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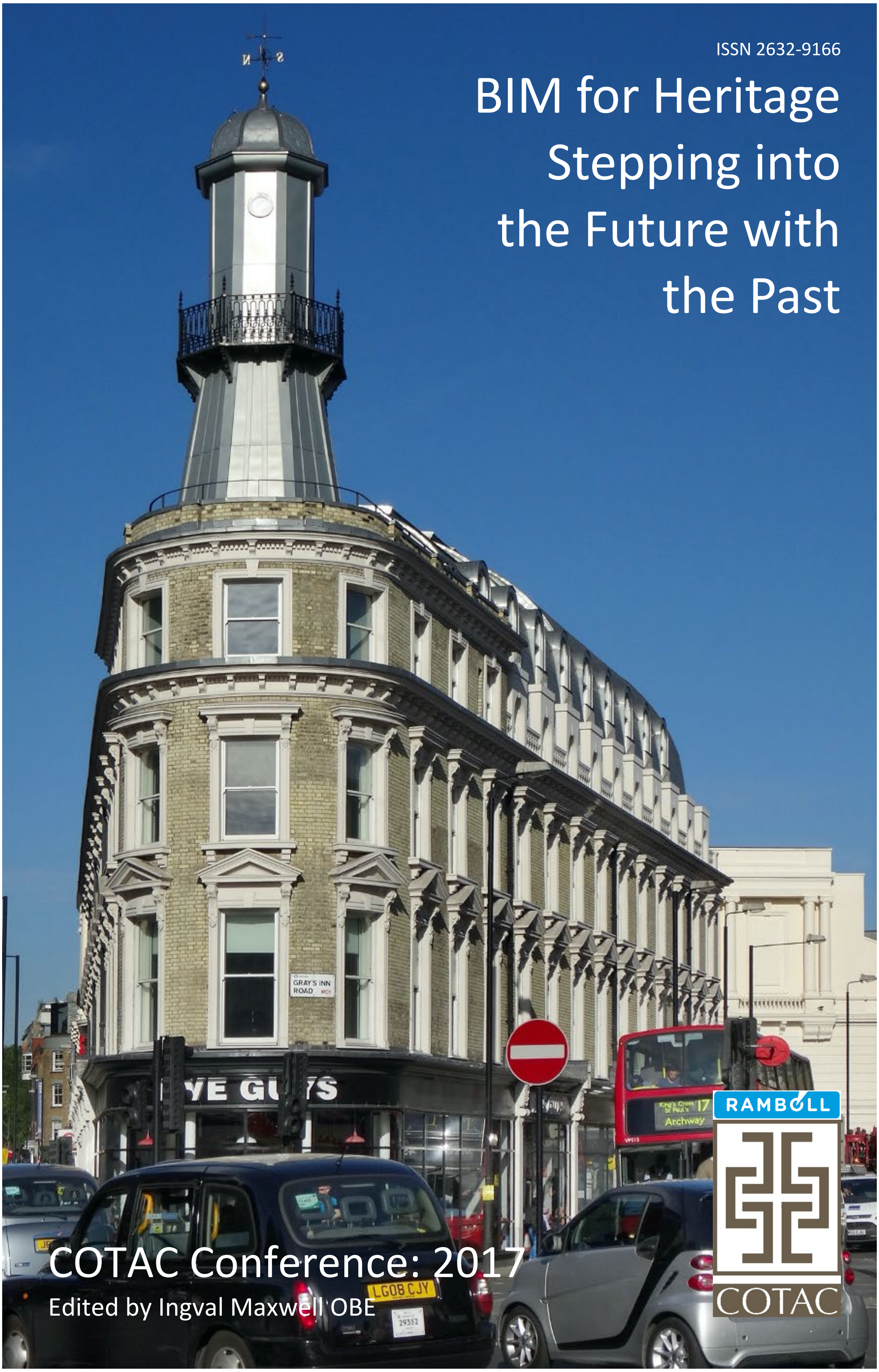
BIM for Heritage Stepping into the Future with the Past



COTAC Conference: 2017

Edited by Ingval Maxwell OBE

RAMBOLL

COTAC

BIM for Heritage: Stepping into the Future with the Past
A COTAC Conference in collaboration with Ramboll

Edited by Ingval Maxwell OBE DADun RIBA FRIAS CAABC ACA FSAScot

Acknowledgements:

This Report continues on the theme of the various presentations offered at the COTAC Conferences *"Improving Thermal Performance in Traditional Buildings"* in 2011*, "Past Caring? BIM and the Refurbishment of Older Buildings"* in 2012*; "A Digital Future for Traditional Buildings: Practical Applications for Survey and Management"* in 2013; *"Fire and Flood in the Built Environment: Keeping the Threat at Bay"* in 2014; and *"BIM4Heritage Where We are and Where We are Going"* in 2016, and published on-line by COTAC. These events collectively aimed to start scoping the relevance of BIM, and the issues that need to be considered, in the context of the traditionally constructed built environment. (See: http://www.cotac.global)

BIM is beginning to influence the conservation world through a more specific Historic Building Information Modelling (HBIM) approach. The event explored recent publications and emerging case studies to review the challenges and benefits offered in the greater uptake of knowledge transfer and related developments. As part of this on-going appraisal and assessment, Ramboll arranged and hosted this conference *'BIM for Heritage: Stepping into the Future with the Past"* in their 240 Blackfriars Road, London Offices, on 8 December 2017 in collaboration with COTAC. Thanks are due to Jez Foster, Director, Ramboll, and to his team, for taking the initiative and undertaking all administrative preparations to arrange and hold the event. Thanks are due to all speakers upon whose presentations this reports is founded.

COTAC, the 'Council on Training in Architectural Conservation'

COTAC, the 'Council on Training in Architectural Conservation', originated in 1959 as the 'Conference on Training in Architectural Conservation' in response to the need for training resources for practitioners so they could properly specify and oversee work involved in repairing and conserving historic buildings and churches. Since its inception COTAC has successfully, persistently and influentially worked to lift standards, develop training qualifications and build networks across the UK's conservation, repair and maintenance (CRM) sector, estimated at over 40% of all construction industry activities. This has involved working partnership with national agencies, professional and standard setting bodies, educational establishments and training interests.

Ramboll

Ramboll works across the areas of Buildings, Transport, Planning and Urban Design, Water, Environment and Health, Energy, Oil and Gas, and Management Consulting. Founded in Denmark in 1945, it is a leading engineering, design and consultancy company, employing 12,300 experts and has a strong presence in the Nordics, North America, the UK, Continental Europe, Middle East and India, supplemented by a significant representation in Asia, Australia, South America and Sub-Saharan Africa.

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2D to 4D - Oh! How we have changed: A COTAC Perspective

Ingval Maxwell OBE, Chair: Council on Training in Architectural Conservation

Background

If an underlying aspect of the BIM initiative is the offering of easy access to numerous building elements and details through the compilation of a BIM Objects Library it could be reasonably claimed that various 18th C pattern books and etchings emanating from the various Grand Tours, and the exhibits in the Great Exhibition of 1851 initiated its genesis. Following this 19th C display of the power of the Empire, numerous manufacturers' product catalogues followed. Similarly, the birth of stereoscopically recording buildings (and 'saucy' scenes) in 3D imagery can rightly be traced to the Victorian invention of photography and the private use of hand-held stereoscopic viewers.

Thereafter, resorting to scrutinising various editions of building construction manuals can readily plot the post-1919 changes from traditional solid wall construction, through hybrid forms and emerging technologies, to the loss of the architects' Arts and Crafts design approach that was only just still in place during the late 1950's and early 1960's. With a re-awakening awareness of the significance and value of the past also being recognised from 1960's, this faced stiff competition through compounding technology accelerating the growth in IT and its derivatives.

In consequence, the current 21st C construction industry actually operates in two almost equal halves, yet one half is generally not recognised, the other being commandeered by the new-build world - leaving the conservation, repair and maintenance (CRM) sector well behind, save a few lone voices calling out for its needs to be better understood too.

A COTAC perspective

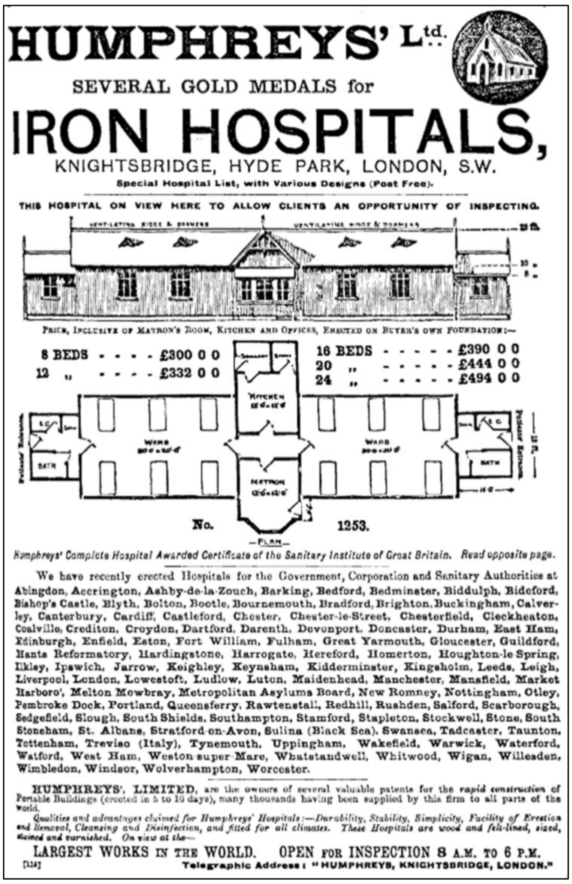
A visual interpretation of the built heritage has always been recognised for its educational value whether it be through etchings, paintings or measured drawings. At a technical level the dissemination of aesthetic and practical information was particularly relevant in consequence of the privileged few who embarked on European Grand Tours in the 18th and early 19th century, returning with edifying details of classical and historic architecture that was to be more generally sourced and influential once back home.

With the advent of photography in the mid-19th-century it wasn't long before the benefits of stereoscopic imagery would be made available to the masses. Although developed in the UK, it was to France where the lead was taken in promoting such innovative realistic views of building and sites beyond their reach for the edification of the personal viewer. A series of wooden handheld devices, locating stereoscopic pairs in front of magnifying glasses, offered such a revolutionary insight for many in their parlour. At the same time building technology remained fundamentally unchanged from earlier times, relying on understanding the power of gravity for structural stability.

The Rise of the Product Manufacturer

Until the early 18th century, and well-illustrated in numerous locations, winning the necessary traditional building materials was quite literally accessed from the immediate locality. But, this supply sourcing changed dramatically with the coming of the canal and railway networks thereby allowing ready access to material sources and markets from further afield as significant supply demand from the growth in urban developments gathered pace.

Accommodating this, constructional technologies that had remained fairly basic, labour intense and handcraft dominant had to adjust to changes in manufacturing as the increased availability of new materials were emerging.



As an example, the two 1895 adverts by Humphreys' Ltd of Knightsbridge, London (established 1834) illustrate the influence emerging on the introduction of corrugated iron as a ubiquitous building material. Their subsequent 1899 advert, stating to be manufacturers to H M Government, 2,000 Corporations, Town Councils, etc., asserts the erection of 12,000 *'Iron Churches, Chapels, Schools, Missions, Reading Rooms, Hospitals, Houses, Bungalows, Hunting Lodges, Stables, Coach Houses, Loose Boxes, Colonial Houses and Golf Pavilions'* in all part of the United Kingdom and abroad. Incorporated as a Limited Company in 1891 Humphrey's also had offices in Manchester, Dublin and Antwerp, with patents held in England, the Argentine Republic, India and elsewhere, with a proclaimed business connection in all parts of the world.

Initiated in 2007, Grace's Guide to British Industrial History is the leading on-line source of historical information on industry and manufacturing in Britain. The web site contains over 126,000 pages of information and almost 200,000 images on early companies, their products and the people who designed and built them. The website explains: *'Its aim is to provide a brief history of the companies, products and people who were instrumental in industry, commencing with the birth of the Industrial Revolution and continuing up to recent times. It provides an overview of topics and points other researchers to the source materials so they can* *find further information.*

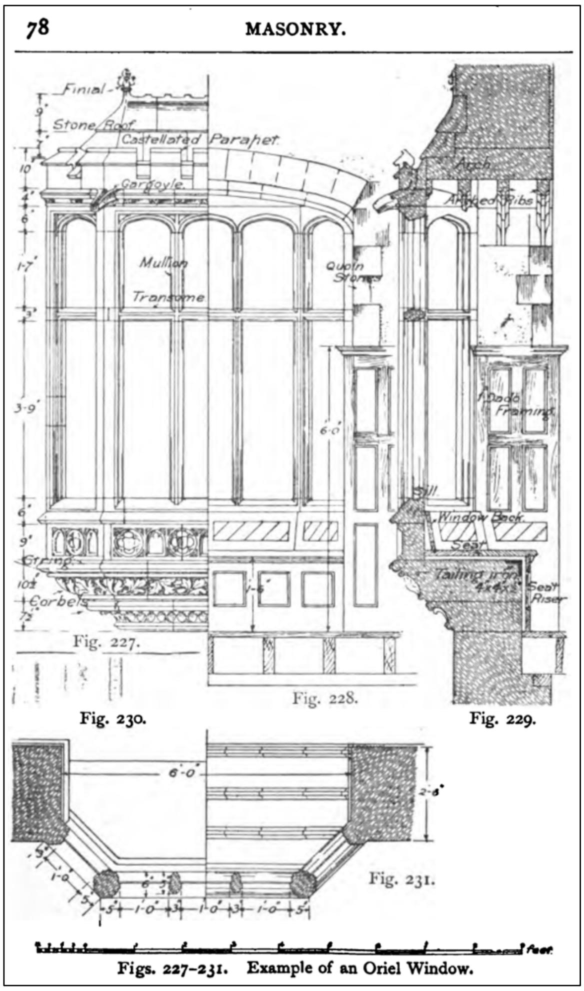
Contemporary manufacturers' catalogues also provide an insight to the changes in supplying the construction industry that were taking place by the end of the 19th century. With the first steel window being manufactured in 1884, the Crittall Manufacturing Co. catalogue of 1896, and subsequent editions, well illustrate the expanded range of pre-manufactured metal building products in *Casements; Sashes; Doors; Gates; Grills; Roofs; Skylights and Manhole covers*. Working in wrot-iron, steel and bronze, such catalogues could readily be described as a historic 'objects catalogue' not that dissimilar in intention to what BIM Object Libraries offer today.

