and floors (per HS e-mail list - partial); date:1906-1907 | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 155 | Ferro Concrete (FC) vol. 3 no. 2 Aug. 1911, p. 59 | Hennebique Ferro-Concrete: Theory and Practice (1909), p. 195/photo and detail | RCAHMS - NO43SW108 - Hennebique internal frame: floors, columns, flat roof | C&CE vol. 2 no. 5 Nov. 1907, pp. 387-391 | Y (HB 25194) | Y - interior and exterior | Y - converted 1995 | |
| 9 | Broadford Works Extension | Broadford Mills, Flax Store; Broadford Firehose and Canvas Works; Richards Factory; South Working and Flax Warehouse | 1911 (1912) | Aberdeen | Maberley Street | Messrs. Richards, Ltd. | Messrs. Wilson & Walker, Aberdeen | | J. Scott and Son, Aberdeen | Hennebique; (also Coignet? - S. Working and Flax Warehouse - per MW) | | ferro - concrete skeleton with brick walls - attached to masonry building adjacent | FC, vol.4, no. 4 Oct. 1912, p.118-121 | MH List 1920, p. 37 | RCAHMS - NMRS Number: NJ90NW 125.02 - internal frame, floors, columns and roof all r.c.; dividing walls red brick | | | Y (HB 43908 - item 995) | Y - construction photo | Y - warehouse converted 1995 per RCAHMS. | |
| 10 | Carpet Manufactory Extension | | 1912 | Glasgow | Glasgow Green | Messrs. Templeton & Co., Glasgow | Wyllie & Blake, A.MM. Inst.C.E.; L.G. Mouchel & Partners Consulting Engineers | | Gray's Ferro-Concrete Contracting Company | Hennebique | Y - above ground floor - vert. ext. | also floors in Templeton's warehouse (FC vol. 3 no. 10, p. 355) | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 185 | FC vol.5 no. 4 Oct. 1913, p. 149-152 (1912) | Thompson, p. 46 | RCAHMS - NMRS Number: NS66SW 74 | | | Y interior; (?)Canmore | | |

| Item | Building Name | Alternate/Historic Name | Year Built | Location | Street Address | Client | Architect | Engineer or Consulting Engineer | Contractor | System | Whole Building? | Portion of Building? | Reference 1 | Reference 2 | Reference 3 | Reference 4 | Reference 5 | Listed? Y or N | Graphic? | Extant? | |
|-------------|--|---|-------------|--|-----------------------------------|---------------------------------------|---------------------------------|---|--|---|-------------------------|--|---|--|--|-------------------------------------|-------------|--|--|---|----------|
| 11 | Central Offices | Office Block for Marine Works | 1919 (1920) | Porterfield, Renfrewshire | | Babcock & Wilcox Ltd. | | L.G. Mouchel & Partners (details for r.c.) | Emery Ltd. | Hennebique | | brick dado infill with metal frame windows above | MH List 1920, p. 29 (1919) | Thompson, p. 67 | (?) RCAHMS - NMRS Number: NS46NE 49 | | | | | | |
| 12 | Chocolate Factory | | 1919 | Motherwell | | The Weber Chocolate Company, Ltd. | | E.J. Culles, AM.Inst.C.E. | | Hennebique | | | MH List 1920, p. 45 (1919) | | | | | | | | |
| 13 | Chryston Epileptic Colony | Stoneyetts Hospital, Woodilee; Meadowhead | 1912 | Glasgow (Lenzie, Dunbartonshire) | | The Glasgow Parish Council | Robert Tannock | | | Hennebique | | brick exterior walls | FC vol. 5 no 4 Oct 1913, p. 153- | MH List 1920, p. 54 (1912) | The Dictionary of Scottish Architects (DSA) 1840-1940, http://www.codexgeo.co.uk/dsa/building_full.php?id=M027486 . | (?) RCAHMS - NMRS Number: NS67SE 58 | | | | | N per MW |
| 14 | Clyde Navigation Meadowside Granary | Meadowside Granary; Meadowside Granaries | 1911-13 | Partick, Castlebank Street, Meadowside, Glasgow | | | | W.M. Alston Esq. MICE | | Considère | Y | per MARK WATSON (MW) notes: concrete floors on steel frame | Considère System of R.C. Design 1912, p. 58 | RCAHMS - NMRS Number: NS56NE 157 (see also NS56NW 54 for photo). | | | | | Y - plan & elevation in Considère; Canmore | N - demo'd. per RCAHMS. | |
| 15 | Columns and Flooring in Bakery (1911) and additional floors and supports for air washing plant (1913) and additional bakery buildings and strong room (1916); bakery building (1919) | | 1911/13/19 | Glasgow | | The City Bakeries, Ltd. | | John Biggar | | Hennebique | (?) structural skeleton | | MH List 1920, p. 38, 40, 45 (1911/1913/1919) | | (?) RCAHMS - NMRS Number: NS56NE 1642 - 15 Clarendon Street, Glasgow, City Bakeries | | | | | (?) HB 33756 (dated 1924) | |
| 16 | Confectionary Works | Confectionary Manufactory; Buchanan's Confectionary Works | | Glasgow (three buildings - one on Ann Street 1912 (warehouse), extension of one facing Steward [sic] Street 1911 and one on Maitland Street 1908 (warehouse)) - one pictured is Ann Street | 35 Stewart Street | Messrs. John Buchanan & Bros., Ltd. | Wyllie & Blake, A.MM. Inst.C.E. | Wyllie & Blake, A.MM. Inst.C.E.; L.G. Mouchel & Partners Consulting Engineers | W.T. Weir Newcastle-on-Tyne (at least per Cusack for Mait); Gray's Ferro-Concrete Contracting Co. per FC article | Hennebique | Y | | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 174 | FC vol. 4 no. 4 Oct. 1912, pp. 135-139; FC vol. 1 no. 5 Nov. 1909, pp. 105-107 | Hennebique Ferro-Concrete Theory and Practice (1909) p. 232 | RCAHMS - NMRS Number: NS56NE 2733 | | Info. in Glasgow City Archive (Mitchell GC f 914.1435 STR);Maitland Street bldg. 5 storeys per Cusack thesis, p. 533 | Y - interior and exterior; Canmore | N - Maitland Street bldg. demo'd. 1967 per Mitchell Lib. record | |
| 17 | Dalmarnock Power Station | | 1914 | Glasgow | | Glasgow Corp. Electricity Dept. | | W. W. Leckie | | Considère | | | C&CE vol. 15 no. 1 Jan 1920, p. 6-19 and vol. 15 no. 11 Nov. 1920, p. 725-7 (follow up art) | RCAHMS - NMRS Number: NS66SW 104 (Built in three stages: 1915, 1921, c.1935.) | | | | Y - Canmore | N - demo'd 1980-1981 per NMRS. | | |
| 18 | East Port Calender Works | East Port Calender Works; East Port Jute Works; East Port Works | 1913 | Dundee | (?)80-100 Canongate (100 Cowgate) | | | | | no system i.d.'d; precast blocks per MW | | r.c. frame | HS e-mail list - 1914 | RCAHMS - NMRS Number: NO43SW 86 | | | | Y (HB 24990) | | Y per MW | |
| 19 (see 41) | Engine House for Flour Mills | Herdman's Flour Mill; Haymarket Mills; John Herdman & Sons Ltd; Haymarket Flour Mills | 1908 | Edinburgh | Haymarket Terrace | Messrs. John Herdman & Sons, Ltd. | | | | Hennebique | | | MH List 1920, p. 34 (1908) | RCAHMS - NMRS Number: NT27SW 1715 | | | | | | N - demo'd | |
| 20 | Engineering Works | | 1917 | Broomielaw, Glasgow | | Messrs. Telford, Grier & MacKay, Ltd. | Miller & Black, FF.R.I.B.A. | | | Hennebique | | brick exterior walls | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 201 | MH List 1920, p. 28, 43 (1917) | | | | | Y - interior and exterior | N - demo'd per Thompson, p. 50 | |

| Item | Building Name | Alternate/Historic Name | Year Built | Location | Street Address | Client | Architect | Engineer or Consulting Engineer | Contractor | System | Whole Building? | Portion of Building? | Reference 1 | Reference 2 | Reference 3 | Reference 4 | Reference 5 | Listed? Y or N | Graphic? | Extant? | |
|------------|---|---|------------------|----------------------------|---|---|--|-----------------------------------|--|---|-----------------|---|---|--|--|--|--|---------------------------------|--|---|-----------|
| 21 | Engineering Works New Office and Workshop Buildings; also, roofing for engineering workshop (1915) | | 1914 | Glasgow | | Messrs. David Auld & Sons, Ltd. | Brand & Lithgow | L.G. Mouchel & Partners | Gray's Ferro-Concrete Contracting Company | Hennebique | | possibly brick infill wall panels | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 198-9 | MH List 1920, p. 41 (1914) | Thompson, p. 46 | | | | | Y - interior and exterior (F-C vol. 7 1915-16) | |
| 22 | Factory at Hillside | (?) Hillside Works, Hilltown | 1910 | Dundee | | T.L. Miller & Co. | Maclaren Sons & Soutar | | | Hennebique | | brick facade | MH List 1920, p. 37 (1910) | (?) RCAHMS - NMRS Number: NO43SW 690 | | | | | | | Y? per MW |
| 23 (see 9) | Flax Stores | Broadford Mills Flax Store (Broadford Firehose and Canvas Works) | 1912 | Aberdeen | Maberley Street | Messrs. Richards, Ltd. | Messrs. Wilson & Walker | | | BRC (& Hennebique) | Y | per RCAHMS - internal frame - floors, columns, roof =ferro-conc. (Henn.) | Applications of BRC (1917), p. 28 | RCAHMS - NMRS Number: NJ90NW 125.02 | | | | | Y - construction photo | Y - converted into 'Bastille' flats 1995 per NMRS | |
| 24 | Foundation for New City Hall, Caird Hall (1914); Superstructure (1915); Ferro-concrete skeleton & flooring, and Engine House (1918) | | 1914/15/18 | Dundee | | The Dundee City Council | James Thompson, FRIBA, City Architect | | | Hennebique | | | MH List 1920, p. 64 (1914/5/8) | (?) RCAHMS - NMRS Number: NO43SW 194 (would need to verify address and ck. file - architect and dates are a match) | | | | | | | Y |
| 25 | Glasgow Head Post Office (extensions) | | 1914-1916 | Glasgow | Ingram Street (btwn. S. Frederic and Hanover) | His Majesty's Office of Works | W.T. Oldrieve, F.R.I.B.A., Principal Architect in Scotland for H.M. Office of Works and C.J.W. Simpson | L.G. Mouchel Consulting Engineers | Perry & Co. (Bow) Ltd., London | Hennebique | | ferro-concrete skeleton b/f addition of the masonry curtain walls/masonry outer walls | MH List 1920, p. 25/26 (1913) | Thompson, pp. 61, 63 | Hennebique Ferro-Concrete Theory and Practice, 1921, p. 94-5 | FC vol. 5, no. 8 Feb. 1914, p. 328-336 | RCAHMS - NMRS Number: NS56NE 658 (Side blocks) | | Y - construction and int. photos | Y - converted to retail complex 2000 per RCAHMS. | |
| 26 | Grain Silos | Swanfield Roller Flour Mills silos | 1913 | Edinburgh | Bonnington Road, Leith, | Messrs. John Wilson & Co. (forming part of the Swanfield Flour Mills) | | L.G. Mouchel & Partners | Yorkshire Hennebique, Leeds | Hennebique | Y | | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 228 | FC vol. 4 no. 7 Jan. 1913, p. 242-3 | MH List 1920, p. 51 (1913) | RCAHMS - NMRS Number: NT27NE 903 | | Y - exterior; Canmore | N - demo'd in 1990s | | |
| 27 | Grain Silos | | 1913 | Leith | | A.R. Todd, Ltd. | | | | Hennebique | | | MH List 1920, p. 51 (1913) | | | | | | | | |
| 28 | Grand Stand at Scotstoun | | | Glasgow | | The Glasgow Agricultural Society | | Warren & Stuart, MM.Inst.C.E. | Gray's Ferro-Concrete Contracting Co., Pollokshaws | Hennebique | Y | all but roof | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 292 | FC vol. 4, no. 1, July 1912, p. 24-27 | MH List 1920, p. 61 (1911) | | | | Y - exterior | | |
| 29 | Heathall Uniroyal Factory; The Gates Rubber Co. | Lochthorn; Arrol-Johnson Motor Car Company; Arrol-Johnston Works; Arrol-Johnson Factory; Gates Factory, Main Road | 1915 (1909-1912) | Heathall, outside Dumfries | Edinburgh Road | | T.C. Pullinger, Arch. & Messrs. Kerr & Watson, Assoc. Archs. | | S. & T. Stevenson & Co., Glasgow | Trussed Concrete Steel Co. (Kahn bars + (plain round and square)) | | concrete frame, floors, roof; brick and glazed infill (mult. sys. appear to be in use - see building plans in Dumfries) | Dinardo & Ballinghall, 'Major Concrete repairs,' The Structural Engineer 17 May 1988, 66(10), pp. 151-160 | HS e-mail list - 1913 | C.&CE vol. 10 no. 9 Sept. 1915, pp. 433-440 | Thompson, p. 89 | RCAHMS - NMRS Number: NX97NE 159.00 and 159.01 | Y (HB 3819) | Y - MW photo (file photos RCAHMS?); Dinardo art. | Y | |
| 30 | Hillhead Picture Salon | Hillhead Salon Cinema | 1915 (1912-1913) | Glasgow | 17 Vinicombe Street/ Cranworth St. or Ln. | Picture Houses, Ltd. | Brand & Lithgow | | Gray's Ferro-Concrete Contracting Co. | Hennebique | | Ferro-conc. With exception of curtain walls | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 263 | FC vol. 6, no. 7 Jan. 1915, p. 261-264 | MH List 1920, p. 64 (1915) | RCAHMS - NMRS Number: NS56NE 841.00 | | Y - int.; ext. photo in Canmore | Y | | |
| 31 | Holburn St. School | | 1911 | Aberdeen | | The Aberdeen Education Board | J.A.O. Allan | | | Hennebique | | | MH List 1920, p. 59 (1911) | | | | | | | | |
| 32 | Insurance Office Building | Royal Insurance Company | 1910 | Aberdeen | (?) 208, 210 Union Street; (?) Huntly Street | The Royal Insurance Co. | G.B. Mitchell | | | Hennebique | | | MH List 1920, p. 23 (1910) | RCAHMS - NMRS Number: NJ90NW 488 | | | | | | | |

| Item | Building Name | Alternate/Historic Name | Year Built | Location | Street Address | Client | Architect | Engineer or Consulting Engineer | Contractor | System | Whole Building? | Portion of Building? | Reference 1 | Reference 2 | Reference 3 | Reference 4 | Reference 5 | Listed? Y or N | Graphic? | Extant? |
|-------------|--------------------------------|--|--|----------------------------------|--|---|---|---------------------------------|--|--------------|-----------------|---|--|--|---|---|---------------------------------------|----------------|------------------------------------|--------------------------------|
| 33 | Labour Homes | | c.1909 | Rosyth Naval Base, Inverkeithing | | Rosyth Naval Base Mansions, Ltd. | William Williamson, Kirkaldy | | Messrs. J. A. Mactaggart & Co, Glasgow | Hennebique | | with exception of outer walls | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 306 | FC 2(5), pp. 150-160 (1909) | MH List 1920, p. 66 (1910) | (?) RCAHMS (need to go through Rosyth Naval Base files) | | | Y - interior and exterior | |
| 34 | Linthouse Buildings | Holmfauld Road Linthouse Offices; Alexander Stephens and Sons; Linthouse Shipbuilding Yard | 1914 | Glasgow | 87, 91 Holmfauld Rd. | Messrs. Alex. Stephens & Sons, Ltd. | Mr. F. G. Orr | | Messrs. Melville, Dundas and Whitson | Considère | | r.c. frame, brick infill; 'the entire superstructure is of reinforced concrete' | HS e-mail list - 1914 | 87/154/MW/29 (MW file) | C&CE vol. 11 advert w/ pic; C&CE vol. 10 no. 8 August 1915, p. 389 memo. | RCAHMS - NMRS Number: NS56NW 35 | | Y (HB 33309) | Y - C&CE; Canmore | Y per MW |
| 35 | Lion Chambers | | 1904-7 (1906) | Glasgow | 170-172 Hope Street (and Bath Lane) | Mr. W.G. Black | Salmon, Son & Gillespie, FFRIBA | | Yorkshire Hennebique, Leeds | Hennebique | Y | | Hennebique Ferro-Concrete: Theory and Practice, 1921, p.112-3 | MH List 1920, p. 19 (1906) | Hennebique Ferro-Concrete: Theory and Practice (1909), p. 180/pix of interior | HS e-mail list - 1904-8 | RCAHMS - NMRS Number: NS56NE 67 | Y (HB 33059) | Y - interior and exterior; Canmore | Y |
| 36 | Mansion at Tillycorchie | Tillycorchie Mansion House ; Tillycorchie House | 1911-12 | nr. Udry, Aberdeenshire | | Mr. James Duncan | John Cameron, Aberdeen | L.G. Mouchel & Partners | James Scott & Son, Aberdeen | Hennebique | Y | with exception of roof per Cusack, p. 543 | MH List 1920, p. 66 (1912) ; Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 296 | HS e-mail list - 1912 | Historic Concrete series no. 92, p. 15 (have xerox) 'Concrete' vol. 16, no. 9 | RCAHMS - NMRS Number: NJ92SW 114.00-10 | FC vol. 4 no. 4 Oct. 1912 pp. 122-124 | Y (HB 50881) | Y - exterior | Y - converted 1980s per RCAHMS |
| 37 | Motor Garage | | garage floors and columns 1910; extension 1911 | Glasgow | Berkeley Street | Western Motors Co., Ltd. | | | Gray's Ferro-Concrete Contracting Co., Glasgow | Hennebique | appears so | | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 216 | MH List 1920, p. 47 | (?) RCAHMS - NS56NE 1176 or NS56NE 2840 (Wylie & Lochead - 2 garages on Berkeley St.) | | | | Y - interior | |
| 38 | Motor Works and Garage | | 1912 | Aberdeen | | T.C. Smith & Co. | John Cameron | | | Hennebique | | | Hennebique Ferro-Concrete: Theory and Practice, 1921 (1912), p. 214 | MH list 1920, p. 47 | | | | | Y - interior | |
| 39 | New Dye Works | Campbell's Dye Works; Perth Dye Works | 1919 | Perth | | Messrs. Campbell | Messrs. Smart & Stewart, Perth | | Messrs. Bain & Brown, Leith | Indented Bar | | Y 'said to be the first purely r.c. building in Perth.;' red brick infill panels (no pic) | C&CE vol. 15, no. 9 - Sept 1920 - built 1919 | RCAHMS - NMRS Number: NO12SW 355 - orig. bldg. destroyed by fire 1919 - is this replacement? | | | | (?) HB39526 | | |
| 40 | New Galleries | | | Glasgow | Sauchiehall Street & Renfrew Street | Corporation of Glasgow | A.B. Macdonald, M.Inst.C.E. | | | Considère | | | Considère System of R.C. Design 1912, p. 71 | | | | | | | |
| 41 (see 19) | New Grain Silos and Flour Mill | Herdman's, Herdman's Flour Mill; Haymarket Mills; John Herdman & Sons Ltd; Haymarket Flour Mills | 1906-8 (1907 per Henn. list) | Edinburgh | Haymarket Terrace (btwn. Murrayfield Rd. (to N) and rail line (to S); Haymkt. Goods Depot to the east) | Messrs. John Herdman & Sons, Ltd. | T.J. Gueritte (L.G. Mouchel & Partners) | | Robert Thorburn & Sons, Edinburgh | Hennebique | Y | | Hennebique Ferro-Concrete: Theory and Practice 1909, p. 209/photo and detail MH List 1920, p. 50 | Hennebique Ferro-Concrete: Theory and Practice 1921, p. 226 | RCAHMS - NMRS Number: NT27SW 1715 | Struct. Engr. 11(3) March 1933, pp. 106-115 | FC vol. 1 no. 4 Oct. 1909 pp. 76-81 | | Y - exterior; Canmore SC679435 | N |
| 42 | Office & Warehouse Building | | 1914-17 | Glasgow | West Nile Street - just N. of line of W. Regent on east side of W. Nile | Messrs. John Menzies and Co, Ltd.(booksellers and newsagents) | Brand & Lithgow | L.G. Mouchel & Partners | Gray's Ferro-Concrete Contracting Company | Hennebique | | ferro-concrete skeleton - 'stone facing for columns at front wall and white enamel brick covering back walls' | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 118 | FC vol. 6, no. 1 July 1914, p. 35 | 1914 + additional raft 1915 - per MH list 1920, p. 28 | | | | Y - exterior | |
| 43 | Office Building, 4 Floors | | 1906 | Edinburgh | | Gibson, Dalziel & Brodie, Ltd. | Peddle & Washington Brown, Architects | | | Hennebique | | | MH List 1920, p. 20 (1906) | | | | | | | |