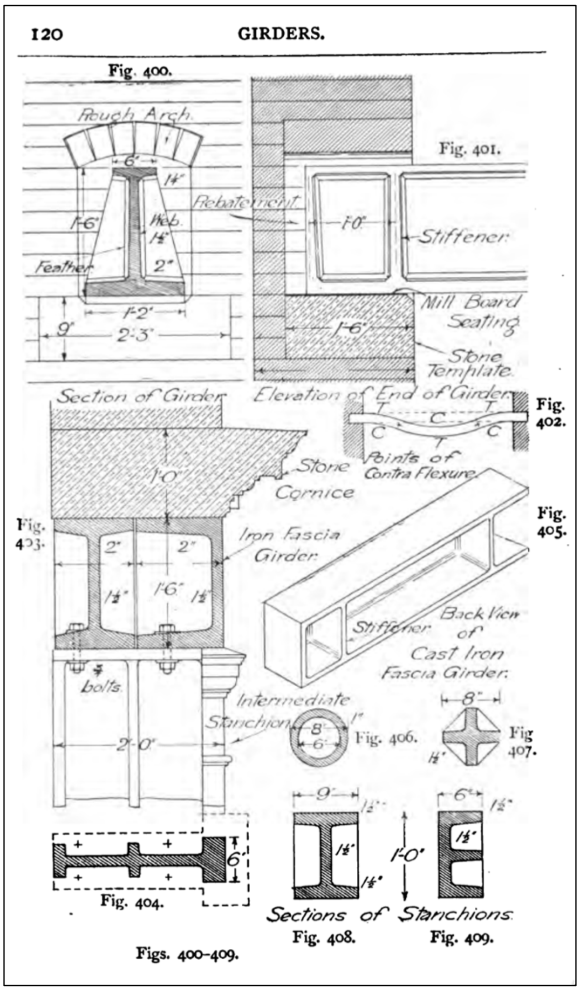
Specifically the Crittall Windows Ltd. 2007 short publication *"History Worth Repeating"* notes that from being established in 1849… *"Over the years, Crittall pioneered and standardized the window industry and became the dominant source of metal windows and doors internationally, with manufacturing facilities on five continents".* Highlighting a number of landmark buildings it notes *"A number of these buildings have since been refurbished with new Crittall product frequently matching the original sightline"* whilst reflecting on its 1879 Crittall Metal Casements Catalogue item that *"When first built, the Tower of London was equipped with metal windows. After 800 years of constant service these are now being replaced by CRITTALL, Metal Casements."* Change indeed. *

At the beginning of the 20th C the pace of the need for a revolution in how the country was to construct and maintain its buildings gathered momentum. This was to increasingly move away from traditional solid wall forms of building to become more innovative in how the increasing availability of new components, materials and evolving constructional technologies could be used.

Building Construction Handbooks and Guidance

In tracing subsequent developments and emerging influences, reference to a variety of building construction manuals and related volumes published from the late 19th C and throughout the 20th C is informative. In terms of what was being promoted as good practice and principles, they also offer a valid reflection and awareness on how the professions and industry reacted to emerging design influences, a growing number of available components, and new materials and skills. Currently available (2017) as a 'Print on Demand' version, Charles F Mitchell's original 1894 volume "*Building Construction and Drawing*" was subsequently published in various revised editions until the mid 1950's. The 1902 Sixth edition (available as a pdf download) with 1,000 illustrations was offered to assist pan-professional students preparing for the examinations '*…of the Board of Education, the Royal Institute of British Architects, the Surveyor's Institution, the City and Guilds, Civil Service and other examinations'.* As a relevant 'historic' document the 1902 edition also provides the base line of how the professions and industry were still operating with a detailed understanding of traditional solid wall construction (as shown in Figs 227-231 on page 78, as below). Although emerging guidance on how to incorporate cast iron and steel technologies was also offered (Figs 400-409, page 120), in this interim state it is interesting to reflect on Mitchells' perceived need to suggest a masonry-relieving arch (the so-named 'Rough Arch' in Fig 400) to spread the wall loading from being directly imposed on top of the cast Iron girder!



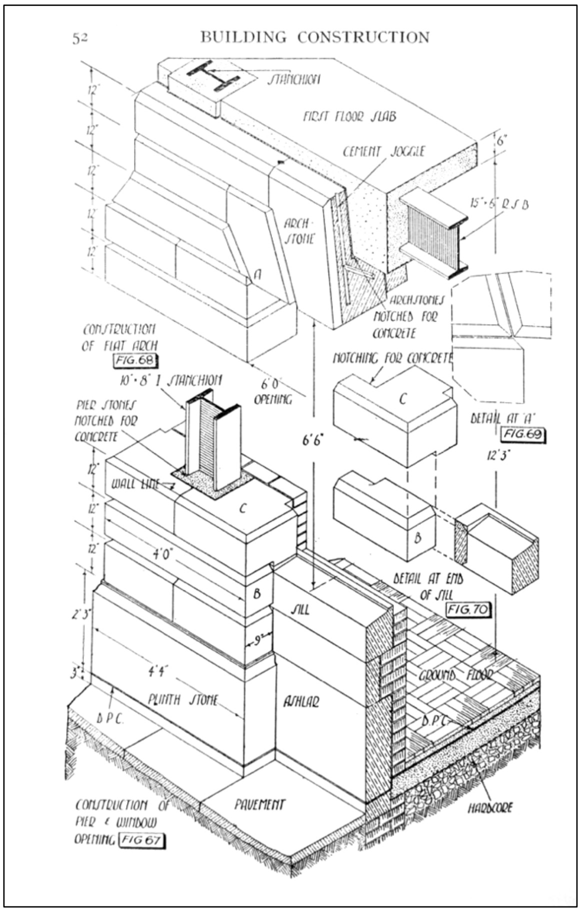


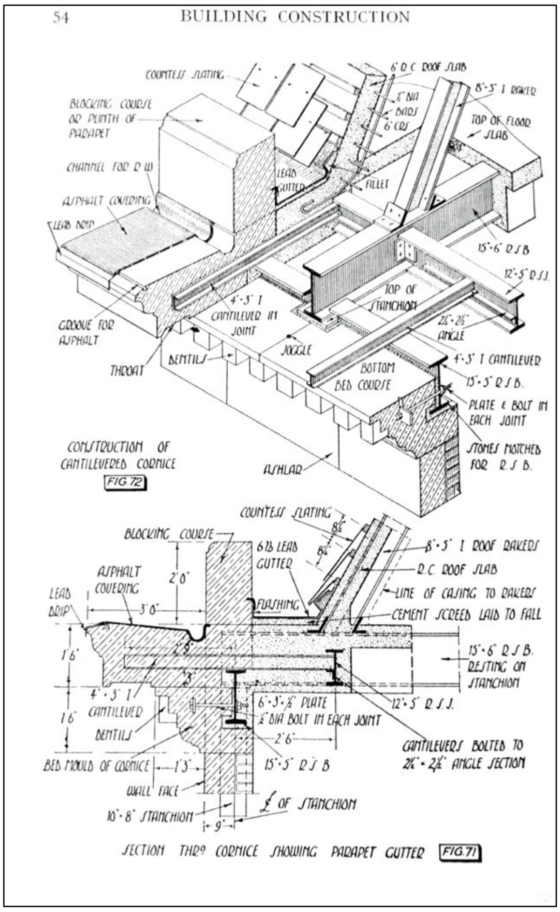
Charles F Mitchell: Example Masonry + Girders: pages 78 + 120: *Building Construction and Drawing* 1894

The 1902 Mitchell also helpfully includes Appendix copies of ‘turn of the century’ Course Syllabus and related *Building Construction Elementary Examination Papers.* These clearly reveal how much has gone out of fashion and receded from our knowledge base over the course of the 20th C. Yet, many buildings from this era can still be encountered as being in-use today, and it is suspected that should practitioners (including myself!) try to undertake the syllabus tests today, many would find them a significant challenge! The message here being that, from a BIM perspective, trying to gain a full understanding of how these buildings were previously constructed and detailed can be a daunting task.

But, a contemporary study of the book could be rewarding, and reference to the numerous end-piece lists of contemporary publications readily provides the basis for more detailed research into the titles given their value as a re-learning resource. Comparing the 1902 version with Mitchell’s revised and enlarged Eighth edition of 1915, the enhanced number of illustrations (at 1,100) offers a baseline of how the construction industry was developed through the early years of the 20th C. An understanding of stone and brick load-bearing construction was still the core need of the industries’ educational requirements and, with that, the skills of the roofer, joiner, carpenter and plasterer, and stone and wood carver. For areas of the country not well blessed with building stone, the later volume describes structural and decorative brickwork techniques: including brick on edge coursing; dental coursing formed by bricks laid at an angle of 45°; brick on edge coursing; plaster cornicing with brick and stone backing, and gaged brick cornicing - examples of which can still be readily found. Although the potential of load bearing cast-iron columns was well understood, the development of steel in construction was still marred by limited steel mill production technologies. Here the steel structural elements of the day were illustrated as being made from built-up simple rolled sections riveted together to form the necessary more complex structural forms - perhaps nowhere better revealed than in the railway architecture that still serves across the country today.

In 1939, E. G. Warlands, Head of the Department of Building and Architecture at Liverpool's City Technical College, published a volume entitled *"Building Construction for the National Certificate".* Here, in promoting the emerging elements of the 1930's International Style of modern architecture with its hybrid concrete encased steel framed and masonry-clad construction, the form can be explored in detail. But, the revealing cutaway drawings and cross sections provide a revealing insight into the new thinking of that time. Inevitably, and in consequence of the integrating mix of traditional building techniques and the of new forms of construction, many buildings of this period are now characteristically showing defects as a result of prolonged exposure and weathering.



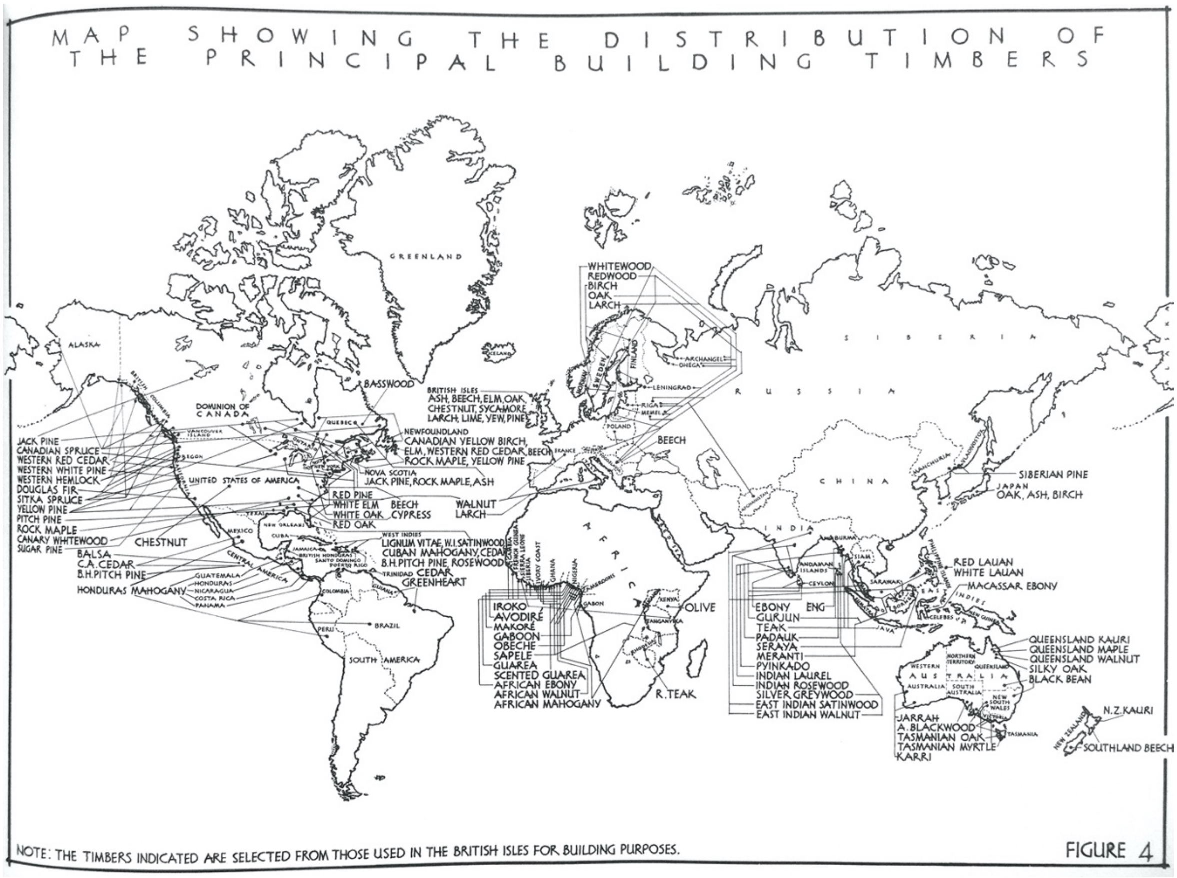


E.G. Warlands: Example pages 52 + 54 *Building Construction for the National Certificate.* 1939

The fundamental error was to ignore the reality that the applied façade masonry (sandstone and limestone in particular) could be a porous material. As a result the consequences of repeated rainwater penetration and evaporation, in repetitive wetting and drying cycles, were fully taken into account. In traditional solid wall construction this frequency is readily accommodated by the wall thickness. However, where masonry façade blocks were routered out to wrap around structural steel elements in the 1930's form of hybrid construction, penetrating rainwater can readily extend through the reduced thickness cover into the structural steel zone.

As a result, present day evidence shows that corrosion and rust expansion of the steel work has occurred, especially where the original infill concrete or cement grout pour, intended to fill remaining voids and encase the steelwork, was less effective in doing so. Over the intervening years associated localised fracturing and physical disruption of façade masonry has emerged in consequence of rust expansion pressures whilst, with exploratory investigations, affected structural steel members can also be found to be significantly corroded. Easily explained with hindsight, this problem was potentially foreseeable, but was unconsidered at the time of promoting 'best practice'. Although this issue and the consequences of its failure are deliberated upon more fully in the 2000 publication: *"TAN20 – Corrosion in Masonry Clad Early 20th Century Steel Framed Buildings"* there are general lessons to be learnt in the need to fully appreciate and understand all aspect of building construction, irrespective of age.

The 1942 volume *"Architectural Building Construction – a textbook for the architectural and building student"* by Walter R. Jaggard and Frances E. Drury was also produced in various editions. But, perhaps un-surprisingly, the learning emphasis returns to how domestic architecture should be built. Fully acknowledging the need, this wartime book was published as considerable destruction of the existing housing stock was occurring across the country.



W. B. Mackay: Example page Figure 4: *Building Comnstruction*

Such a domestic orientated trend continued in W. B. Mackay's three volumes of *"Building Construction"* that were vogue in the 1950's – 1960's. Mackay also provides an insight into the international standing of the UK's building industry material supply routes that subsequently waned dramatically. In addition to illustrating in microscopic detail the structure of wood, the volumes included a world map showing the distribution of the supply sources of the principal species of timber used in the British Isles for building purposes. Illustrating a diverse range, sources emanate from Scandinavia, North and South America, Western Africa, India, Indonesia, Australia and New Zealand. Clearly having been used in the construction of many of the existing mid 20th C building stock, from a BIM perspective, this diversity of species and locations compounds the needs of modern-day information gathering and understanding if such structures are to be fully understood.

Although, in the mid 20th C construction industry, times were changing, by noting the key quarries for sourcing limestone, magnesium limestone, granites and sandstones, Mackay also includes a map on the distribution of indigenous building stones in Great Britain and Ireland. Whilst the map also carries a qualification that it does not include the many quarries producing stone for road paving, course aggregates and locally used building stone, it does offer an indication of where the main concentrations of stone production lay at the time - notably in the North-east and Central belt of Scotland, around the Solway, the Midlands, and on a significant run extending across England from the Wash to Land's End. To offer the student an awareness as to what stone is, MacKay's' diagrams address the various geological structures and indicate how stone was prepared, finished and tooled by hand, in addition to illustrating masonry production machines operating at the time.

With hindsight, a telling 'note' that the map 'does not include locally sourced building stones' significantly underplays the historic situation. In Scotland, for instance, it is now recognised that some 12,000 building stone quarries probably operated across the face of the country over the centuries. Mackay's reference to only 10 sources illustrates the scale of this discrepancy, and highlights the need for professionals to be perceptive in analysing what stone might have been used in each individual building when they have to consider matching any 'like-for-like' masonry work or repairs. A similar situation also exists in the other home countries.

A Hankering Back to Arts and Crafts

Between 1953 and 1971 the contents of the 14 volume series of *"Architects Working Details",* published by the Architectural Press, could be interpreted as an indication that architects of the time were still able to pursue an Arts and Crafts ideal of designing bespoke individual pieces of architectural detail and structure.

Illustrated by photograph and clearly annotated individual technical drawing details, the series promoted the adoption of many new building materials and techniques that were beginning to appear in the supply chain and marketplace. The ready adoption of profiled aluminium, asbestos panels, building paper interfacing between internal and external conditions, along with exemplars such as specifically designed work benches, signs, and clocks were published to inspire a new generation of architectural educational cohorts and practices.

Whilst, in specific projects this approach can still be relevant today, encountering each bespoke item (or object) created during that time adds to the diversity of what could be encountered in the range of issues that a BIM initiative might chance upon – more so if the asset, in turn, has achieved a formal recognition of its heritage value by being listed. The Working Details series therefore highlights a further complexity in understanding the unfolding developments from the mid to later 20^{th} C era.

The Emergence of Conservation Awareness
But, things were also about to change in another direction. In the 1960's greater attention was being paid to the existing built heritage, as public opinion started challenging what was, frequently brutally, happening to that heritage.

Following the Council of Europe's initiative in declaring 1975 European Architectural Year, considerable European efforts were made to make the public more aware of the irreplaceable cultural, social and economic values that were represented by historic monuments, groups of old buildings and other interesting urban and rural sites. As a significant early leader in promoting the practical care of this heritage, the 1978 publication of the *"The Care and Conservation of Georgian Houses Maintenance Manual*" was enlightening and quickly became a model for others to follow.

Emanated from the work of the Edinburgh New Town Conservation Committee, and still regarded as the authority on the detail of Georgian houses today, it ably illustrated that a recognition was dawning that the construction industry was, perhaps, operating in two parts: That of the new build sector and that of how to better look after the existing building stock.

Moray Place, Edinburgh: Georgian development 1835 © Ingval Maxwell

Whilst the volume offered explicit isometric cutaway drawings of Georgian buildings it went much further into their detail by exploring how chimneys were constructed, what chimney pots were used, the design and detail of dormers, the variation found in door fanlights, and the specific ironmongery that was used, including locks, letter plates and house numbers.

Dowanhill, Glasgow: Victorian Development: Mid 19th C © Ingval Maxwell

With a growing movement looking afresh and what challenges needed to be faced in the 1970-80 period, a "*Tenement Handbook"* was produced in 1992 in consequence of analysing the problems and issues surrounding Victorian tenemental Glasgow. This guide offered practical advice to living in a tenement, included direction on *"how to get organised, keeping the rain out, getting the most from your factors, what are the common and private repairs, keeping the close clean and secure, living with your neighbours, how the tenement was built and bother with the buildings and how to get a grant".* Again, a series of explicit detailed cutaway isometric drawings and cross sections were particularly revealing in offering an understanding of such a genre.

In the 1980's, is awareness of the breadth of built heritage grew, the Royal Commission on Ancient and Historical Monuments of Scotland produced a volume entitled *"Monuments of Industry".* In this, examples drawn from across the country were well illustrated by plans, sections, photographs and explicit isometric projections of how the industrial processes were performed. A particular emphasis was placed on machinery although details of fireproof floor construction in the Atlantic and Pacific Mills in Paisley, Renfrewshire do have a resonance with the information produced by Mitchell in the early 1910's.

In 1996 ICOMOS produced its *"Principles for the Recording of monuments, groups of buildings and sites*", sets out the reasons why such recording was essential. Inevitably this coincided with the period where a variety of innovative new surveying and other technologies and techniques were gaining ground.

From the advent of CAD in the 1970's, what might be referred to as a period of compounding technology accelerating IT growth has, over the past 40 years, created significant changes in how the industry has developed: laser scanning, cloud computing, parametricism, 3D printing, algorithmic modelling, and interoperateability are all moving towards what some industry forward-thinkers project as a paperless construction business in the not too distant future.

Computer aided automatic milling of sandstone, illustrated in two stages © Ingval Maxwell

The essence of time - the fourth dimension - is determining change. Along the way the industry is catching up. Relatively recently in various stone yards, for instance, computer driven stone saws are left to run overnight to rough out the shapes of masonry mouldings for hand finishing. But, that approach too, in more up-to-date times is over, as the sensitivity, accuracy and quality of controlled milling machines capable of producing remarkably effective architectural sculptural details in stonework is now a reality.

Add to that the automatic processing of survey details from laser scans, aided by a variety of improvements such as the walk-through scanning of small architectural spaces, and the advent of unmanned aerial vehicles, and robotics has pushed the boundaries and accuracies of surveying technologies considerably forward over the last decade. All this, of course, is being achieved more economically than hand surveying or hand craftwork and provides a considerably different base upon which more detailed considerations and actions are applied. In addition, advances in 3D printing of architectural elements and, indeed, entire buildings also coming on the marketplace, as are robotic bricklaying, wall rendering, and the 'printing' of blockwork roads and pavements.

An increasing variety of new devices and technologies have the potential of bringing economic benefits, but at the same time, creating challenges for practitioners to keep pace with the changes, and from a BIM perspective how to future-proof emerging results and effect adequate record keeping. Despite the idealism of a adopting a BIM approach, immediate concerns such as how to deal with new data protection legislation, liability matters and consequences have not yet been tested in detail.

But, with regard to obtaining a fuller understanding of the physical properties and needs of the existing heritage building stock, the increasing use of smart phone imagery that emulates and expands on the Victorian stereoscopic takes the economics of such an approach to remarkably low levels. And so, with developments over time, might the wearing of virtual reality goggles become commonplace in the industry to visually see a disaggregation of what is has been built in a manner that also reveals its problems and informs solutions. The question remains unanswered as to whether or not within the existing built heritage can be explored effectively through such a virtual reality approach to reach a sufficient level where the viewer can virtually disaggregate its construction to offer a full understanding of the needs of what we are currently in temporary charge of. The future is challenging but potentially it offers considerable benefits is properly considered.

Historic England BIM for Heritage Guidance

Paul G. Bryan BSc, Historic England

Historic Building Information Modelling (BIM) is, by definition, a multi-disciplinary process that requires the input and collaboration of professionals with very different skillsets. It is also a fast-developing field in terms of research, official guidance, standards and professional practice. To help address the issues surrounding the production and use of BIM for historic buildings Historic England, the public body that looks after England's historic environment, has recently published their first technical guidance document on BIM. Entitled "BIM for Heritage: Developing a Historic Building Information Model" this presentation will consider the development and scope of this document and how by combining guidance and information on the heritage application of BIM with a series of case studies that demonstrate its real-world application, it aims to offer guidance on BIM for building owners, end-users, heritage and construction professionals.

I first heard about BIM whilst attending the Association for Preservation Technology (APT) November 2009 conference in Los Angeles USA. The event included a special session on:

- "*Capturing the Past for Future Use: Integrating Documentation with Repair, Design and Construction Practice in Historic Buildings*"
- Included a variety of historic building related presentations that referred to BIM - a new term that I hadn't heard before!
- In January 2013 I established English Heritage's BIM Special Interest Group (BIMSIG) BIMSIG aimed to: *Assess the relevance and potential adoption of BIM across English Heritage's own estate of more than 400 historic properties*
- Chaired by me this comprised representatives from a variety of teams across the organisation including Estates; Heritage Protection and Planning; Archaeology and Architecture; Remote Sensing; Conservation and Science Coordination and Archive
- Linked to the National Heritage Science & English Heritage Science Strategies - important development for EH and HE

Facilitating the development of research within heritage and heritage science contexts a number of current research projects are underway:

The application of Building Information Modelling (BIM) within a heritage science context

The overall finding of this project is that BIM within a heritage context is likely to be more complex than for New-Build as it nearly always involves measurement to establish any kind of model, the coordination of different types of legacy information and the organisation of often unique objects.

Heritage BIM: New ways of digital data management for the historic built environment

The aim of the project is to investigate how a widely-used IT system for the centralised storage and dissemination of information about a building (Building Information Modelling) can be applied to existing, and specifically historic, built environments

Building Information Models from monitoring and simulation data in heritage buildings

Aims to develop a new Building Information Modelling (BIM) paradigm that supports the management and future-proofing of the built heritage. Research will focus on exploring the integration of types of information that are relevant for heritage science, and which are not part of current BIM practice.

Contribute to the development of technical guidance by EH and HE "BIM for Heritage Developing a Historic Building Information Model" *Offers guidance on BIM for building owners, end-users, heritage and construction professionals and the potential advantages a BIM approach now offers across heritage projects.*

What BIM is and isn't

BIM is a collaborative process for the production and management of structured electronic information and illustrating, in digital terms, all the elements that compose a building

BIM isn't a specific software package or a type of 3D digital model; simply a newer version of 3D CAD or a 3D visualisation too or new technology

Its origins are in object-based parametric (rule-based) modelling applications for mechanical systems design in 1980's, BIM has been in use for the last 20 years in the architectural, engineering and construction (AEC) industry, Now widely applied in the UK and internationally, mainly in the new-build sector (building and infrastructure)

How BIM works

BIM (specifically Historic BIM) consists of:

- *Geometry (2D and 3D) – typically generated from data captured by laser scanning, photogrammetry (ground-based or mounted on a drone), lidar, closer range scanning, mobile mapping or a combination of methods*
- *Non-geometric information – refers to physical building characteristics such as materials, appearance & condition*
- *Linked documents and data - includes archival data, product specifications, operation and maintenance (O&M) manuals, reports, condition surveys, audio and video recordings documenting visitor experience, inspection logs or other digital file types*

- A 'BIM-ready' 3D model formed as an assembly of native BIM components which represents the geometry of the existing fabric
- Often the result of Scan-to-BIM - the process of creating, manipulating and placing BIM components by directly referencing the underlying point cloud
- Scan-to-BIM workflows depend on BIM software ability to import point clouds
- Modelling tolerance refers to how accurately a model fits against the as-existing survey, usually a point cloud
- Level of detail (LOD) is used to describe how much geometric detail is included in the derived BIM components
- 15 Historic England Metric Survey Specifications for Cultural Heritage
- Construction Industry Council (CIC) BIM Protocol - *an important document that provides the legal framework which will facilitate and promote the use of BIM*

Managing BIM Data

- BIM and collaborative working processes offer considerable benefits for construction and asset management, with similar potential for heritage sector
- Successful implementation, especially in large or complex projects, based on:
  - A robust IT infrastructure – *software for producing, managing, exchanging, using and archiving information*
  - Well-thought-out workflows governed by standards and protocols - *there are currently no BIM standards specifically developed for the heritage sector*
  - A sustainable strategy for long-term data management

Commissioning BIM

- Asking for 'BIM' or 'full BIM' on a project is simply not enough without further defining what that requirement involves
- Knowing what you want - clear vision of what you're using BIM for is the first and fundamental step when commissioning it
- Within standard BIM approach client requirements take the form of the EIR (Employers Information Requirement)

- For Historic BIM the BEP (BIM Execution Plan) outlines selected survey acquisition approach and use of existing legacy data
- BIM specifications can help clients define their requirements for the procurement of BIM-ready datasets

Are you required to procure/deliver a project using BIM: points to consider on deciding?

Currently the UK government mandate for BIM Level 2 adoption applies to all centrally procured public projects regardless of value

- *How could you benefit from adopting BIM on a heritage project?*

BIM can be a valuable tool for historic asset management and offers a robust information management framework that can be highly beneficial for heritage research and analysis

- *Who will be responsible for maintaining the Asset Information Model (AIM)?*

Imperative it is maintained, checked and updated to reflect changes in physical asset

- *Do you always need a 3D geometric model?*

3D enables better understanding of spaces and components that constitute an historic building 2D is appropriate for linking documents and data within small or less complex site

- *Can you do this yourself?*

Delivering a project using BIM tools and processes, especially involving complex or significant historic assets, can be a daunting prospect. In the heritage sector adoption of BIM and collaborative working requires organisations and individuals to embrace change and accept traditional roles and practices may need to be adapted to successfully deliver BIM projects. Clients must pay close attention to tolerances and LOD when undertaking scanning and model development. It is highly important to make BIM relevant to the heritage sector, from small projects to large; in other words, heritage won't change to accommodate BIM. Being fit for purpose is of utmost importance: at times, 2D is sufficient.

Hybrid Modelling in the BIM Process

Carl Brookes, Ramboll

Using case studies of modest complexity, the presentation will look at the process of combining existing asset information captured through point clouds with proposed alterations using new-build BIM methodologies. The process is increasingly described as hybrid, and tends to focus BIM on interfaces between old and new. In recent projects data captured using laser scanners and digital photogrammetry is being used to provide BIM environments of historic assets: in particular, processes where data and models have then been used for subsequent conservation and engineering activities and lessons are being learnt.