| Item | Building Name | Alternate/Historic Name | Year Built | Location | Street Address | Client | Architect | Engineer or Consulting Engineer | Contractor | System | Whole Building? | Portion of Building? | Reference 1 | Reference 2 | Reference 3 | Reference 4 | Reference 5 | Listed? Y or N | Graphic? | Extant? | | |
|---------------|--|---|------------|----------------------|---|---|--|--|--|--------|-----------------|--|--|---|---|---|--------------------------------|----------------|----------|---------|--------------------------------|---|
| 44 (see 2) | Offices | Albion Motor Works | | Glasgow | (?) 1272 South Street, Scotstoun | Albion Motor Car Company, Ltd., Glasgow | A.M. Paterson, M.A., A.R.S.A., and Messrs. Brand & Lithgow | | | | | | Considère System of R.C. Design 1912, p. 70 | (?) RCAHMS - NMRS Number: NS56NW 83 | | | | | | | N per MW | |
| 45 | Offices at Germiston works | | 1917 | Glasgow | | Sir W. G. Armstrong, Whitworth & Co. Ltd. | J.T. Cackett & R. Burns Dick, FF.R.I.B.A. | | | | | | MH List 1920, p. 28 (1917) | (?) RCAHMS - NMRS Number: NS66SW 658 - Armstrong's Garage, 8 Davaar Street, Glasgow | | | | | | | Y - ext. in Canmore | |
| 46 | Paper Warehouse | | 1911 | Airdrie | | Messrs. Robert Craig & Sons, Ltd. | | Messrs. L.G. Mouchel & Partners, Glasgow | The Yorkshire Hennebique Contracting Co., Ltd. | | | | FC vol. 3 no. 2 Aug. 1911, p. 110 | MH List 1920 (1911) | | | | | | | | |
| 47 | Parkside Printing Works - Office and Paper Works | Nelson's Parkside Printing Works; Thomas Nelson; John Bartholomew's Works | 1906 | Edinburgh | Dalkeith Road (Parkside Terrace) | Thomas Nelson & Sons | Cousin, Ormiston & Taylor, FF.R.I.B.A. | | | | | | Hennebique Ferro-Concrete: Theory and Practice, 1909, p. 222 | MH List 1920, p. 20 (1906) | note: info. on Nelson & Sons at Scottish Studies Library L3 Fla. (2001) | Twelvetrees 1907, p. 390 paper stores, printing works | RCAHMS-NMRS Number: NT27SE 513 | | | | Y - interior; exterior Canmore | N - demo'd. (now Scottish Widows Head Office) |
| 48 | Pattern Shops and Store Buildings | | | Kilmarnock | | Messrs. Glenfield and Kennedy, Ltd. | James A. Morris | L.G. Mouchel & Partners | Mr. John Bertram, Strathaven | | | | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 196 | FC vol. 6, no. 7 Jan. 1915, p. 272 | | | | | | | Y - exterior only | N - demo'd. per Thompson, p. 41 |
| 49 | Pattern Shops and Stores | | 1914 | Govan | Copeland Road | Messrs. McKie and Baxter, Ltd. | George S. Armstrong | L.G. Mouchel & Partners | Gray's Ferro-Concrete Contracting Company | | | brick outer wall panels | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 195 | FC vol. 6 no. 2 Aug. 1914, pp. 70-72 | | | | | | | Y - interior and exterior | |
| 50 | Pattern Shops and Stores | | 1917 | Glasgow | | Sir W. G. Armstrong, Whitworth & Co. Ltd. | J.T. Cackett & R. Burns Dick, FF.R.I.B.A. | | | | | possibly brick infill wall panels | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 197 | MH List 1920, p. 43 (1917) | | | | | | | Y - interior and exterior | |
| 51 | Picture Salon | | 1913 | Glasgow | 90 Sauchiehall Street; Renfrew Lane to rear | Picture Salon, Ltd. | Thomas Baird, Jun., F.R.I.B.A. | | | | | Ferro-Concrete skeleton, ferro-conc. floor in auditorium, ferro-concrete balcony, roof of auditorium | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 260-2 | MH List 1920, p. 63 | | | | | | | Y - interior and exterior | N - demo'd. per DSA http://www.codexgeo.co.uk/dsa/building_full.php?id=L000357 |
| 52 | Port Dundas Distillery | | | Port Dundas, Glasgow | (?) 76 - 80 North Canal Bank Street | The Distillers Co., Ltd. | Messrs. F. Burnet and Boston, Glasgow | | Messrs. Melville, Dundas and Whitson | | | | C&CE vol. 10, no. 8 Aug. 1915, pp. 381-392 | RCAHMS - NMRS Number: NS56NE 1573 | | | | | | | Y - C&CE | |
| 53 | Power House and coal bunkers | Glebe Sugar Refinery | | Greenock | (?) Ker Street (Crawford Street; Patrick Street; West Blackhall Street) | The Glebe Sugar Refining Co., Ltd. | | Home-Morton, Ker & Gibson | | | | | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 202 | RCAHMS - NMRS Number: NS27NE 23 (relevant info. in file?) | | | | | | | Y - exterior | N per MW |

| Item | Building Name | Alternate/Historic Name | Year Built | Location | Street Address | Client | Architect | Engineer or Consulting Engineer | Contractor | System | Whole Building? | Portion of Building? | Reference 1 | Reference 2 | Reference 3 | Reference 4 | Reference 5 | Listed? Y or N | Graphic? | Extant? | |
|------|---|----------------------------------|---|---------------------|---|--|-----------------------|---|--|------------|----------------------------------|---|--|---|--|---------------------------------------|-----------------------------------|----------------|--|-------------------------------|---|
| 54 | Public Library | Carnegie Central Library | 1914 (additional staircase 1915) | Dunfermline | Abbot Street (St. Margaret Street) | The Dunfermline Burgh Council | James Shearer | | | Hennebique | | new portion added in 1913; ferro-concrete interior construction - foundation sills, columns, floors, staircases, arched roof of central hall (general reading room) | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 286-7 | MH List 1920, p. 63, 64 (1914/5) | RCAHMS - NMRS No: NT08NE 179 - World's 1st Carnegie Library (J C Walker, 1883); 'extension' (new building) by James Shearer, WWI delayed completion until 1922 | | | | Y - interior and exterior | Y | |
| 55 | East wing of Robert Gordon College | | Reconstruction of East wing 1912; addition 1913 | Aberdeen | | The Robert Gordon Technical College | J.A.O. Allan | | | Hennebique | | | MH List 1920, p. 59 (1912/3) | (?) RCAHMS - NMRS Number: NJ90NW 377.00 | | | | | | | |
| 56 | Riverside Mills Grain Silos | | 1913-15 | Glasgow | Shearer Street | Riverside Milling Co., Ltd. | | Home-Morton, Ker & Gibson, MM.Inst.C.E. | | Hennebique | Y | | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 232-3 | MH List 1920, p. 51 (1913 + additional work (1914) and cantilever roof addition (1915)) | RCAHMS - NMRS Number: NS56SE 1222 | | | | Y - interior and exterior; Canmore | N - demo'd. 1988 | |
| 57 | Rivet Storehouse at Whiteinch Shipbuilding Yard | | 1918 | Glasgow | | The Lloyd Royal Belge Co. Ltd. | | | | Hennebique | | | MH List 1920, p. 44 (1918) | | | | | | | | |
| 58 | Rope Factory | | 1912 (1911) | Rutherglen, Glasgow | 141 Farme Loan Road | Messrs. Todds, Ltd. (John Todd & Son) | | Wyllie & Blake, A.MM. Inst.C.E.; L.G. Mouchel & Partners Consulting Engineers | Gray's Ferro-Concrete Contracting Company | Hennebique | Y | | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 169 | FC vol. 3 no.10 April 1911, p. 312-313 (1911) | Thompson, p. 43 | | | | Y - interior and exterior | N per MW | |
| 59 | Royal Sick Children's Hospital | Royal Hospital For Sick Children | 1911-1916 | Yorkhill, Glasgow | Dalnair Street | | Sir John James Burnet | | | Hennebique | | | RCAHMS - NMRS Number: NS56NE 150 | | | | | | | N - demo'd 1965 -74 per NMRS. | |
| 60 | Sentinel Works | | 1903-4 (1905) | Polmadie, Glasgow | 61-89 Jessie Street | Messrs. Alley and Maclellan | | Archibald Leitch, Engineer; L.G. Mouchel & Partners, Consulting Engineer | | Hennebique | Y, plus fireproof room for plans | | Hennebique Ferro-Concrete: Theory and Practice, 1909, p. 217 | MH List 1920, p. 32 (1905) | HS e-mail list - 1903-4 | RCAHMS - NMRS Number: NS56SE 146 | | | Y (HB 33693) | Y - Canmore | Y |
| 61 | Shoe Factory and Warehouse | | 1910 | Glasgow | 111 Saracen St., Possilpark at Killearn St. W (128 feet to Saracen Street and 66 feet to Killearn Street) | Messrs. Greenlees & Sons, Glasgow (Easiephit Footwear) | | Wyllie & Blake, A.MM. Inst.C.E.; L.G. Mouchel & Partners Consulting Engineers | Gray's Ferro-Concrete Contracting Company | Hennebique | Y | | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 194 | FC vol. 3 no. 6 Dec. 1911, p. 174, p. 179-183 | 1910 from MH List 1920 | Thompson, p. 57 | RCAHMS - NMRS Number: NS56NE 2593 | | Y - interior and exterior; incl. Canmore | | |
| 62 | Stores | | 1914 | Burntisland | | John G. Cunningham | Wm. Williamson, FRIBA | | | Hennebique | | | MH List 1920, p. 27 (1914) | | | | | | | | |
| 63 | Stores at Port Dundas | | 1914-19 | Port Dundas | Bank Street | Townsend, Ltd. | G.M. Brand | details: Considère Construction Co. | Melville Dundas and Whitson (Thompson, p. 105) | Hennebique | | ferro-concrete skeleton with brick curtain walls (FC vol. 12 1920-21, p. 45) | FC vol. 12 1920-21, p. 45 | MH List 1920, p. 29 (1919) | Thompson, p. 52 | (?) RCAHMS - NMRS Number: NS56NE 1573 | | | (?) Canmore - see note at left | | |

| Item | Building Name | Alternate/Historic Name | Year Built | Location | Street Address | Client | Architect | Engineer or Consulting Engineer | Contractor | System | Whole Building? | Portion of Building? | Reference 1 | Reference 2 | Reference 3 | Reference 4 | Reference 5 | Listed? Y or N | Graphic? | Extant? |
|------|---------------------------------------|---|-----------------------------|--------------------|---|-----------------------------------|---|--|---|--|-----------------|--|--|---|----------------------------------|-----------------------------------|---|----------------|---|-----------------------------|
| 64 | Telephone Exchange | | (?)1910 | Tradeston, Glasgow | Cook Street | | Mr. Colin Menzies | | | Considère | | appears that facing in masonry | Considère System of R.C. Design 1912, p. 45 | DSA http://www.codexgeo.co.uk/dsa/building_full.php?id=M007876 | | | | (?) HB33060 | | Y per MW |
| 65 | Textile Factory | Woodside Bakery Ext. | 1921 | Hamilton | 24 Woodside Walk; (?) 24 Woodside Place | Messrs. Samuel Gilchrist Ltd. | Miller & Black, Glasgow | | | no system i.d.'d | | r.c frame, brick infill | HS e-mail list - 1921 | (?) RCHMS - NMRS Number: NS56NE 3330 | | | | Y (HB 34611) | | |
| 66 | Usher Hall | | 1910-14 | Edinburgh | Cambridge Street, Grindlay Street, Lothian Road | | Messrs. Stockdale Harrison and Sons, and Howard H. Thompson, FRIBA, Leicester | Messrs. F.A. Macdonald and Partners, Glasgow | | Considère - structural; Expamet - decorative - see rt. | | balconies; foundations ...; below-ground portions of the retaining walls; the internal pillars supporting drum wall and dome roof; Grand Tier gallery, the Upper Tier gallery; the floors, beams and lintels; the horizontal air ducts; and the roofs; Expamet lathing used for plasterwork in ceilings, wall coverings, circle fronts, etc. | HS e-mail list - 1910-14 | C&CE vol. 9 no. 5, pp. 295-306 'first designs ...Sept. 1910' | RCAHMS - NMRS Number: NT27SW 69 | | | Y (HB 27780) | Y - Canmore | Y |
| 67 | Victoria Malthouse | Kirkcaldy Malthouse | 1919 | Kirkcaldy | | Messrs. R. Hutchinson & Co., Ltd. | William Williamson, FRIBA | | | Hennebique | Y | outer walls of the malthouse brick; interior construction and upper part of kilns are ferro - concrete' | Hennebique Ferro-Concrete: Theory and Practice, 1921, p. 187 | FC vol. 3 no. 11 May 1912, p. 336-338 | MH List 1920, p. 45 | | | | | Y per MW |
| 68 | The Wallace-Scott Tailoring Institute | Wallace Scott And Co. Ltd. Tailoring Institute, Workshops; Cathcart Works; S.W. Electricity Board; Scottish Power Building; Cathcart House, Scottish Power Headquarters | 1914 | Cathcart, Glasgow | 42 Spean Street | | Messrs. John Burnet & Son, Glasgow for Forsyths | | | Considère | | ferro-concrete skeleton with brick panels p. 103 | C&CE vol. 9 no. 12, pp. 710-721 | Thompson, p. 95 = 'now offices for Electricity Board - altered' | RCAHMS - NMRS Number: NS56SE 179 | | | | Y - pix in C&CE; xerox of loc. map in Thompson | Y |
| 69 | Warehouse | | 1921 | Glasgow | Saracen Street, Possilpark | Panther Ltd. | Wylie & Blake | L.G. Mouchel & Partners | McBride & Gray | no system i.d.'d | | | Thompson, p. 54 | | | | | | Y - see xeroxes from Thompson | |
| 70 | William Park, motor car body builder | Park's Motor Works; Coachbuilder's Works; Arnold Clarke Ltd.; Ritchie St.; Francis St.; Motor Car Works | 1914 | Glasgow | 40-44 Kilbirnie Street | William Park & Sons | Richard Henderson, Glasgow | | Gray's Ferro-Concrete Contracting Company | Hennebique (HS says Truscon) | | | HS e-mail list - 1913 | FC vol. 3, no. 11 May 1912, p. 370 | Thompson, p. 84 | RCAHMS - NMRS Number: NS56SE 156 | | Y (HB 33515) | Y - Thompson xerox - poor qual.; ext. photo Canmore | N - demo'd |
| 71 | William Ramsay Technical Institute | Portobello Chocolate Factory | 1906 (design); 1907 [bldg.] | Edinburgh | Portobello Road, 90 - 102 Inchview Terrace | Messrs. Schulze & Co., Portobello | J & J Hall, Galashiels | | Stuart's Granolithic Co., Ltd. | E.P. Wells | | all r.c. except for external brick walls and some internal brick walls | HS e-mail list | Cusack | C&CE 2(6) Jan. 1908 pp.459-467 | RCAHMS - NMRS Number: NT27SE 5107 | note: info. available at Borders Regional Archives D30230 | | Y - C&CE; Canmore | Y - converted to flats 1995 |

The Statistical Framework

The total number of items on Historic Scotland's *Statutory List* at the time this research was carried out was 47,617. When 'reinforced concrete' was entered as a search term, 143 items came up. This number included civil engineering works, military structures, buildings partially constructed using reinforced concrete and a number of buildings outside of the date range under consideration (the majority of these post-1920). Of this number, only 11 buildings were identified either as reinforced concrete framed or fully reinforced concrete structures; however, not all of them were constructed using proprietary reinforced concrete systems.¹⁴⁴

Further searches of the *Statutory List* by building name or other keywords were required to find three more listed buildings constructed using concrete from 1903 through the early 1920s, bringing the total up to 14. Three historic building records, indicated by a (?) HB in Table 2, were possible matches for other buildings on the list. Finding a greater number of historic building records relevant to this study might be possible through additional keyword searches of the *Statutory List* or through cross-referencing building data with HB numbers catalogued in *The Dictionary of Scottish Architects* online.