In New Build BIM – The information delivery cycle:

- Benefits of the new-build process are being recognised
- Challenges influencing uptake may relate to Capex investment expected yet Opex receives greatest benefits

- Handover of Project Information Model (PIM) becomes the Asset Information Model (AIM)

On existing heritage sites:
- Benefits of BIM are less clear
- There is no handover Asset Information Model (AIM)
- Existing information is likely to be a combination of forms, reports, sketches, 2D CAD etc.
- Asset database in use, for instance Tribal K2
- Some sort of spatial framework/model will need to be produced

3D model and drawing production have different processes and drivers
- Drawings, orthogonal projections
- 3D Pont cloud
- Scaled 2D drawings
- Point cloud RGB
- 3D geometry model

Towards automation
Using a mixture of propriety software, in-house data processing software and a dedicated server to organise massive data sets associated with point clouds we generate object based 3D models for AutoDesk Revit and other BIM related systems of the existing environment. Graphical fidelity is specified using a system of Level of Detail (LoD) developed by Ramboll specifically for representing existing assets. LoD also relates to appropriate survey technology, point cloud densities and type of process used for BIM. Many aspects of this work can now be automated and this trend is developing fast.
- Automated extraction of walls and services for an existing building for use within BIM
- Automated extraction of plant within an industrial facility

Typical project point cloud used as a feed to BIM
- Generated with VRMesh

Point cloud to revit model
- Existing environment scanned, modelled, and new equipment designed and accurately fitted.
- Reduces risk of expensive snags during construction

Point cloud applications within hybrid CAD is a better process relevant to BIM for heritage
- Use of hybrid environment to avoid modelling

New and traditional measurement rapidly growing data acquisition methods

The following table offers a classification of survey techniques and processes, listing:
Generally mass data collection
  - Point clouds
  - Direct or processed

Classes based on

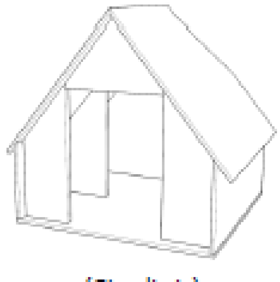
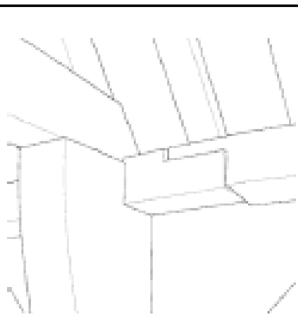
- Range and point cloud density
- Typical cost (low, medium high)

Potential application use

Class	Process (example equipment)	Range [m] (typical point cloud density [mm])	Typical Cost	Potential Uses
L0	Laser measuring (1D) device (Leica DISTO D1)	0.2 – 30 (≤3 discrete measurements)	Low	Sketches and 2D drawings (typically plan only)
L1	Ground based photogrammetry	1 – 20	Low	Facades, impressions of surface features/sculptures, simple building forms
L2	UAV based photogrammetry	5 – 50	Low	3D site topography, roofs, building footprints/layouts
L3	Low resolution, medium range handheld laser scanners (GeoSLAM Zeb-Revo)	2 – 30 (≤10)	Low	3D building interior layout, close range externals
M1	3D Topographical survey	2 – 200	Medium	3D site topography, ground level services, building footprints/layouts, floorplans
M2	High resolution, close range handheld laser scanners (Faro FreeStyle)	0.1 – 2 (≤1)	Medium	Small scale, local details where high detail is needed
M3	Static tripod supported laser scanners (Z+F Imager 5016)	2 – 150 (≤5)	Medium	3D site topography, complex building forms,
M4	Long range static tripod supported laser scanners (Riegl VZ-6000)	100 – 6000 (≤100)	Medium	Terrain, landscape, archaeology, geological monitoring
M5	UAV based LIDAR	5 – 200 (≤20)	Medium	Terrain, 3D site topography, complex building forms, roofs, site services (powerlines etc), penetration of vegetation
H1	Aerial LIDAR	500 – 4000 (≤50)	High	Terrain, 3D landscape topography, land usage, archaeology, penetration of vegetation

Establishing relevant Level of Detail (LoD) requirements (Harmondsworth Barn example)

- LoD could be based on:
    - Potential uses
    - Model tolerance
    - Listing grade
- Once LoD is established survey class provides options for measurement and data acquisition methods
- Higher LoDs have object based geometry modelling
- Similar tables produced for 2D information, archive drawings, sketches, 2D CAD
- Simple viewers are important too for desktop inspection

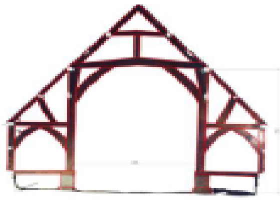
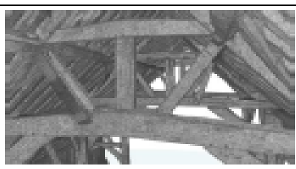
LoD	Description	Visual example (model tolerance)	Survey Class (listing grade)	Potential Uses
1	A simplified representation of the overall size and arrangement Includes walls and floors/ceilings No doors or windows Modelled as single or multiple objects Information/data potentially tagged to locations and/or simple objects	 (Simplistic)	L1 L2 L3 (any)	Simplest way of providing spatial context to building/site Linking Asset management data using information tagged to locations
2	Primary features are represented in a simplified form Window and door openings Most objects modelled as correct category wherever possible Most objects modelled as individual forms of approx. correct size, shape and location Information/data can be attached to each part	 (low)	L1 L2 L3 M1 M3 (any)	Site orientation and single coordinate system for positioning Geometry complete enough to plan conservation projects Asset management data added to representative individual objects
3	Most building features are represented using illustrative family types or modelled-in-place elements of correct type where possible Windows and doors as families/components in the style of the actual objects	 (medium)	L2 L3 M1 M3 (II*,I)	Site orientation and single coordinate system for positioning Geometry complete enough to plan in detail conservation projects Asset management data added to representative individual objects Accurate Visualisation Clash detection
4	As many features as possible represented as realistically as possible Potentially using custom built families Walls potentially showing inclined and/or bowed profile Beams and columns showing actual shape (i.e. loaded shape) Connection details to be included	 (high)	M2 M3 M5 (I)	As LoD 3 but geometry modelling detailed enough to fabricate, fit and manufacture repairs/restoration of parts Geometry models good enough for 3D printing technology

Hybrid Environments

It is often impossible, within reasonable effort, to represent existing assets with new-building BIM tools. Demonstrated a system where a user can utilise a web browser to view various model data sets, making the data highly accessible and manipuable

QR codes can be placed directly on drawings, allowing a user to scan and be taken straight to the model data in a web browser

- Hybrid methods allow a host of benefits, including being a cheaper and easier way to achieve project aims, these typically consist of keeping the laser scan point-cloud in its native format, and adding the new elements with software packages such as Revit
- By not needing to convert the point-cloud into elements, time and cost can be saved
- Can use multiple surveys over time to monitor movement and other changes to buildings over time
- Explained some pitfalls of being careless when developing a model
- Need to understand the internal forces, which can't always be 'seen', if ignored, the unexpected can happen
- Don't copy and paste elements in an existing building: although elements can look the same to the human eye, there could be differences which need to be accounted for

LoD	Description	Visual example (drawing/model tolerance)	Survey Class (listing)	Potential Uses
H 0c	Orthographic point cloud projections/elevations with/without CAD outlines	 (medium)	L3 M3 (any)	A rapid way of producing correctly proportioned and scalable drawings with surface detail Produced by a prescribed volume of the 3D point cloud in 2D drawing space More information than LoD 0c and an alternative to LoD 2
H 1	Avoids the effort required for even simple modelling. Ideal for tagging information to spatial locations	 (medium)	L3 M3 (any)	Linking Asset management data using information tagged to locations (red objects in example) within the point cloud Similar uses to LoD 1
H 3	Avoids the considerable effort required to CAD and create 3D objects of existing asset Includes LoD 3 for new conservation work (new tie beam added in the example) Information/data potentially tagged to locations and/or simple objects	 (medium)	L3 M3 (any)	Provides all the uses of LoD 3 for new conservation projects Existing detail and usage is LoD H 1
HM 3	Automatic meshing of point cloud to varying densities Includes LoD 3 for newly added elements as H 3. Information/data potentially tagged to locations and/or simple objects	 (medium)	L3 M3 (any)	Provides all the uses of LoD 3 for new added elements Existing detail and usage is LoD H 1 Good viewing options
HM 4	Automatic very fine meshing of point cloud to varying densities Includes LoD 4 for newly added elements. Information/data potentially tagged to locations and/or localised detailed objects	 (high)	L1 M2 M3 (any)	Provides all the uses of LoD 4 for new added elements. Extremely high level of detail allows surface detail to be represented including carving, markings, texture and structure, erosion Good viewing options

Level of detail – hybrid environments (Harmondsworth barn example: above)

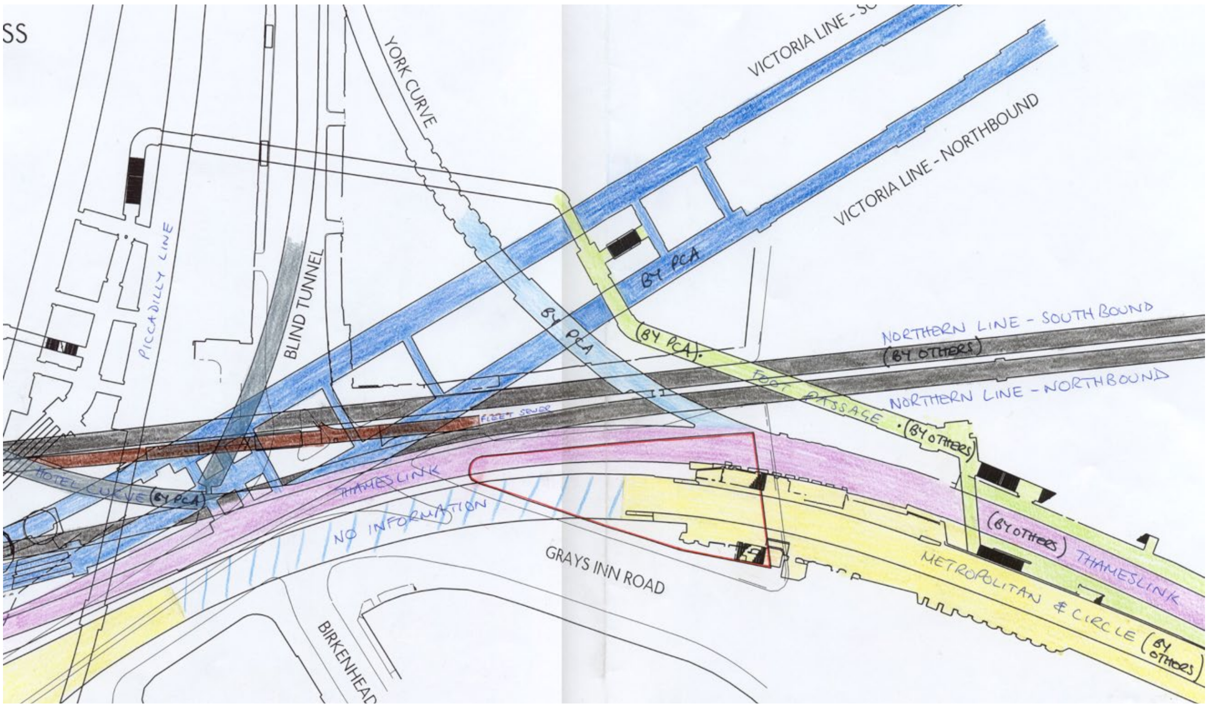
As before, LoD based on: Potential uses; Model tolerance; Listing grade - Once LoD is established survey class provides options for measurement and data acquisition methods. Big advantage – no object based geometry modelling of existing fabric. Spatial framework for tagging information (links)

LoD H1 example point clouds with links to supporting material
L3 - Low resolution, medium range handheld laser scanners: Shows proposed new beam/tie

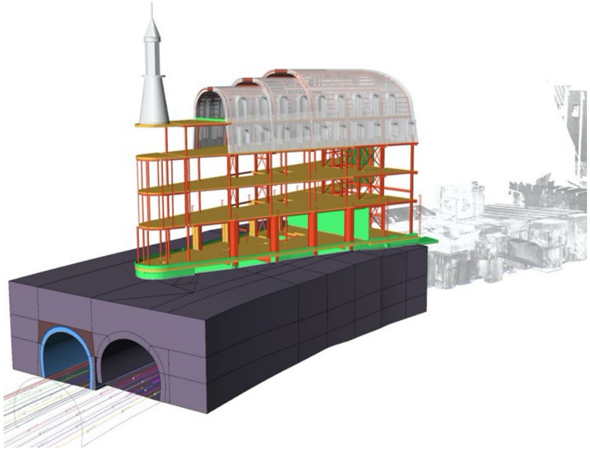
Comparing datasets: time dependant data is important
Useful to track major changes: Missing parts and new additions. Image compares laser point clouds from 2013 pre-conservation with 2015 post-conservation. Monitoring small changes: Condition monitoring: Software: Pointools V8i, CloudCompare, in-house post-processing software. Image compares point clouds from 2013 pre-conservation photogrammetry with 2015 post-conservation

Kings Cross, The Lighthouse Building: BIM contributed to unlocking the project

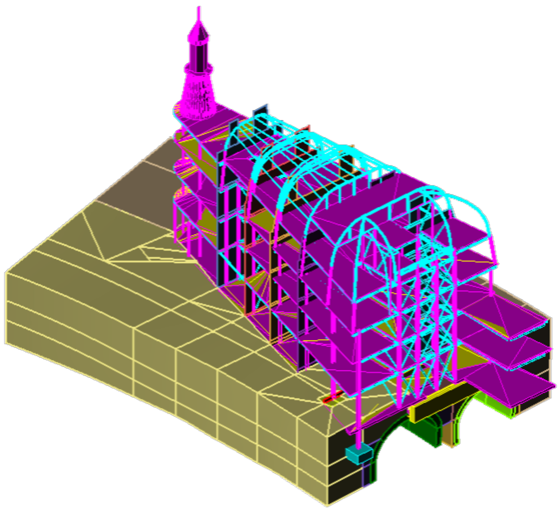
Grade II listed – English Heritage at risk register. Property unusable in current form. Refurbishment blocked for years because of complex problems. Built over deep tunnels and immediately above near surface tunnels.



Existing records providing little real information on geometry and condition, but enough to show complexity. Understand complex geometrical relationship of the tunnels, foundations and existing buildings. A key process to help regenerate this property. Understanding the existing asset was key. Technology now exists to help unlock these blighted parts of our cities: for instance, 3D Laser scanning and simulation. Extracting geometry and building models.



Introducing the design: Combining new work with the existing: Extracting geometry for subsequent analysis. Predict how removal of parts of the original building and the construction of the new foundations and structure interact with the live tunnels.



Movement tolerances critical over live railways. (Thameslink is the busiest stretch of railway on the UK network – 12 car train every 2 mins) Not just statics. Dynamic performance and vibration isolation required to achieve satisfactory comfort criteria within the building. Monitoring comparing point clouds – major changes.

The finished article albeit still virtual: solved complex problems, retained cultural heritage and provided more flexible liveable spaces

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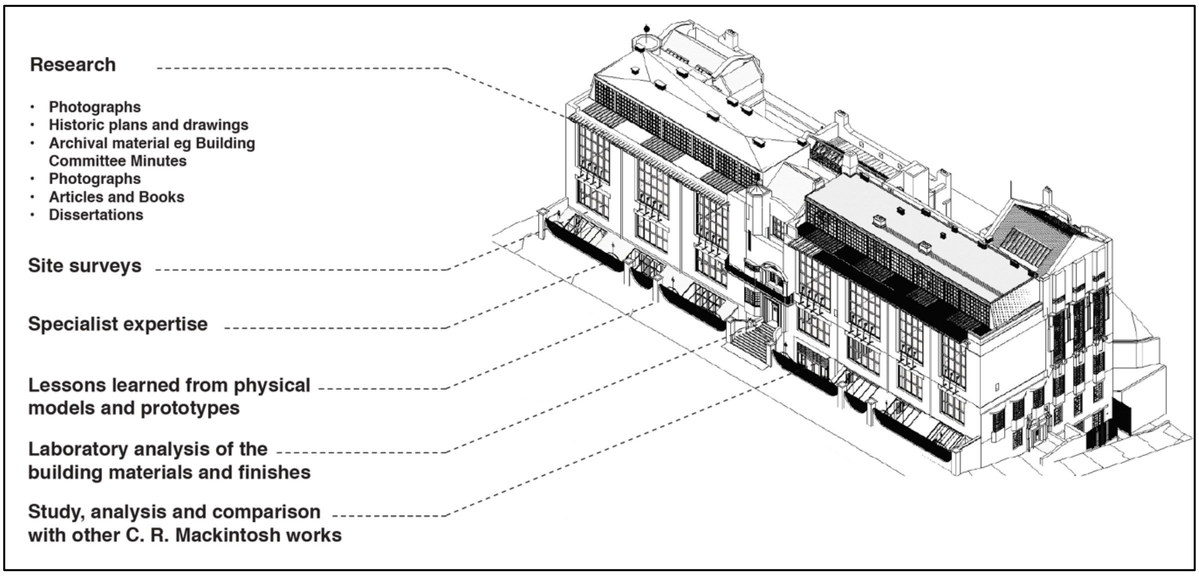
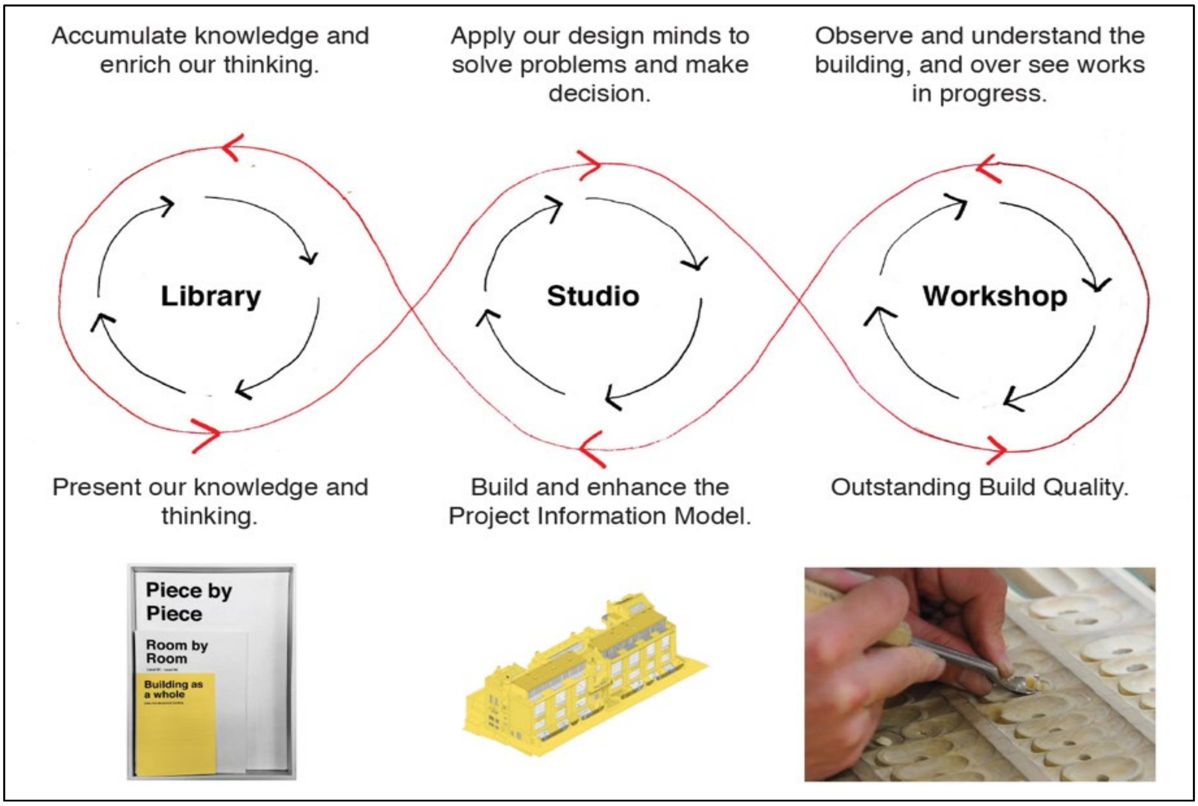
Glasgow School of Art – Mackintosh Restoration

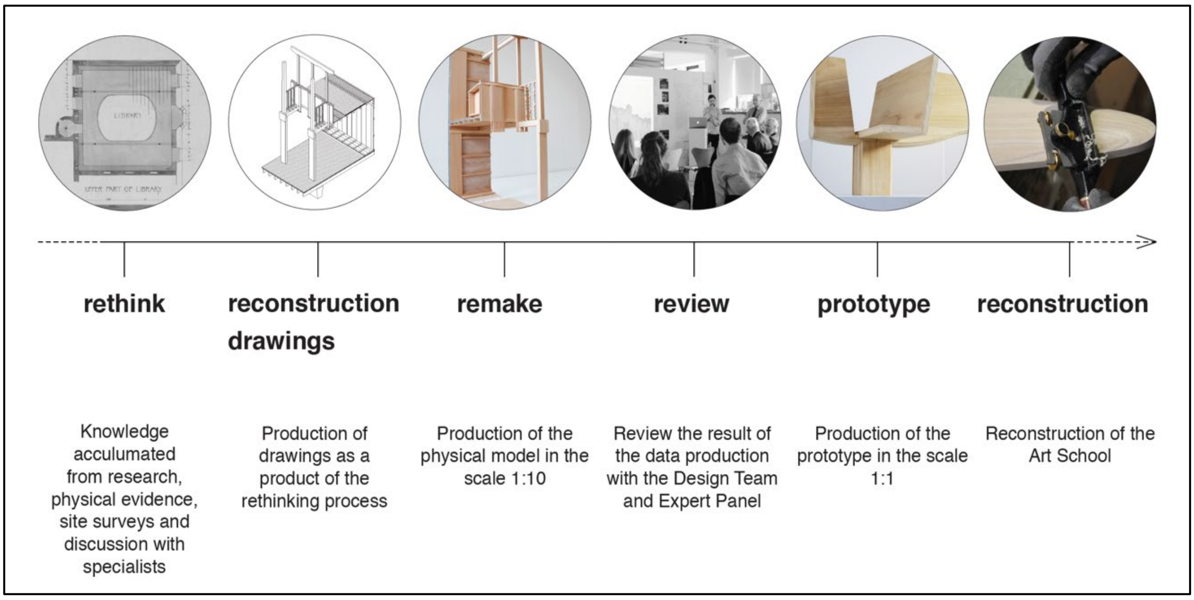
Marianne Partyka, Page/Park

The modern world is all about data; we have the ability to access and manipulate huge amounts of information in a way that was previously unimaginable. The opportunities presented by BIM, are the key to efficiently harnessing and exploiting large amounts of information for the betterment of a project, both in build quality and throughout its lifecycle. The reconstruction of the Glasgow School of Art attempts to exemplify how this modern technology can be effectively applied to a heritage project.

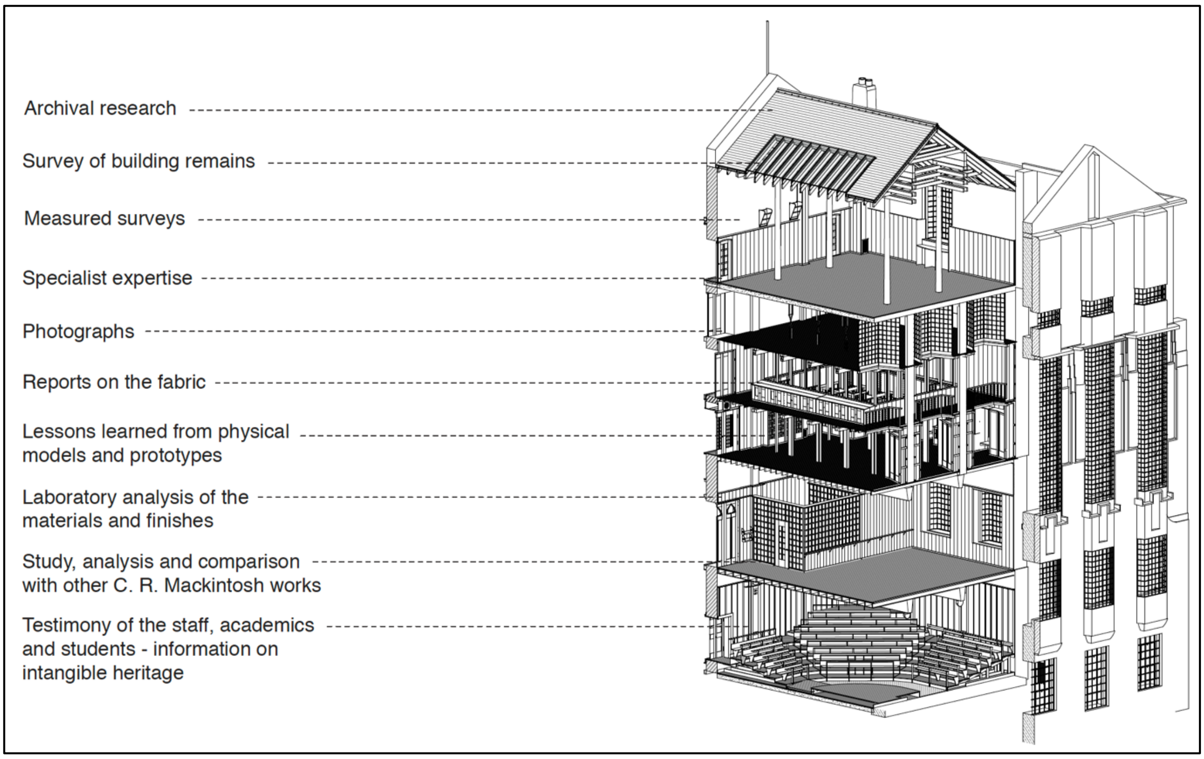




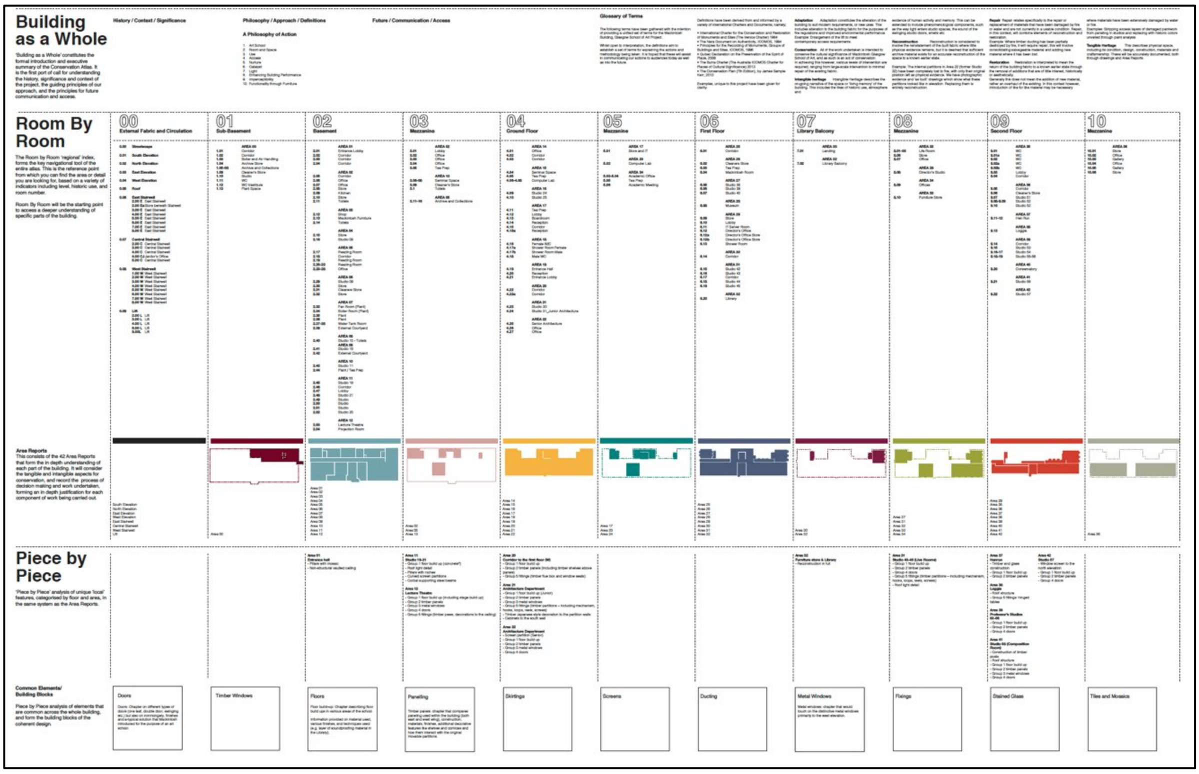
Methodology of handling data to enable greater efficiency and effectiveness