As date of construction and dates of subsequent alterations are not individual fields in the *Statutory List* (this information is included in 'free text' fields), it was not possible to search for buildings within a date range to compare the number of listed

¹⁴⁴ Historic Scotland, *Historic Buildings Statutory List* (accessed 8 August 2007).

structures within that period to the overall number of listed reinforced concrete structures. A field for the engineer and/or construction system is also not included, which makes information regarding the buildings' significance appear to be biased toward architectural design rather than technological innovation. The situation is similar with the RCAHMS' Canmore database. These databases seem to be set up in line with historic attitudes toward this material and non-architect-designed buildings, although a number of the buildings involved the work of an architect.

CHAPTER 5: OPPORTUNITIES FOR FUTURE RESEARCH

First, this final chapter comments on the quality of this paper as a starting point for further research. Areas for future research are then outlined, including additional research and field survey work needed to prepare for a Scotland-wide building inventory. These include other avenues for research related to Scottish reinforced concrete buildings. The end of the chapter lays out conclusions and recommendations.

PHASED RESEARCH

As stated earlier in the discussion of Table 2 in Chapter 4, this work provides a pre-inventory of early reinforced concrete buildings in Scotland that includes guidance to sources of material for additional research. Although the listed sources in no way constitute an exhaustive bibliography, they give future researchers a wealth of material upon which to draw.

Phase I – Additional Research

A first phase of additional research would include revisiting the source material referenced in Table 2 to expand the table and to build up more detailed building descriptions. In addition, primary source material, including unpublished material, available at public and private archives, universities and Scottish local authority offices could be mined for architectural drawings and construction specifications, as well as further narrative source material. Unpublished material could prove a fruitful source of information, particularly since a number of the companies had multiple offices within Scotland.

Additional fields could be added to the table, including the grid reference, a legal description of the site boundaries (including bounding streets), and the site area (in square meters). Other information fields could include each building's original use, current use, current owner/occupier and contact information and details regarding accessibility.

Phase II – Inventory

Original construction dates for many of the buildings are already included in the table, but this information could be further broken down into design dates, completion date, alteration dates and a field that could include a description of the scope of alteration work. There also could be an area for discussion of the building's significance and importance in terms of historical or architectural context as defined by theme, period, and geographic scope.

This tabular information could then be linked to an individual file on each building, which might include further textual record (for example, a description of character-defining features) and a visual record, including a location map, scale drawings (where available) and photographs. Source, scale, date and other relevant information about each graphic should be included on the form and on the back of each hard-copy graphic included in the building file. The graphics and forms should also be kept up-to-date in digital format and linked to the table. Each form should also include the preparer's name and the dates it was prepared and updated. Updated language could be flagged within the free-text fields for tracking purposes. This phase could also involve importing the building location

data to a Geographic Information System, so that a Scotland-wide map and local area location maps could be generated.

Possibly the most important aspect of the thematic inventory would be the development of a context statement. The structure typology could be discussed within the Scottish context, the wider British context, within the extent of the former British Empire and internationally. This context statement could then be linked to information in each building file that addresses its integrity in terms of Historic Scotland's listing criteria:

- Association with nationally famous people, major historic developments or events;
- Context and setting;
- Technological or material innovation;
- Works of well known architects and patrons;
- Good examples within individual building types; and,
- Distinctive regional variations in design and use of materials.¹⁴⁵

Phase III – Post-Inventory

After completion of the building inventory, phone and e-mail communication could be used to identify any existing reports generated on the individual buildings, be they condition assessments, structural reports, or feasibility studies for proposed work. These documents would provide additional information on each building and could possibly provide leads to additional reference material. They would also be important in defining the possible value of the buildings for continued use and providing technical information that could be of assistance to the development

¹⁴⁵ Historic Scotland, *Guide to the Protection of Scotland's Listed Buildings: What Listing Means to the Owners and Occupier* (Edinburgh: Historic Scotland, 2006), 6-7.

community in preparing sensitive re-use proposals. Additional areas for research could include:

- The identification of testing and sampling work already completed on these buildings, and
- Identification of subjects for additional assessment and new sampling and testing.

This research could also generate:

- Further historic research regarding details of patents and their duration. This information could then be used to note changes in the systems over time and particularly at times when new or revised regulations took effect. Shifts in trends in overall system use at the expiration of an individual company's patent could also be examined.
- A sample library of material from buildings that have undergone repair, demolition or partial demolition. This is valuable as these buildings appear similar. An examiner often has to look at the profile of the reinforcing bar to identify the system used.
- Fodder for petrographic analysis to identify local variation of the concrete used within Scotland, including investigation into how the material holds up in different locations, and under different environmental and climatic conditions.
- Examination of regional differences in material, i.e. aggregates used.¹⁴⁶
- Comparison of this petrographic research with that done on buildings in other locations outside Scotland.

¹⁴⁶ Stirling, "Early Concrete," 3; Stewart Stirling. Pers. comm. 18 April 2007.

- A performance comparison of structures dating from the same year under different climatic conditions. For example, examination of Hennebique structures in two or more countries.¹⁴⁷
- The development of comparative case studies from the UK and abroad regarding conservation approaches and how successful they have been.
- Examination of parallels in conservation approaches toward reinforced concrete buildings and traditional mass material buildings in the UK and elsewhere.¹⁴⁸
- A firmer definition of the architectural typology of these buildings, including plans, details and finishes.
- Further study in changes in attitude toward reinforced concrete and how these impact its conservation.
- Historic concrete repair guidance documents for key heritage agencies such as Historic Scotland.
- A conservation strategy for proprietary reinforced concrete buildings within Scotland.

This research could also be expanded to include the non-monolithic systems mentioned briefly in Chapter 2. Early drafts of Table 2 contained 182 buildings, when some of the other system buildings were included.

¹⁴⁷ Stirling, "Early Concrete," 3; Stewart Stirling. Pers. comm. 18 April 2007.

¹⁴⁸ Stirling, "Early Concrete," 3; Stewart Stirling. Pers. comm. 18 April 2007.

CONCLUSIONS AND RECOMMENDATIONS

Reinforced concrete technologies from the 1850s up until the First World War were all proprietary, or patented, technologies. This paper focused on the 'monolithic' proprietary reinforced concrete systems, where a company's unique reinforcement was incorporated into building frames and structures of its own design, defined in Chapter 2. This study identified seventy-one Scottish buildings constructed between approximately 1900 and the 1920s using six of these proprietary systems. Twelve, and possibly as many as fifteen, of these were already listed. This was the first known attempt to identify all of the buildings of this type constructed in Scotland through review of books, company catalogues, journals and other documents.

The key to successful evaluation of documentation rests with its value in building understanding of the importance of the research subject, in this case proprietary reinforced concrete buildings in Scotland.¹⁴⁹ In conducting this pre-inventory, it was obvious that information available in existing official records is limited, creating a gap in the timeline for the development of reinforced concrete.

Although its importance may be questioned by some who consider it a 'modern' material, reinforced concrete is one of the most commonly used construction materials and reinforced concrete structures make up a substantial part of the built environment. 'This ... [has] happened despite[:] [initially] widespread institutionalised resistance ... to the adoption of [this] untried material', building

¹⁴⁹ Darvill et al, "A question of national importance": 398.

regulations that discouraged its use and 'engineering and architectural professions [that] were unsure of its value and possible applications.'¹⁵⁰

Negative attitudes toward reinforced concrete buildings persist, although the material provides a document of technological and material innovation in the 20th, and into the 21st, century. '[T]he development of reinforced-concrete design is one of the most interesting in civil engineering' and architectural history.¹⁵¹ However, due to their perception as 'common', reinforced concrete buildings as a type are little-studied and, therefore, their importance misunderstood. Although these attitudes appear to be changing, as evidenced by recent conservation initiatives on the Continent, in the United States and farther afield, they are not reflected by Scottish initiatives to list reinforced concrete buildings.

This problem is compounded by the fact that conservation of reinforced concrete structures is not a straightforward task, bringing into question the conservation tenets of authenticity and integrity. As pressure increases for their re-use, research will help to bridge the gap between negative attitudes toward these buildings and the need to conserve them. Notwithstanding, early reinforced concrete structures are worthy of research. The work in this paper is only a small step toward a comprehensive study of these structures in Scotland.

¹⁵⁰ Mike Chrimes, "Historic Material: Why reinforced concrete deserves an exhibition of its own ["Reinforced concrete: evolution or revolution?]," *The Architect's Journal* 9(204) (12 September 1996). Suppl. *Concrete Quarterly* 180 (Autumn 1996): 16.

¹⁵¹ Chrimes, "Historic Material": 16.