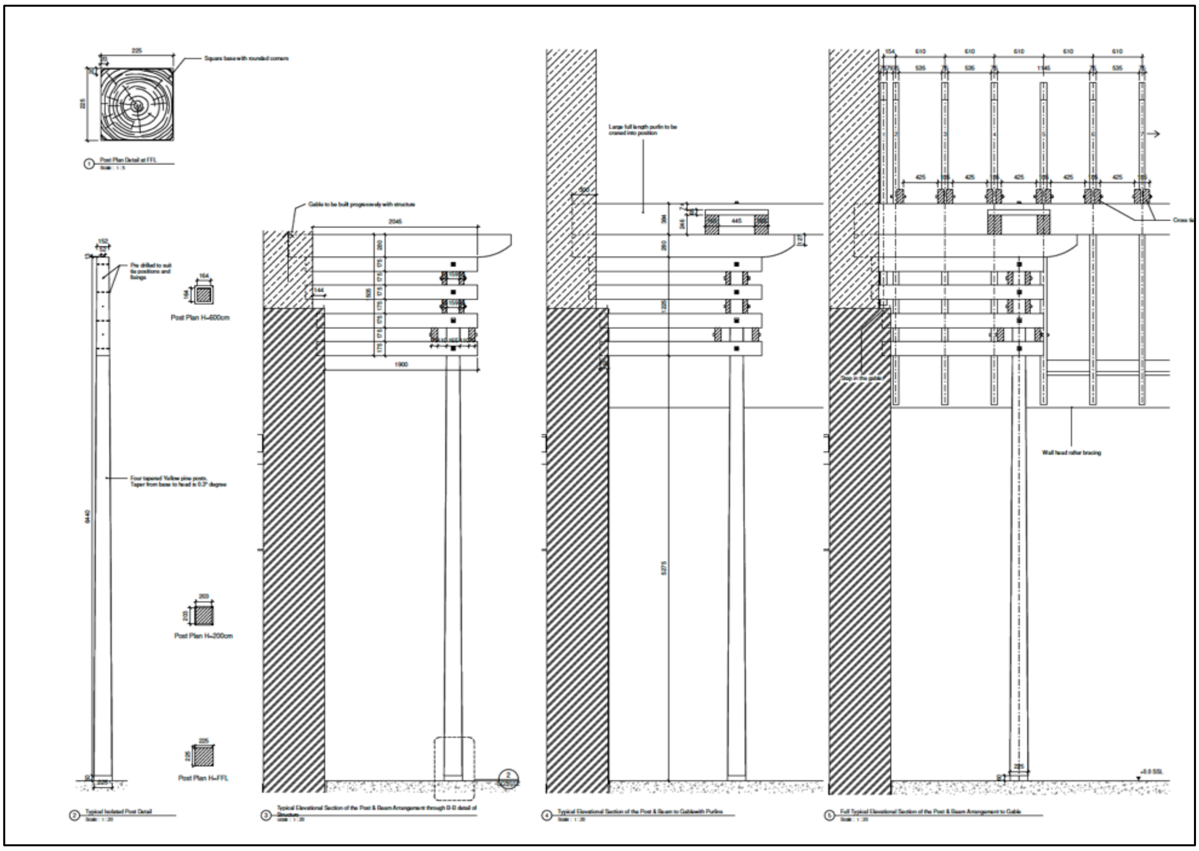
Methodology of reconstruction



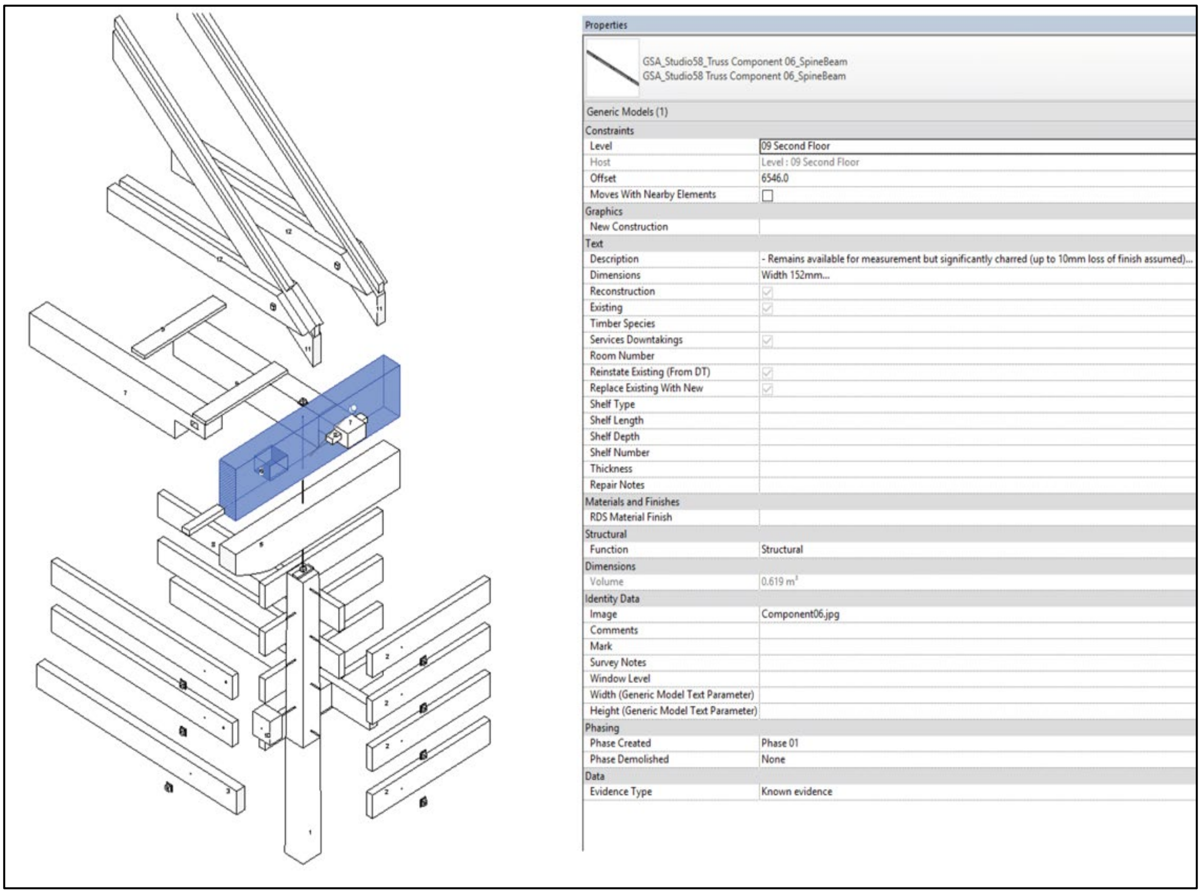
Building Information Modelling



Conservation Atlas



Method of reconstruction Level of Detail



Method of reconstruction Level of Detail

4.23 South Wall Panel Schedule

Room Number	Panel No.	Quantity	Thk	Joint Type	Height (mm)	Width (mm)	Timber Species	Finish	Reconstruction	Existing	Notes	Replace Existing With New	Reinstate Existing (From DT)	Description
4.23	S.14-15	2	20mm	T&G	5190	264	Douglas Fir	Duct T423.1	Yes					
4.23	S.13	1	20mm	T&G	5165	251	Douglas Fir	Duct T423.1						
4.23	S.25	1	20mm	T&G	5165	252	Douglas Fir					Yes		
4.23	S.32	1	20mm	T&G	5165	259	Douglas Fir	Duct T423.3	Yes					
4.23	S.26-28	3	20mm	T&G	5165	273	Douglas Fir					Yes		
4.23	S.20-21	6	20mm	T&G	5165	273	Douglas Fir	Duct T423.2	Yes					
4.23	S.49-50	2	20mm	T&G	5165	278	Douglas Fir	Duct T423.4	Yes					
4.23	S.29	1	20mm	T&G	5165	287	Douglas Fir					Yes		
4.23	S.22	1	20mm	T&G	5165	294	Douglas Fir	Duct T423.2	Yes					
4.23	S.51	1	20mm	T&G	5165	372	Douglas Fir	Duct T423.4						
4.23	S.48	1	20mm	T&G	5165	383	Douglas Fir	Duct T423.4						
4.23	S.16, S.19	2	20mm	T&G	5165	392	Douglas Fir	Duct T423.1, T423.2						
4.23	S.37	1	20mm	T&G	5165	402	Douglas Fir	Duct T423.3						
4.23	S.23-24	2	20mm	T&G	5165	414	Douglas Fir	Duct T423.2						
4.23	S.30-31	2	20mm	T&G	5165	415	Douglas Fir	Duct T423.3						
4.23	S.41, S.45	2	20mm	T&G	3725	88	Douglas Fir							
4.23	S.56	1	20mm	T&G	3725	110	Douglas Fir		Yes					
4.23	S.46-47	2	20mm	T&G	3725	194	Douglas Fir							
4.23	S.42-44	3	20mm	T&G	3725	225	Douglas Fir					Yes		
4.23	S.57-58	2	20mm	T&G	3725	231	Douglas Fir		Yes					
4.23	S.38-40	3	20mm	T&G	3725	250	Douglas Fir							
4.23	S.52-54	3	20mm	T&G	3725	271	Douglas Fir							
4.23	S.55	1	20mm	T&G	3725	271	Douglas Fir					Yes		
4.23	S.17-18	2	20mm	T&G	3725	275	Douglas Fir							
4.23	S.10-12	3	20mm	T&G	3725	319	Douglas Fir							
4.23	S.05-09	5	20mm	T&G	3677	212	Douglas Fir		Yes					
4.23	S.01-04	4	20mm	T&G	3677	265	Douglas Fir			Yes				

Highly structured digital categorisation system allowed interlinking with the geometry, provides designers with an interactive ability to handle massive amounts of project data. Allows for advanced levels of clash-detection in the design process. Put QR codes throughout the physical building so that the digital environment could be as accessible as possible

Practical Applications of Digital Technologies in the Conservation and Asset Management Fields by Scotland's National Heritage Body

Joann Russell, HES

Background

As early adopters, Historic Environment Scotland (HES) continues to pioneer practical applications for digital technologies in conservation and asset management. HES are currently leading the heritage application of BIM in Scotland; exploring and developing BIM as a holistic tool to manage and access relevant inter-related digital datasets both for project delivery and asset management. As part of its organisational BIM strategy, several pilot HES-BIM projects are being delivered to determine the most appropriate use of BIM across a diverse cross section of the property's portfolio, ranging from Edinburgh Castle to Neolithic standing stones. In the absence of a commercially available heritage asset management system that is not based on asset obsolescence or asset renewal HES has developed a bespoke digital national asset management system to manage operations, inform decisions and prioritise investment. BIM is one of the key strands of this Asset Management System.

The Properties in Care Asset Management System (PICAMS) will provide a portal to access, link and integrate the myriad of internal and external datasets that HES hold for the properties in care. It will include information relating to designation, significance, condition, facilities management, archaeology, climate change, digital image and drawing archives.

The development of a new digital condition monitoring tool, HES - SIGMA, is another critical component of PICAMS. The innovative system uses a geospatial relational database on an ArcGIS system to record condition and provide a versatile planning tool for scheduling works, specifying materials, identifying skills needed for repairs and allocating resources. Linking this data into BIM and PICAMS is currently under development.

HES uses digital tools for a range of data including:

- Coastline changes
- Stone decay
- Environmental monitoring
- Historic construction processes
- Disaster recovery
- Condition Surveys

AR provides an interactive way of accessing data for non-experts

Asset Management program uses a matrix approach to risk management; it can then be utilised in the development of Investment Plans and Maintenance Plans; also helpful in resource planning

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Classifying and Linking the Condition of the Asset

Brian Johnston, Topscan

At present 'Topscan' is delivering an asset survey of the British Library including fabric for use in a BIM enabled CAFM package, during this project it will classify the condition of the asset or structure and supply that information alongside a Revit Model.

Classifying within the BIM environment

- Turns information from data-centric to model-centric
- Information is key= Water is life… you can still drown
- Beware the "industry standard"
- Classification enables management of risk
- A sustainable model is one which saves clients' money in the medium to long term

Data Standard

BIM enabled model file sizes can restrict its effectiveness and therefore limit its benefit

- Accurate
- Appropriate
- Accessible
- Interrogatable
- Manipulatable

Classifying Assets- Risk Management

The surveyor will populate the assessment parameter fields with a condition rating, within the range of A-D depending on ranking for each asset type.

The entry grade of the current condition for an asset is in accordance with the following criteria;

- Condition A: (Good) within the first half of the expected life, performing as intended and operating effectively.
- Condition B: (Average / Satisfactory) over halfway through the life expectancy, performing as intended but exhibiting minor deterioration.
- Condition C: (Poor), past the expected life, exhibiting major defects and/or not operating as intended.
- Condition D: (Bad), life expired and/or serious risk of imminent failure.

Each category has a gradient of 1-4 so A1 is brand new, A4 means it is verging on moving into the B category due to its age / condition

Data within your Model

- More than just "What & Where"
    - Make/Model & Serial Number
    - Parent/ Child relationship
    - Maintenance/ Installation Calendar
    - Replacement/ Service Costs
    - Compliance Standard

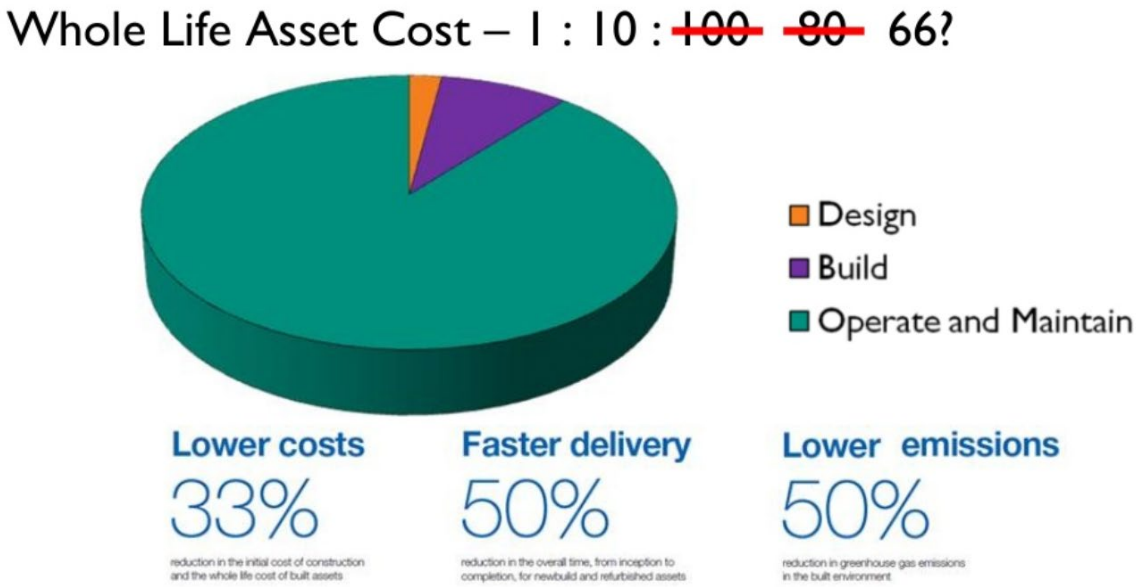
- Asset History

- BIM enabled Asset Registers allow wider engagement of stakeholders through model centric presentation of information

Accessing your Asset Information - Sustainability

- BIM vs. BIM Linked
- Cloud based vs Hosted
- Smart Device vs Desktop

Benefits of Classifying Asset Condition within BIM?



Return on Investment

- Creating a central data-rich model accessible by all stakeholders allows for better informed decisions which should reduce “unexpected costs”.

- This data rich model, when populated with accurate information will then become the single reliable resource for operational maintenance, capital planning and user engagement and allow for effective investment delivering value for money across your estate.

Digital technologies enables the management of risk

- It needs to be cost-effective, otherwise can get drowned in data; need to ensure the data gathered is relevant and useful

- Topscan maintains a database of components which includes historical condition so changes can be tracked – this can include various relationships amongst components

- Need to ensure hosted data set is Appropriate, Accessible, Interrogatable, Manipuable

Is there a Need for an HBIM Objects Library?

Ingval Maxwell OBE, Chair: Council on Training in Architectural Conservation

Context

In the opening presentation, the background to the current imbalance that exists in the construction industry was rehearsed. The question remains, what can be done to ameliorate the situation? Over the past two decades a variety of reports, including a comprehensive series covering the country published by the (now unsupported) National Heritage Training Group, have set out to reveal what has been lost and what might be done about it. Inevitably, each focuses on the scale of the issue with over 6 million pre-1919 buildings, and the need to integrate knowledge, appropriate skills and relevant materials if the existing stock is to be properly attended to.

Whilst the challenge is considerable, there is a way of initiating that understanding by, once again, referring to building construction manuals of the past. In them, building details of the era are well illustrated and described to such an extent that what goes on behind the surface is readily explained. Given that they informed the construction processes of the past, numerous comparative examples can be found in the field.

Might then a digitisation of these details provide the base line upon which an HBIM Object Construction Library emerge? Others appear to be thinking in much the same direction. In the 2012 European *"Commission recommendation on the digitisation and online accessibility of cultural material and digital preservation*", the "*Orphan Works Directive"* (Directive 2012/28/EU) and the *"Memorandum of Understanding on Out-of-commerce Works"* aims at facilitating the digitisation and access to it.

Time will tell if such an approach can become a reality in offsetting the present imbalance created by the heavy promotion of 'new-build orientated' object library BIM data.

Is there a need for an HBIM Objects Library?

The earlier presentation questioned whether or not there was a possibility of using virtual reality to look at an existing building and interpret what was happening beyond the visible surface in a manner that could aid conservation, repair and maintenance activities. This contribution looks at where a start might be made to achieve this goal should it be considered a realistic prospect.

There is little doubt that the various National Building Specification National BIM Surveys illustrate the growing interest in the adaptation and adoption of BIM, with the 2015 survey noting 48% of the respondents now use BIM, with 77% agreeing that BIM is the future. It also indicated that 59% of respondents were operating at BRM Level 2. Within this analysis, clearly the question needs to be raised as to whether or not there is an equal balance in the number of respondents to the survey to get a true picture of what is actually happening in the industry. In part this can be offset by the Skills survey that looked into demand, labour and training requirements for the period 2012 - 2017 noting that there were some 6 million traditionally constructed pre-1919 buildings across the face of the country, with some £2.25 billion being spent in 2012 on work on these buildings using traditional materials, with an estimated workforce of 93,000 being required to undertake work on them.

But here, the diversity of the existing built heritage is considerable taking into account the refined cast-iron productions of glasshouses, significant brick and terracotta constructions, the complexity of slated roofed and masonry constructions all raise the question as to what might inform the development of a BIM objects library for heritage constructions.

Here, a base point may go back to looking at what educated the construction industry at the time, through the various building construction manuals, and what was promulgated as best practice. In particular, the isometric and cross-sectional drawings in such publications could provide a useful starting point.

With regards to roofs, where they are readily accessible a survey record can be taken off them without too much difficulty but a persistent uncertainty will remain where the timber members are embedded in the masonry solid wall construction to hold them in place. It would seem therefore although the drawings could provide a base line; supplementary information is necessary where the detail was hidden from surface view.

Regards a building performance a key issue is the need to keep the weather out whilst with a traditional built form the same need is there to allow the building to breathe effectively, and not be hermetically sealed.

Again, construction manuals can be helpful in looking, say, at lead work details on chimneys, gables and fire stop roof projections, whilst slating details, plain, pan, Italian and Spanish tiling detailing can be informative on what happens at the various constructional junction points. Similarly, the construction manual details of lead work are explicit in how best practice should be affected and over the years, this information has been significantly expanded by organisations such as the Lead Sheet Association to give practitioners the best understanding of constructional technology using lead - a material given its long-standing pedigree from historic times to the present day.

Architectural detailing is also addressed with sheets of information providing design details of cornices, guttering and constructional forms both in solid and in timber form. With regard to the solid form, a close interpretation of what was being promulgated as best practice can, with hindsight and an understanding of performance in use, be recognised as having in-built failures resulting in deterioration of the fabric, either through disaggregation of masonry or efflorescence build-up’s, water penetration of the interiors, etc. Here, it is always easy be critical in hindsight but what seemed to been missing from the 1930’s promotion of integrated modern (i.e. steel and concrete encased steel in juxtaposition to solid masonry) was the recognition that masonry can be porous and that steel in the vicinity of masonry that is damp can trigger rusting to such a degree the structural problems emerge whilst, at the same time, the persistent wetting and drying of moisture through solid masonry can lead to surface disaggregation in some materials such as stone.

In terms of timber detailing of cornices the make-up of the various parts can also be explicitly revealed and how they are jointed in such a way as to shed water from surface run out. This involves sophisticated grooving and overlapping within the timber elements making up the construction but at the same time, the adoption of ideal classical forms can be found throughout the country in the adaptation of the detail

Vertical slating and plane tiling can also extend the understanding of roofing technology onto the vertical face of some buildings. However, additional understanding is required to ensure that the vertically layer hung elements do not obey gravity and descend unhindered. The technique of vertical plane tiling therefore requires an additional degree of understanding regarding security of the individual elements

A wide variety of decorated brickwork does exist in areas of the country where brick technologies prevail. Again, patterns illustrated in the manuals of the time can be readily found as actual examples across these areas. Perhaps more difficult to understand however as we are reinforced brickwork exists although the manuals can be helpful in identifying the likely applications in the use of columns and in straight spanning of openings. An understanding of the technology is also required where brick arching and corbel work is adopted - relying on the security of adjacent members to ensure that the corbels remained secure and firm.

In terms of apply details such as casement and solid frame windows, in addition to sash and case designs, there is no shortage of examples to follow. But here, regional variations based on climatic needs can also be found. In the less severe parts of the country windows are taken to the outer face of buildings whilst in the more prevalently severe areas of the country to high rainfall, windows are held back within masonry check recessed in the wall thickness.

In terms of shedding moisture clearly dressings around windows and doors can have an active part to play in ensuring that the underlying architectural details of the pediments, door surrounds and doors themselves are given additional protection. Inevitably, a variety of stone mouldings and details apply in immense variation across the country although, in the main, they tend to reflect back on classical architecture as their genesis.

Similarly, as we have seen, cast-iron ware has got a vast range of previous uses in the country's architectural heritage

Variations also exist in the construction of timber floors within the structure and the construction manuals illustrate strengthening that is necessary to accommodate this with the addition of herringbone struts, appropriately mortised or stub jointed technologies, the appropriate nailing of floorboards to joists and soundproofing details for multi-occupancy buildings being adequately revealed. The issue here however is that unless investigatory work is carried out in the premises to determine exactly what technologies have been used, the same problems exist in that surface investigations from a photo record or laser scan will not provide all the answers.

Internal access stairways are also addressed but the diversity here is also considerable from the domestic block risers and treads in routered stringers with the use of templates to ensure that manufacturing accuracy, to pen-check cantilevered masonry treads in open hallways from entrance level. More careful investigation is required to ensure a full understanding of such elements is obtained.

There is no shortage of guidance and details regarding the types of doors, panel mouldings, details of door casings, methods of fixed things, cross-sectional architraves, skirtings, picture rail and angle beads that are adopted and promulgated across the range of the construction manuals. The diversity of these also period related, and care needs to be exercised when adopting an understanding of them to ensure that they are relevant to the period in question, given that many properties can go through significant adjustments over their lifetime in use. Similarly, a wide variation exists in the adoption of plaster details for ceilings, cornices and ornamental features.

Add to that applied decorative challenge, an understanding of painted decoration and the complexity of dealing with the internal structure, it's framework and detail becomes recognised as considerable. Even more complicated is the primary, secondary and tertiary constructions of timber ceilings with applied bosses emulating Gothic architecture in built timber form, with individual details applied to each of the element bosses.

A whole new category of understanding is also required with architectural embellishments through the use of terracotta specific to buildings, with statuary, swags, details and projections as an individual level in each building, and the challenges of pulling together a comprehensive BIM library of Historic Objects becomes evident.

That said, with adequate integration there is also the possibility of building upon what actually happens on the ground to increase that knowledge base. In many masons' yards were replacement elements are being carried out – particularly in cathedral workshops – not only the elements may be recorded after they are finished, but the processes of recording templates that are used in the cutting process can also be informative

However, the challenges in dealing with a distressed building which is of considerable architectural merit, significance and value does raise a number of significant questions given the individual concerns and needs of such a property. At the heart of these is whether or not the creation of a BIM objects of historic detail can only be specific to that property or whether or not this has a broader application therefore making its creation a more economic possibility.

In summary, there is also a fundamental issue for the application of new-build where every piece of construction has been designed afresh and put together much like a large-scale Lego kit of parts to create the entire structure. Where an existing building exists that kit of parts is already in place - it is diverse, it is unique and it is generally unavailable and there lies the dilemma.

It is that uniqueness and significance that marks the value of the historic structures in the first instance and, perhaps, occasions the need to be thinking about the application of BIM to the existing built heritage in a different manner where more emphasis is placed on achieving a better understanding of its key significance, its value, its constructional techniques and technologies, the range of elements contained within it, and the need to be sensitive in the handling of all of these in any intervention work that is intended.

The BIM4Heritage Group - Future Intentions

Edonis Jesus

BIM4Heritage is a special interest group established within the BIM4Communities to champion Building Information Modelling (BIM) within the Historic Environment. The group is formed of various specialists, including those from within the AEC industry, Conservation, Heritage Organisations, Academic Departments, and end-users.

The vision of the BIM4Heritage Group is to provide a forum for organisations and industry professionals to share knowledge and lessons learnt on BIM applied to historic structures. Its purpose is to promote the learning, awareness and understanding of BIM within the conservation and heritage sector of the built environment, and to influence and integrate this with wider industry needs.

Involving a range of disciplines and conservators who have the current stewardship of the existing building stock, it will also aim to enable industry to understand the importance of information relating to conservation requirements.

The issue of poor performance in terms of productivity has been identified within the AEC industry in the past decades. In the 1990's several reports were produced in the UK, with a view to drive efficiency and eliminate waste in the industry, the most relevant being:

Latham Report (1994) titled '*Constructing the team'*.

- Industry inefficiencies caused by industry fragmentation
- Partnering and collaboration to improve efficiencies within the construction industry.

Egan Report (1998) titled '*Rethinking Construction'*

- Performance could be improved through elimination of waste (non-added- value activities) from the construction process.

Strategic Forum for Construction Report (2002) titled *'Accelerating change'*.

- Underlined the potential importance of information technology in achieving greater integration

But these seemed to have failed, in terms of impacting the industry….
Following the global financial crisis of 2008, the government decides to tackle the issue of poor performance and to reduce capital and operational costs, and mitigate against the impact of carbon in both the construction and operation of the built environment and in 2011, published the Government Construction Strategy. This study detailed a programme of measures to reduce:

- Capital expenditure costs by 20%
- Whole life costs by 33%
- The carbon burden of the built environment

BIM is one part of the overall improvement strategy. Other measures to be adopted include the greater use of:

- Value engineering and lean procurement initiatives
- "Soft landings" that seek to reduce the hidden costs of adapting completed spaces to suit specific end user needs

- Standardisation to generate efficiency and procurement savings

In the Strategy, BIM is defined as a:

> *'…collaborative way of working, underpinned by the digital technologies which unlock more efficient methods of designing, creating and maintaining our assets. BIM embeds key product and asset data and a 3 dimensional computer model that can be used for effective management of information throughout a project lifecycle – from earliest concept through to operation'.*
> [HM Government – Building Information Modelling - Industrial strategy: government and industry in partnership (2012)]

BIM is perceived as a process to:

- Reduce project risks; time, cost, quality, and safety
- Reduce project waste; material and efforts
- Increase certainty of outcomes
- Improve communications
- Increase visibility of the design and delivery processes
- Better outcomes

Against this background, drawings don't fully communicate design intent as not everyone can interpret floor plans, elevations and sections resulting in views such as:

- *"We couldn't visualise exactly what it was we we're buying."*
- *"Design changes at later stages are costly and can cause delays to the programme."*

BIM is more than 3D geometry: the key of BIM is information.

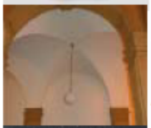
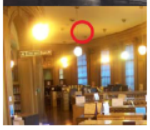
Set against *A Central data management system* our operational processes are in a fairly disorganised state. We don't have a central data management system and information is difficult to find…

> *"When work needed to be done on a building, rather than waste time using an out-dated information (drawings, O&Ms etc.), staff gets a completely new survey done."*
> *"The first priority should be to find a better way to store, manage and update information to support better decision-making."*

Ministry of Justice announced £800,000 savings on first BIM project:

Capital Expenditure Examples

- Cookham Wood Prison project Savings: – 18% In 2013 the Young Offenders Institution, in Rochester, Kent, was completed by contractor Interserve earlier this year after a 44-week contract, reduced from a projected 50 weeks.
- Wrexham Prison project Value: £157 million Savings: - 26%

		NO BIM		WITH BIM		Saving	
	VENTILATION MOTOR REPLACEMENT	4 Wks	14 MHrs	1 Day	3 MHrs	£285	Reduced disruption & inconvenience to Theatre by 27 days Avoids adverse reputational damage
	ALCOVE LIGHT REPLACEMENT	6 Wks	10 MHrs	1 Day	2 MHrs	£108	Reduced disruption & inconvenience to Public/Staff. Avoids adverse reputational damage
	EXTRACT DUCT - UNKNOWN WATER BUILD UP	12 Wks	23 MHrs	1 Day	10 MHrs	£838	Reduced disruption & inconvenience by 92 days Avoid time & money wasted on lengthy monitoring periods
	PUBLIC LIFT REPAIR	5 Wks	16 MHrs	2 Day	6 MHrs	£260	Reduced disruption & inconvenience to Staff & Public Avoids adverse reputational damage
	CEILING LEAK IN HERITAGE AREA	3 Days	14 MHrs	1 Day	3 MHrs	£286	Reduced disruption & inconvenience to Public & Staff Avoids adverse reputational damage

Operational Expenditure savings examples

Level Definitions

- **Level 0**: Unmanaged CAD probably 2D, With paper as the most likely data exchange mechanism
- **Level 1**: Managed CAD in 2 or 3D format with a collaboration tool providing a common data environment, Commercial data managed by standalone cost packages with no integration
- **Level 2**: Managed 3D environment held in separate discipline's with attached data. Commercial data managed by an CDE. The approach may utilise 4D Programme data and 5D cost elements
- **Level 3**: Fully open process and data integration enabled by IFC or similar. Managed by a collaborative model server. Could be regarded as iBIM (integrated BIM) potentially employing concurrent engineering processes

Level 2: distinguished by collaborative working. Collaborative working is about how the information is exchanged between different parties including:

- MOD
- Home Office
- Department for Education
- Education Funding Agency
- Defence Infrastructure organisation
- Homes and Communities Agency
    - Healthcare need to be BIM Level 2 compliant.

Local authorities are NOT covered by the government's BIM mandate, although many are falling in line. Although London Underground is not directly subject to the government's BIM mandate on using Level 2 BIM, it does receive government funding and has therefore chosen to pursue BIM as a priority. Level 2 BIM will be available for use on LU projects by April 2016." London Underground was taking a stepped approach towards achieving Level 2, by first ensuring that new projects can achieve Level 1. By 3 October 2016, all centrally funded departments will need to have "the capability to electronically validate BIM information delivered from the supply chain" and will also need to be "making progressively more use of supply chain data for key business activities" by this date.