BIBLIOGRAPHY

- [Alex. Stephens/Linthouse] [Memoranda]. *Concrete and Constructional Engineering* 10(8) (Aug. 1915): 389.
- Armstrong, George S. "Fireproof Pattern Store for Messrs. McKie and Baxter, Govan." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 6(2) (Aug. 1914): 70-72.
- Australia ICOMOS. "The Australia ICOMOS Charter for the Conservation of Places of Cultural Significance (*The Burra Charter*)." ICOMOS.
<http://www.icomos.org/australia/burra.html>.
- Baird, Thomas. "Picture Salon: Glasgow: An Attractive Theatre in Ferro-Concrete." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 5(11) (May 1914): 415.
- Bartoss, P.J.M. *Results of Testing Carried out on Lion Chambers Samples*. (Paisley, University of Paisley Advanced Concrete and Masonry (ACM) Research Institute, 20 March 1998). [Available from: Glasgow City Council Listed Building File #574].
- Bell, Dorothy. *The Historic Scotland Guide to International Conservation Charters*. Edinburgh: Historic Scotland, 1997.
- Berger, John. *Ways of Seeing*. New York: Penguin Books, 1977.
- Borden, Iain and Katerina Rüedi Ray. *The Dissertation: An Architecture Student's Handbook*. 2nd ed. London: Elsevier, 2006.
- Bowley, Marian. *The British building industry: four studies in response and resistance to change*. Cambridge: Cambridge University Press, 1966.
- Bowley, Marian. *Innovations in Building Materials: An Economic Study*. London: Gerald Duckworth & Co., Ltd., 1960.
- Brand, George M. "Hillhead Picture Salon, Glasgow." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 6(7) (Jan. 1915): 261-264.
- British Reinforced Concrete Engineering Company. *Applications of the B.R.C. System of Reinforced Concrete Construction*. Manchester: British Reinforced Concrete Engineering Co., 1917.
- British Reinforced Concrete Engineering Company. *B.R.C. Reinforcements: the British Reinforced Concrete Engineering Company*. 8th ed. Stafford: British Reinforced Concrete Engineering Co., 1924.

- British Reinforced Concrete Engineering Company. *B.R.C. Reinforcements: the British Reinforced Concrete Engineering Company*. Stafford: British Reinforced Concrete Engineering Co., 1932.
- British Standard. *Guide to the Principles of the Conservation of Historic Buildings, BS7913*. London: British Standards Institution, 1998.
- "Broadford Works: Aberdeen. A Six-Storey Extension in Ferro-Concrete." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 4(4) (Oct. 1912): 118-121.
- Broomfield, John. "The Repair of Reinforced Concrete." 1996.
<http://www.buildingconservation.com/articles/concrete/concrete.htm>.
- Bussell, Michael N. "The era of proprietary reinforcing systems." *Proceedings of the Institute of Civil Engineers: Structures and Buildings* 116 (1996): 295-316.
- "Carpet Manufactory: Glasgow." [Templeton's Carpet Manufactory]. *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 5(4) (Oct. 1913): 149-152.
- Catt, Richard. "A preservation dilemma for the commercially-minded." *Property Week*, 18 May 1995, 29.
- "Characteristics of the Chief Systems of Reinforced Concrete applied to Buildings in Great Britain." *Concrete & Constructional Engineering* 2(6) (January 1908): 427-444.
- Chrimes, Mike. "Historic Material: Why reinforced concrete deserves an exhibition of its own." ["Reinforced concrete: evolution or revolution?"] *The Architect's Journal* 9(204) (12 September 1996). Suppl. *Concrete Quarterly* 180 (Autumn 1996): 16-17.
- [Chryston Epileptic Colony]. *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 5(4) (Oct. 1913): 153.
- Coignet, Edmund Limited. *Reinforced Concrete Constructions – Coignet System*. Westminster, London: Wightman & Co, Ltd, 1910.
- Collins, Peter. *Concrete: the vision of a new architecture. A study of Auguste Perret and his precursors*. London: Faber and Faber, 1959.
- Considère, Armand. *Experimental researches on reinforced concrete*. Translated by Leon S. Moisseiff. New York: McGraw, 1903.
- Considère, Armand. *Experimental researches on reinforced concrete*, by A. Considère. Translated by L. S. Moisseiff. 2nd ed. New York: McGraw-Hill, 1906.

- The Considère Construction Company, Ltd. *The Considère System of Reinforced Concrete Design (Considère Spiral Patents)*. London: The Considère Construction Company, Ltd.: 1912.
- "Considère System." [Advertisement including a photograph of A. Stephen [sic] offices]. *Concrete and Constructional Engineering* 11: xi.
- Council of Europe. "The Convention for the Protection of the Architectural Heritage of Europe (1985)." <http://conventions.coe.int/treaty/en/Treaties/Html/121.htm>.
- Council of Europe. "Recommendation No. R (95) 3 on Co-ordinating Documentation Methods and Systems Related to Historic Buildings and Monuments of the Architectural Heritage (1995)." <https://wcd.coe.int/ViewDoc.jsp?id=528215>.
- Council of Europe. "Resolution on the compilation of national inventories of monuments, groups of buildings and sites of historical or artistic interest (72/21) (1972)." [http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res\(72\)21.asp#TopOfPage](http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res(72)21.asp#TopOfPage).
- Council of Europe. "Resolution criteria and methods of cataloguing ancient buildings and historical or artistic sites (66/19) (1966)." [http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res\(66\)19.asp#TopOfPage](http://www.coe.int/t/e/cultural_co%2Doperation/heritage/resources/Res(66)19.asp#TopOfPage).
- Curtis, William J. R. *Modern architecture since 1900*. 2nd ed. Englewood Cliffs, New Jersey: Prentice-Hall, 1987.
- Cusack, Patricia. "Reinforced Concrete in Britain, 1897-1908." PhD thesis 32/2/6394, University of Edinburgh, 1982.
- Cusack, Patricia. "François Hennebique: the specialist organisation and the success of ferro-concrete: 1892-1909." *Transactions of the Newcomen Society* 56 (1984-1985): 71-86.
- Cusack, Patricia. "Lion Chambers: A Glasgow Experiment." *Architectural History* 28 (1985): 198-211.
- Cusack, Patricia. "Architects and the Reinforced Concrete Specialist in Britain 1905-1908." *Architectural History* 29 (1986): 183-196.
- Cusack, Patricia. "Agents of change: Hennebique, Mouchel and ferro-concrete in Britain 1897-1908." *Construction History: Journal of the Construction History Group* 3 (1987): 61-74.
- "Dalmarnock Power Station, Glasgow." *Concrete and Constructional Engineering* 15(11) (Nov. 1920): 725-727.

- Darvill, Timothy, Andrew Saunders, and Bill Startin. "A question of national importance: approaches to the evaluation of ancient monuments for the Monuments Protection Programme in England." *Antiquity* 61(231) (March 1987): 393-408.
- Day, Roy. "Ferro-Concrete: The Construction Industry enters the 20th Century." *Bristol Industrial Archaeological Society Journal* 13(1980): 26-30.
- deCourcy, John W. "The Emergence of Reinforced Concrete 1750-1910." *Structural Engineer* 65A(9) (September 1987): 315-322.
- Delhumeau, Gwenaël. "Hennebique and Building in Reinforced Concrete around 1900." *Rassegna* 49(1) (March 1992): 15-25.
- Department of Scientific and Industrial Research (Building Research Station) and S. B. Hamilton. *A Note on the History of Reinforced Concrete in Buildings, NBS (National Building Studies) Special Report No. 24*. London: Her Majesty's Stationary Office (HMSO), 1956.
- Desch, Cecil H. "The Electrolytic Corrosion of Steel Reinforcement." *Concrete and Constructional Engineering* 6(11) (Nov. 1911): 840-847.
- Devine, Tom M. *The Scottish Nation: 1700-2000*. London: Penguin Books, 1999.
- The Dictionary of Scottish Architects (DSA) 1840-1940 online*.
<http://www.codexgeo.co.uk/dsa/index.php>
- Dinardo, C. and J.R. Ballinghall. "Major concrete repairs and the restoration of factory structures – Uniroyal, Ltd., Dumfries, Scotland." *The Structural Engineer* 66(10) (17 May 1988): 151-160.
- "Early Use of Reinforced Concrete." *The Builders' Journal & Architectural Engineer Concrete & Steel Supplement* 23(20) (20 June 1906): 17-21.
- 11th ICOMOS General Assembly. "Principles for the Recording of Monuments, Groups of Buildings and Sites (1996)." ICOMOS.
http://www.international.icomos.org/charters/recording_e.htm.
- The Everyday Uses of Portland Cement*. 3rd ed. London: The Associated Portland Cement Manufacturers (1900) Ltd., 1913.
- Expanded Metal Company Ltd. *The Expamet handbook (pamphlet no.5): Expamet and kindred materials: production, properties & applications*. 3rd ed. London: The Company, 1935.
- "Extension of Eagle Buildings, Dundee." *Concrete and Constructional Engineering* 6(2) (Feb. 1911): 118-123.
- Feilden, Bernard M. *Conservation of Historic Buildings*. 3rd ed. Oxford: Elsevier, 2003.