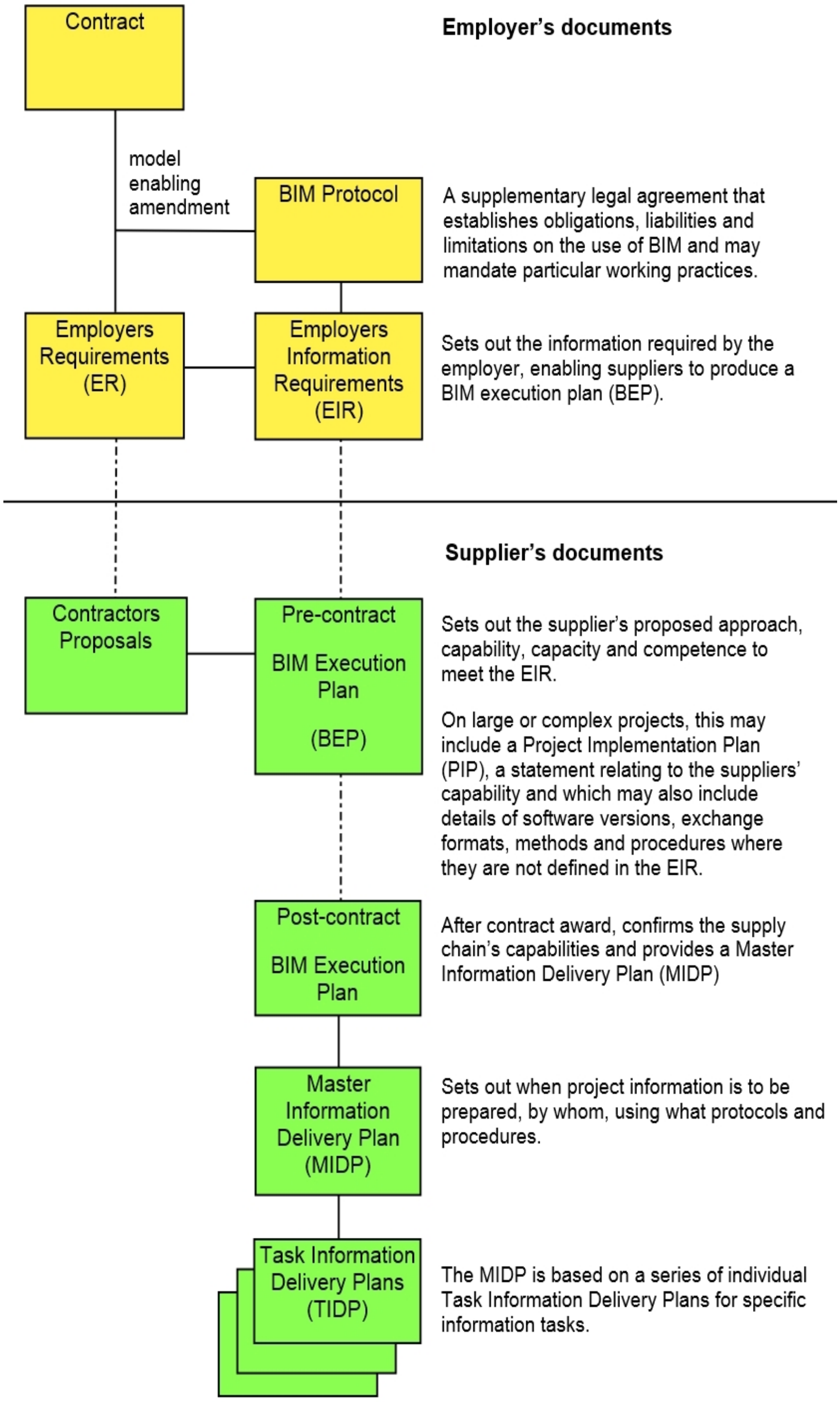
Industry Standards related to BIM Level 2

Level 2: distinguished by collaborative working
Collaborative working is about how the information is exchanged between different parties

BS (British Standard) PAS (Publicly Available Specification)
Information created and exchanged must follow Standards and Protocols

- BS1192:2007 - Collaborative production of architectural, engineering and construction information – Code of practice
- PAS1192:2 -Specification for information management for the capital/delivery phase of construction projects using building information modelling
- PAS1192:3-Specification for information management for the operational phase of assets using building information modelling
- BS1192:4-Collaborative production of information Part 4: Fulfilling employer's information exchange requirements using COBie – Code of practice
- Government Soft Landings (GSL)
- Uniclass 2015
- DPoW
- CIC BIM Protocol
- BS7000-4 - Design Management Systems: Guide to managing design in construction

- BS 8541 - standards for library objects for architecture, engineering and construction



Source: Designing Buildings Limited, 2015

BIM Level 2 Process:

- Agreement on Standards and Process to be used
- BIM Protocol and Model Production Delivery Table included in appointment contracts
- Provision of Employers Information Requirements (EIR) document

- Provision of a Pre-Contract BIM Execution Plan and Project Implementation Plan
- Assessment of suppliers BIM capability before appointment
- Appointment of Project Information Manager
- Provision of a Common Data Environment (CDE)
- Development of Post-Contract BIM Execution Plan
- Development of Task Information Delivery Plans (TIDP)
- Development of Master Information Delivery Plans (MIDP)
- Production of the Project Information Model
- Production of the Asset Information Model
- Compliance check against BIM documents and standards

Why BIM for the Historic Environment?

> *'Understanding of any component of heritage is beyond understanding the physical characteristics of existing building, because each individual heritage object is a message from the past, and it remains as living witnesses of the age's tradition'.*
> (The Venice Charter, 1964)

Why BIM for the Historic Environment? (Perceived benefits)

- Support activities to the understanding of the historic built environment
- Digital representation of historic structures
- Support CRM assessments and decision making
- Assist archaeological/structural analysis
- Enhance building performance
- Support the management of Heritage Information
- Improve communication with the public
- Demonstrate safe methods of working, logistics planning and movement
- Support conservation, restoration, rehabilitation, repair and maintenance activities
- Capture knowledge

The BIM4Heritage Special Interest Group

Integrates the former COTAC BIM4Conservation Group, it was established in 2016 within the BIM4Communities to champion Building Information Modelling (BIM) within the Historic Environment. The vision of the BIM4Heritage Group is to provide a forum for organisations and industry professionals to share knowledge and lessons learnt on BIM applied to historic structures.

Our purpose is to promote the learning, awareness and understanding of BIM within the conservation and heritage sector of the built environment, and to influence and integrate this with wider industry needs. Involving a range of disciplines and conservators who have the current stewardship of the existing building stock, it will also aim to enable industry to understand the importance of information relating to conservation requirements.

The BIM4Heritage Group Goals:

- Provide leadership in establishing how BIM can be used for heritage conservation, repair and maintenance processes.
- Develop consistency of messaging, support and standards of BIM Implementation within the Historic Built Environment.

- Provide opportunities for communicating best practice, and debating issues concerning the adoption of BIM in both private and public sectors, and with increasingly advanced applications of BIM.
- Collaborate with other BIM4 Communities to advance knowledge and influence understanding in the broader context of the industry and built environment, and to initiate the culture change necessary to fully benefit from digital and information technologies and processes.
- Promote historic structures BIM case studies to demonstrate best practice.
- Establish collaborative links to academia.
- Ensure that the group activity and outputs are coordinated and integrated with the other BIM4 community groups and CIC regional hubs.
- Develop its website http://www.BIM4heritage.org

Historic England published its new technical guidance document relating to BIM and Heritage entitled *"BIM for Heritage: Developing a Historic Building Information Model".* This publication is intended to help heritage sector owners, end-users and professionals successfully implement Building Information Modelling (BIM) for heritage projects.

The Feb 2017 Group meeting included a presentation by Sarah Delany, Head of Classification and Technical Author, NBS, about Uniclass2015 and its application in heritage and conservation projects. This offered a brief overview of the Uniclass2015 tables, how they were structured, and how they were intended for used. The overall conclusion was that there was a need to add historic elements to the Uniclass2015 tables, including:

Heritage Modelling:

- Modelling methods (scan to BIM, libraries, etc)
- Levels of Detail requirements
- Technical issues

Heritage Information requirements:

- Conservation
- Repair
- Maintenance

Classification systems

- Survey elements classification

2018 intended projects include:

- Defining deliverables information requirements for heritage conservation, repair and maintenance processes.
- Defining LOD/LOI for heritage metric survey specifications/ model production.
- Developing and publishing heritage BIM case studies

Future projects include:

- Developing BIM implementation guidance for asset owners - how BIM can be used for heritage conservation, repair and maintenance processes.
- Developing an LOD/LOI manual for multiple scenarios

- Developing guidance on the combination of point cloud data and BIM geometry for the heritage sector.
- Data collection/sharing standard
- Classifications specific to heritage
- EIR/BEP specific to heritage

BIM4Heritage Strategic Objectives – FY17 to FY22

Champion business case for BIM implementation within the Historic Environment (End Users)

- Compile evidence based on metrics to demonstrate clear benefits (ROI) on the implementation of BIM within the historic environment
- Dissemination forum

Raise awareness on BIM implementation within the Historic Environment

- Brand elevation: Marketing (Industry media, institutes, etc.)
- Networking
- Publications
- Events
- Launch e-learning portal for Heritage sector

Educate industry on the implementation of BIM for Heritage

- E-learning portal (free courses) to up-skill the heritage sector on the application of BIM for Heritage
- Associate to universities and explore ways to collaborate on teaching BIM for Heritage to students
- Associate to industry Institutes and explore ways to collaborate on teaching BIM for Heritage to professionals

Develop heritage (BIM Level 2) solutions that allow industry users to implement BIM within the historic environment

Heritage Modelling:

- Modelling methods (scan to BIM, libraries, etc.)
- Levels of Detail (graphical) requirements – LOD Survey
- Technical issues (software)

Heritage Information Requirements:

- Conservation
- Restoration
- Rehabilitation Repair Maintenance
- LOI Surveys

Classification systems

- Align classification system – e.g. FISH and NBS
- Unified classification system
- Survey elements classification

Develop Case Studies

Expand Group abroad

- Partnering (w/existing BIM for Heritage community abroad)
- Creating BIM for Heritage communities abroad

Lead Research and Development

- Associate to universities

- Explore ways to collaborate on researching/Innovate UK Knowledge Transfer Partnerships schemes

Define BIM Level 3 within the heritage sector

- e.g. Intelligent information management; performance evaluation, etc.
- Looking at other industries in terms of digitalisation and data management (healthcare industry, etc.)
- Preserving structures and its contents (e.g. museums)
- Materials database (potential partnership with Kirkaldy Testing Museum – who are looking into developing a library on the history of materials testing)

Define BIM Level 4 within the heritage sector

Kirkaldy's Testing Museum

The museum occupies the ground floor and basement of 99 Southwark Street, London just south of The Tate Modern. The building was built in 1874 specifically to house "*Kirkaldy's Testing and Experimenting Works*". Here experiments took place on materials to determine their strength mainly using David Kirkaldy's own testing machine design. Kirkaldy (1821897) helped form the Institution of Engineers in Scotland and was the first person to set up a load-testing machine for construction materials powerful enough to deal with the largest specimens. The original 48 fool long machine could apply a load of over 300 tons and is still in position in the building. The buildings' door pediment calls for *"Facts not Opinions".*

The Objectives of the Museum:

- To preserve David Kirkaldy's machine in good working order and close to its original condition
- To retain as far as possible the Victorian character of the Works
- To explain to the public Kirkaldy's role in developing quality control by regular monthly opening and special open days
- To store and exhibit the Kirkaldy archive, and develop a library on the history of materials testing

- To build and maintain a representative collection of working testing machines

BIM should be used for Heritage because of the large amount of waste reduction as well as being a Government Requirement**.** It can be challenging at first to develop the processes involved, but is invariably worthwhile in the long run**.** BIM4Heritage pushing to include more heritage related initiatives and requirements into successive rounds of industry legislation Need to ensure models aren't just laser-scanning, but include information-rich objects

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General Discussion

It was noted an inherent dilemma currently ongoing throughout the industry, that clients are responsible for owning and maintaining their data post project completion. However, currently clients tend not to be doing so, whether due to a lack of expertise, understanding, resources, or because of copyright issues. Thus further projects dealing with the same asset tend to have to go back and 'reinvent the wheel' as prior projects' data simply isn't kept in an accessible manner.

IM opened up the remaining time in the conference for a general discussion amongst the audience. The following notes summarise some of the comments and questions generated:

- Start small when developing BIM; e.g. assemble data in a digital format
- Can be especially challenging to assemble data in a piecemeal format; e.g. small contracts over time on a single historic building
- Push providers to provide data in an interactive, digital format; e.g. vendors, manufacturers, producers
- Could conservation / maintenance plans be adopted to incorporate BIM?
- Establish a simple framework for digital data compilation
- Database of HBIM projects? Could a filter be applied to CIOB's project database?
- Funding / Resources an always-limiting factor in the wider rollout of new tech
- Universities starting to incorporate BIM into curriculum, not as a stand-alone subject but enmeshed into the various subjects
- CPD courses for the industry would be useful
- Need to ensure solutions / tools are effective for clients now, not just far into the future; otherwise, clients won't buy-in
- Could a consistent template be developed?
- Is 'Heritage BIM' incorporating existing, but not listed, buildings? Debate about the definition of 'Heritage BIM' as most agreed 'Heritage' does not mean 'Listed' but instead incorporates any and all existing buildings.
- How to incorporate intangible items into BIM; e.g. smell, texture, sound
- Current clients are typically not retaining digital data even though as part of projects the data is being developed; how to change this?

BIM for Heritage: "Stepping into the Future with the Past"

A COTAC Conference, Friday 8 December 2017, London

Programme

09.30		***Coffee on Arrival and Registration***
10.00 – 12.30		**Session 1: 2017: A Year of Developments!**
	10.00	***Welcome and Introduction*** Jeremy Foster, Ramboll
	10.10	***2D to 4D - Oh! How we have changed: A COTAC Perspective*** Ingval Maxwell, COTAC
	10.40	***Historic England BIM for Heritage Guidance*** Paul Bryan, Historic England
11.10 -11.30		***Break***
	11.30	***Hybrid Modelling in the BIM Process*** Carl Brookes, Ramboll
	12.00	***Glasgow School of Art – Macintosh Restoration Case Study*** Marianna Partyka, Page Park
12.30 – 13.30		***Lunch and Networking***
13.30 – 15.00		**Session 2: Where Will 2018 Take Us?**
	13.30	***The Practical Application of Digital Technologies in the Fields of Conservation and Asset Management*** Joann Russell, Historic Environment Scotland
	14.00	***Classifying and Linking the Condition of the Asset*** Brian Johnston, Topscan
	14.30	***Is there a Need for an HBIM Objects Library?*** Ingval Maxwell, COTAC
15.00 -15.30		***Break***
	15.30	***The BIM4Heritage Group - Future Intentions*** Edonis Jesus, Lendlease
	16.00	***Discussion***
16.30		***Close and COTAC AGM***

Benefits of attending:
BIM is influencing the conservation world through a more specific Historic Building Information Modelling (HBIM) approach. The event will explore recent publications and emerging case studies to review the challenges and benefits offered in the greater uptake of knowledge transfer and related developments.

Who will benefit:
Heritage organisations, the BIM, Conservation, Repair and Maintenance industry sectors, and Education and Training providers.

Delegate Attendance Fee:
£75.00 Booking on Eventbrite

Venue:
Ramboll Office,
240 Blackfriars Road,
London, SE1 8NW

Nearest Tube:
Southwark: Jubilee Line

Sponsors:

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Council on Training in Architectural Conservation

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