- "Ferro-Concrete in Architecture." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 2(1) (July 1910): 2-7.
- "Ferro-Concrete in Scotland." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 2(5) (Nov. 1910): 150-152.
- "Ferro-Concrete Grain Silo Building - Edinburgh." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 1(4) (Oct. 1909): 76-81.
- "Ferro-Concrete Warehouse Constructed for Messrs. Greenlees and Sons, Glasgow." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 3(6) (Dec. 1911): 174, 179-183.
- "Fire at a Scottish Distillery and Means of Averting Similar Disasters (W. Bond Dundee)." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 3(2) (Aug. 1911): 59.
- "Fireproof Store: Kilmarnock." [Pattern Shop for Glenfield and Kennedy]. *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 6(7) (Jan. 1915): 272.
- Frampton, Kenneth. *Modern Architecture: A Critical History*. 3rd ed. London: Thames and Hudson, 2006.
- Friedman, Donald. *Historical Building Construction – Design, Materials and Technology*. London: Norton, 1995.
- Glasgow Building Preservation Trust. *Lion Chambers: Rediscovering a Lost Cause*. Glasgow: Glasgow Building Preservation Trust, 1999. [Available from: Glasgow City Council Listed Building File #574].
- Glasgow City Council Listed Building File #574: Lion Chambers [Accessed 30 January 2007, 11 April 2007].
- Glasgow City Council Listed Building File: Sentinel Works [Accessed 30 January 2007].
- [Glasgow General Post Office]. *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 5(8) (Feb. 1914): 328-336.
- "A Glasgow Warehouse Building for Messrs. John Menzies and Co. Ltd." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 6(1) (July 1914): 35.

- Government of Ireland. *Architectural Heritage Protection: Guidelines for Planning Authorities. Guidance on part IV of the Planning and Development Act 2000. Department of the Environment Planning Guidelines, no. 9.* Dublin: The Stationary Office, 2004.
- "Grand Stand: Glasgow – Built for the Glasgow Agricultural Society." [Scotstoun]. *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 4(1) (July 1912): 24-27.
- Gueritte, T. J. "Ferro-concrete construction" (Paper read at the Edinburgh Architectural Association 29 Nov. 1905). *Edinburgh Architectural Association Transactions* 5 (1905-6, publ. 1910): 16-23.
- Gueritte, T. J. "Reinforced concrete grain silos: a general and historical survey." [Herdman's Granary]. *The Structural Engineer* 11(3) (March 1933): 106-115.
- Hall, S.J. "Conservation of Early Reinforced Concrete Structures and the Dilemma of the Lion Chambers." MSc diss., Heriot-Watt University, 2004.
- Heaven, Frank H. "The Effect of Reinforced Concrete upon Architectural Design." [The Administration Building of G. & J. Weir Pump Manufacturers and Heathall Uniroyal Factory]. *Concrete and Constructional Engineering* 10(9) (Sept. 1915): 433-440.
- "Historic Concrete Number 92." [Tillycorthie]. *Concrete* 16(9) (Sept. 1982): 15.
- Historic Scotland. *Guide to the Protection of Scotland's Listed Buildings: What Listing Means to Owners and Occupier.* Edinburgh: Historic Scotland, 2006.
- Historic Scotland. *Historic Buildings Statutory List.* (Accessed 8 August 2007).
- Historic Scotland. "How do we list buildings?" <http://www.historic-scotland.gov.uk/index/historicbuildings/howarebuildingslisted.htm>.
- Historic Scotland. *Lion Chambers, 170 Hope Street, Glasgow: Report on Protective Installation.* Edinburgh: Historic Scotland Technical Conservation, Research and Education Group, 2000.
- Historic Scotland. "Listing: the identification of Scotland's special buildings. Scottish Historic Environment Policy (SHEP) on Listing, 27 March 2007." <http://www.historic-scotland.gov.uk/pastconsultations> and http://www.historic-scotland.gov.uk/sheps_listing.pdf
- Historic Scotland. "1998 Memorandum of Guidance on Listed Buildings and Conservation Areas." 29 April 1999. http://www.historic-cotland.gov.uk/memorandumofguidance_1998.pdf.

- Humm, Louisa. e-mail message to author [document attached to message "ICOMOS UK ISCARSAH Concrete and Iron & Steel Bibliographies"], 20 June 2007.
- Hurst, B. Lawrance. "Concrete and the structural use of cements in England before 1890." *Proceedings of the Institution of Civil Engineer: Structures and Buildings* 116 (1996): 283-294.
- ICOMOS. "International Charter for the Conservation and Restoration of Monuments and Sites (*The Venice Charter*) (1964)."
http://www.international.icomos.org/charters/venice_e.htm.
- ICOMOS 14th General Assembly. "ICOMOS Charter – Principles for the Analysis, Conservation and Structural Restoration of Architectural Heritage (2003)."
 ICOMOS. http://www.international.icomos.org/charters/structures_e.htm.
- Indented Bar and Concrete Engineering Company, Ltd. *Warehouses and Factories*. London, Westminster: Wightman and Company, n.d. c. 1920s.
- Indented Steel Bars for Reinforced Concrete Construction*. London: Patent Indented Steel Bar Company, Ltd., 1907.
- "Industrial Buildings in Glasgow for Messrs. John Buchanan and Bros. Ltd." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 4(4) (Oct. 1912): 135-139.
- "The Institution of Civil Engineers and Reinforced Concrete: Preliminary and Interim Report of the Committee on Reinforced Concrete." *Concrete & Constructional Engineering* 5(10) (Oct. 1910): 707-719.
- Jester, Thomas C., ed. *Twentieth-Century Building Materials: History and Conservation*. New York: McGraw-Hill, 1995.
- Jones, Bernard E., ed. *Cassell's Reinforced Concrete: A Complete Treatise on the Practice and Theory of Modern Construction in Concrete-Steel*. London: Cassell and Co, Ltd., 1913.
- Jukilehto, Jukka. "Conservation Ethics 'The Seven Lamps'." Lecture, Edinburgh, 24 March 199. Reprinted in reader for AC10 History and Theory of Conservation, Edinburgh College of Art, Fall 2006.
- Jukilehto, Jukka. *A History of Architectural Conservation*. London: Elsevier, 1999.
- Jull, S.P. and T.P. Lees. *Studies of historic concrete, EUR 12972EN*. Luxembourg: Commission of the European Communities Directorate-General Telecommunications, Information Industries and Innovation, 1990.

- Kahn, Moritz. "Reinforced Concrete and its Practical Application" (Paper read at the Edinburgh Architectural Association 12 Feb. 1908). *Edinburgh Architectural Association Transactions* 6 (1910): 65-79.
- Kahn, Moritz. "Reinforced Concrete, design, quantities and practice." *Concrete and Constructional Engineering* 4(4) (Sept. 1909): 276-278.
- Knight, John, ed. *The repair of historic buildings in Scotland: Advice on principles and methods*. Edinburgh: Historic Scotland, 1995.
- Lakeman, Albert. "Port Dundas Distillery." *Concrete and Constructional Engineering* 10(8) (Aug. 1915): 381-392.
- Lakeman, Albert. "The Wallace-Scott Tailoring Institute, Glasgow." *Concrete and Constructional Engineering* 9(12) (Dec. 1914): 710-721.
- Littlefield, David. "Grey matters." *Building Design* 1533 (17 May 2002): 16.
- Lonsdale, J. "An examination of historical concrete." BSc diss., Heriot-Watt University, 2002.
- Luebke, Chris. "On The Development of Structural Form".
http://darkwing.uoregon.edu/~struct/resources/essays/influences_on_choice_1.html.
- MacDonald, Calum. "Trust Launches £2M plan in bid to restore innovative concrete building." *The Herald*, 22 May 1995.
- Macdonald, Susan, ed. *Concrete: Building Pathology*. Cambridge: Blackwell Science, 2003.
- Macdonald, Susan, ed. *Modern Matters: Principles and Practice in Conserving Recent Architecture*. Shaftesbury: Donhead, 1996.
- Macdonald, Susan, ed. *Preserving post-war heritage: the care and conservation of mid-twentieth century architecture*. Shaftesbury: Donhead, 2001. Papers originally given at English Heritage's preserving post-war heritage conference, London, 1998.
- Mallinson, L.G. and I.L. Davies. *A historical examination of concrete*, EUR 10937EN. Luxembourg: Commission of the European Communities Directorate-General Telecommunications, Information Industries and Innovation, 1987.
- Marsh, Charles Fielding. *Reinforced Concrete*. London: Archibald Constable and Co., Ltd., 1904.
- Marsh, Charles F. and William Dunn. *Reinforced Concrete*. 3rd ed. London: Archibald Constable and Co., Ltd., 1909.

- Marsh, Charles F. and William Dunn. *Manual of Reinforced Concrete*. 4th ed. London: Archibald Constable and Co., Ltd., 1922.
- Marshall, James D. "Conservation and Repair of historic reinforced concrete buildings." BSc diss., Heriot-Watt University, 2001.
- McKean, Charles. "The way forward for urban concrete – a personal view." ["Urban Concrete - Is concrete's urban image irredeemably tarnished? How can we ensure it more than a supporting role in the future?"]. *The Architect's Journal* 9(204) (12 September 1996). Suppl. *Concrete Quarterly* 180 (Autumn 1996): 18-22.
- McLay Collier and Partners Consulting Civil and Structural Engineers. *Lion Chambers Condition Update Report*. 1998. [Available from: Glasgow City Council Listed Building File #574].
- Mouchel-Hennebique ferro-concrete. 4th ed. London: L. G. Mouchel & Partners Ltd., 1921.
- Mouchel-Hennebique Ferro-Concrete List of Works Executed in the United Kingdom: 1897-1919. London: L.G. Mouchel and Partners, Ltd., 1920.
- Mouchel, L.G. & Partners, Ltd. *Hennebique ferro-concrete: theory and practice: a handbook for engineers and architects*. London: L.G. Mouchel & Partners, Ltd., 1909.
- "New Dye Works, Perth." [Memoranda]. *Concrete and Constructional Engineering* 15(9) (Sept. 1920): 649.
- "New Office Building, Glasgow." [Memoranda] [A. Stephens offices]. *Concrete and Constructional Engineering* 11 (1907): 381.
- Newby, Frank, ed. *Early Reinforce Concrete - Studies in the History of Civil Engineering*. Aldershot: Ashgate Publishing, 2001.
- Newby, Frank. "The innovative use of concrete by engineers and architects." *Proceedings of the Institution of Civil Engineers: Structures and Buildings* 116 (1996): 264-282.
- "Paper Warehouse, Airdrie." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 3(2) (Aug. 1911): 110.
- Paxton, Roland and Jim Shipway. *Civil engineering heritage: Scotland - Highlands and Islands*. London: Thomas Telford, 2007.
- Paxton, Roland and Jim Shipway. *Civil engineering heritage: Scotland - Lowlands and Borders*. London: Thomas Telford, 2007.

- Payne, Alexander. "Concrete as a Building Material" (Paper read at the Royal Institute of British Architects 10 April 1876). *Transactions of the Institute of British Architects* (1875-76): 179-192.
- Planning (Listed Buildings and Conservation Areas) (Scotland) Act 1997*, section 74(1)(a).
- Potter, Thomas. *Concrete: Its Uses in Building from Foundations to Finish*. 3rd ed. London: B.T. Batsford, 1908.
- Powell, Christopher G. *The British building industry since 1800: an economic history*. 2nd ed. London: E. & F.N. Spon, 1996.
- Powter, Andrew. "History, Deterioration and Repair of Cement and Concrete in Nineteenth Century Fortifications Constructed by the Royal Engineers," *Bulletin of the Association for Preservation Technology* 10(3) (1978): 59-77.
- "Progress during a quarter of a century: A record of what has been done since the inception of the industry." *Concrete and Constructional Engineering* 21(1) (Jan. 1926): 111-149.
- Ravanel, Luciana and Maurice Culot. "Introduction." *Rassegna* 49(1) (March 1992): 5.
- "Reinforced Concrete and the Local Government Board." [Editorial notes]. *Concrete & Constructional Engineering* 11(4) (Sept. 1907): 257.
- "A Reinforced Concrete Factory in Portobello, Scotland." [William Ramsay Technical Institute]. *Concrete and Constructional Engineering* 2(6) (Jan. 1908): 459-467.
- "A Reinforced Concrete Factory in Scotland." [Memoranda]. [Albion Motor Car Co.]. *Concrete and Constructional Engineering* 15(5) (May 1920): 366-367.
- Richardson, Clive. "Dating buildings: concrete." *The Architect's Journal* (6 April 2000): 36-39.
- Robinson Low Francis. *Lion Chambers: Budget Cost Appraisal for Structural Repairs and Associated Works*. 1998. [Available from: Glasgow City Council Listed Building File #574].
- Royal Commission on the Historical Monuments of England (RCHME). *Inventories of Monuments and Historic Buildings in Europe*. Proceedings of a Colloquium Held in Oxford, England, 1988. London: Royal Commission on the Historical Monuments of England (RCHME), 1992.

- The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS). "About us: RCAHMS."
<http://www.rcahms.gov.uk/aboutrcahms.html> (updated 31 May, 2007).
- The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS) Canmore database.
http://www.rcahms.gov.uk/pls/portal/PORTAL.wwa_app_module.show?p_sessionid=483188&p_header=true
- The Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS). "Corporate Plan 2004-9 Annex – Survey & Recording Policy Revised April 2004." <http://www.rcahms.gov.uk/aboutrcahms.html>.
- "Ropery Building: Glasgow." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 3(10) (April 1911): 312-313.
- "Royal Institution, Edinburgh." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 2(5) (Nov. 1910): 202-209.
- Salmon, James. "The Decoration of Steel and Reinforced Concrete Structures." *The Builders' Journal and Architectural Engineer* (25 March 1908): 269-273.
- Salvadori, Mario. *Why Buildings Stand Up: The Strength of Architecture*. Paperback ed. New York: W.W. Norton & Co., 1990.
- Sampson, J. A. and E.S.C. Weiner. *The Oxford English Dictionary*. 2nd ed. Oxford: Clarendon Press, 1989.
- Scott, A. and Alban H. "The British Aluminium Company's works." [Kinlochleven]. *Concrete and Constructional Engineering* 5(8) (Aug. 1910): 585-589.
- Scottish Office – Planning and Building. "NPPG 18 Planning and the Historic Environment." <http://www.scotland.gov.uk/publications/1999/04/nppg18>.
- Serraillier, Lucien. "The Reinforced Concrete Specialist." *Concrete and Constructional Engineering* 7(2) (February 1912): 93-97.
- "Silo Granary at Leith." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 4(7) (Jan. 1913): 135-139.
- Simmonet, Cyrille. "The Origins of Reinforced Concrete." *Rassegna* 49(1) (March 1992): 6-14.

- Somerville, G. "Cement and concrete as materials: changes in properties, production and performance." *Proceedings of the Institution of Civil Engineers: Structures and Buildings* 116 (1996): 335-343.
- Souster, Ernest G. W. "Dalmarnock Power Station, Glasgow." *Concrete and Constructional Engineering* 15(1) (Jan. 1920): 6-19.
- "Spanish Villa: Tillycorthie. The First Ferro-Concrete Mansion in Great Britain." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 4(4) (Oct. 1912): 122-124.
- Stirling, Stewart. "Early Concrete Buildings in Scotland." PhD thesis 888, Heriot-Watt University, 2001.
- Stratton, Michael. "Industrial Monuments: A Protection Programme." *Industrial Archaeology Review* 13(1) (Autumn 1990): 35-49.
- "Stuart's Granolithic." [Advertisement]. *Edinburgh Architectural Association Transactions* 8 (1905-7): 66.
- Sutcliffe, George L. *Concrete: Its Nature and Uses*. London: Crosby, Lockwood and Son, 1893.
- Sutherland, James, Dawn Humm and Mike Chrimes, eds. *Historic Concrete: Background to Appraisal*. London: Thomas Telford, 2001.
- "Table of Contents." ICOMOS Joint International Scientific Committee Meeting, Illinois Institute of Technology Campus, Chicago, Illinois, 21-23 June 2007, 115.
- Thompson, George F. "Early Reinforced Concrete Frame Buildings in Glasgow, 1905-1921." B.Arch. diss., University of Strathclyde, 1976.
- Truscon: The first fifty years: A short history of the Trussed Concrete Steel Company Ltd. 1907-1957*. Stevenage: Bay Tree Press, April 1957.
- Twelvetrees, W. Noble. *Concrete and Reinforced Concrete*. London: Sir Isaac Pitman & Sons, Ltd., 1922.
- Twelvetrees, W. Noble. *Concrete-steel. A treatise on the theory and practice of reinforced concrete construction*. London: n.p., 1905.
- Twelvetrees, W. Noble. *Concrete-steel buildings. Being a companion volume to the treatise on "Concrete-steel"*. London: n.p., 1907.
- Twelvetrees, W. Noble. *Treatise on reinforced concrete: including the new standard notation of the Concrete Institute*. London: Sir Isaac Pitman and Sons, Ltd., 1920.

- UNESCO. "Convention Concerning the Protection of the World Cultural and Natural Heritage (1972)." <http://whc.unesco.org/archive/convention-en.pdf>.
- University of Chicago Press. *The Chicago Manual of Style*, 15th ed. Chicago: The University of Chicago Press, 2003.
- University of Chicago Press. *The Chicago Manual of Style Online*, 15th ed. <http://www.chicagomanualofstyle.org/home.html>
- "The Usher Hall of Music, Edinburgh." *Concrete and Constructional Engineering* 9(5) (1914): 295-306.
- Varios. "Micro-Histories of Reinforced Concrete." *Rassegna* 49(1) (March 1992): 44-57.
- "Victoria Malthouse: Kirkaldy." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 3(11) (May 1912): 336-338.
- Walker, Bruce, Christopher McGregor and Rebecca Little. *Earth Structures and Construction in Scotland: A Guide to the Recognition and Conservation of Earth Technology in Scottish Buildings, Technical Advice Note (TAN) 6*. Edinburgh: Historic Scotland, 1996.
- "A Warehouse of Reinforced Concrete in Dundee." [Watson's Bonded Whiskey Warehouse]. *Concrete and Constructional Engineering* 2(5) (Nov. 1907): 387-391.
- Watson, Mark. *File 87/154/MW/29*. n.d.
- Weaver, Martin F. *Conserving buildings: Guide to Techniques and Materials*. Revised ed. New York: John Wiley & Sons, 1997.
- Wikipedia, the online encyclopedia. <http://en.wikipedia.org/wiki/Gazetteer>. (page last modified 6 Sept. 2007).
- [William Park, Motor Car Builder]. *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 3(11) (May 1912): 370.
- Wright, Howard, ed. *Supporting the City: the influence of engineering on Glasgow's buildings*. Caithness: Whittles Publishing, 1999.
- Wyllie, James B. "Ferro-Concrete Warehouse, Glasgow." *Ferro Concrete: A Monthly Review of Concrete and Steel Construction in Engineering and Architectural Practice* 1(5) (Nov. 1909): 105-107.