The Institution of
StructuralEngineers

An introduction to Building Information Modelling (BIM)

Produced by The Institution of Structural Engineers BIM Panel

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Introduction

Introduction

Introduction to BIM

The digitalisation of the built environment represents one of the most profound changes to our industry and profession since the first industrial revolution. BIM (Building Information Modelling) is one of the primary enablers of this change. However, there is significant confusion and mixed messaging about what it is and how it will affect the structural engineering profession. Even the name creates disagreement: 'Building Information Modelling' or 'Building Information Management' or even 'Better Information Management'.

This guidance has been written by the Institution of Structural Engineers BIM Panel to help structural engineers and technicians appreciate the opportunities and challenges that BIM creates. It is designed to help the profession to capitalise on these opportunities and avoid any pitfalls.

To avoid confusion this guidance adopts terms defined by UK national standards unless stated otherwise.

What is BIM?

BIM was defined by PAS 1192-2:2013[1] as 'Building Information Modelling' and as a 'process of designing, constructing or operating a building or infrastructure asset using electronic object-oriented information'.

This definition infers a number of statements that clarify BIM:

- It is a process, not a single technology solution or software. In fact, it is a collaborative process enabled by technology
- It covers the whole life-cycle from designing through to constructing and operating an asset
- It equally applies to buildings or infrastructure assets

The superseding BS EN ISO 19650[2] now defines BIM as 'the use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions. Built assets include, but are not limited to, buildings, bridges, roads, process plants'. This additional definition clarifies that BIM is a shared representation and process aiming to replace the majority of drawn information

These definitions can be reconciled with the acronym BIM as follows:

- 'Building' is the verb 'to build' rather than the noun 'a building'. It is therefore relevant to any asset of the built environment
- 'Model' refers to the 'representation of a system or process' rather than a '3-dimensional representation of a person or thing'. Though there can be no doubt that geometric representation is important, we must be able to simulate the various facets of the design of an asset (structural, architectural, building services etc), the construction of the asset and the operation of the asset
- 'Information' (or more specifically 'the sharing of structured information') is the fundamental concept of BIM. This includes geometric and non-geometric information such as the supplier of an object, its warranty information, fire-rating and corrosion specification.

BIM: 'I' is for information

Structural engineers may find it useful to specify information, such as the design utilisation ratio or maximum force and moments instead of issuing separate drawings for connection design. Many companies are now adding CDM[3] risks into the model and linking this directly to the CDM risk register. Calculations can also be directly linked to objects within BIM.

There is no limit to the information that could be included within BIM. The challenge is ensuring that all members of the project team and the client are aware of the implications for requiring and delivering that information. This includes how structural engineers get this information into BIM and how they verify that it is correct.

Avoid manually adding information to objects within the model as this will be time-consuming, prone to human error and difficult to check. It is common for contract deliverables, such as drawings and schedules, to be extracted automatically as part of the BIM authoring tool. Therefore, if the information within the BIM is incorrect the information on the drawings and schedules may also be incorrect.

The use of BIM does not negate thorough checking and quality procedures on any deliverable, including any 3D models.

What do the different stages of BIM mean?

While the UK Government mandated BIM at Level 2 on all public projects by 2016, the current BS EN ISO 19650[2] standard defines BIM maturity in stages (See Figure 1).

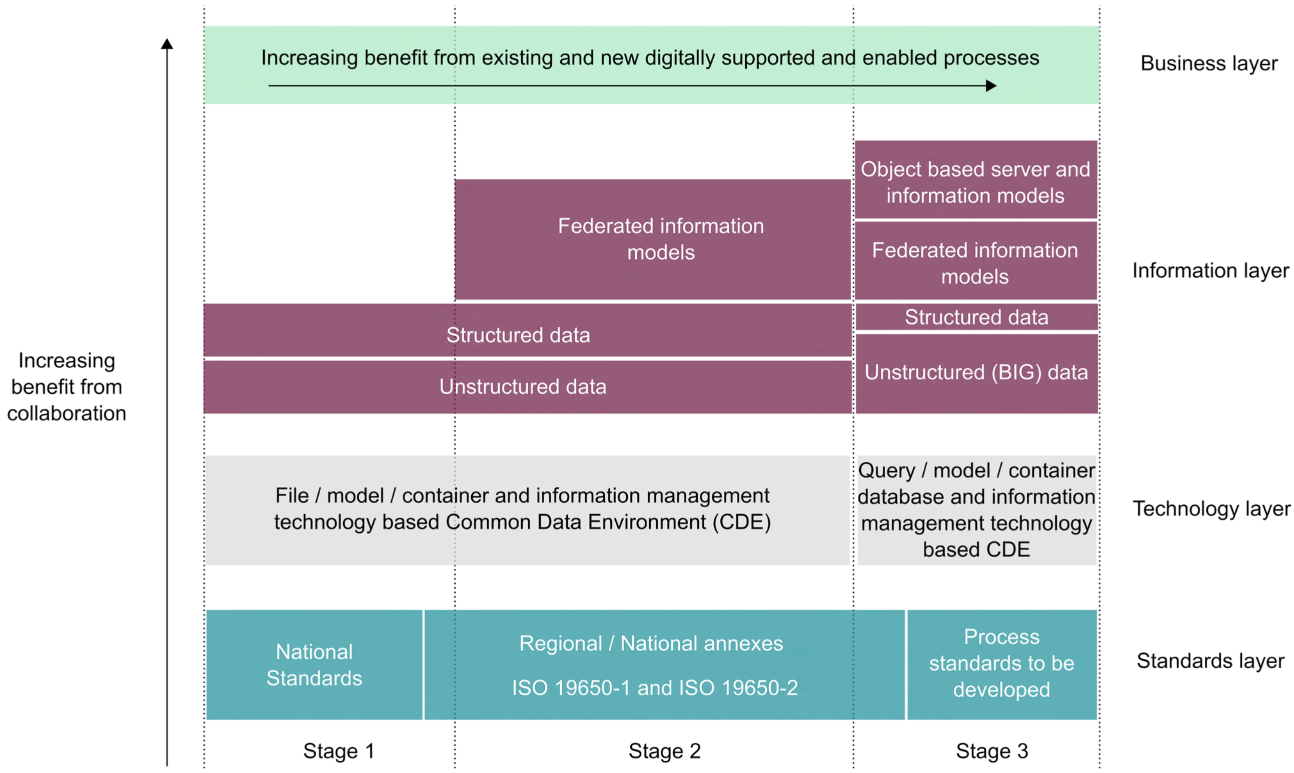

***Fig 1:** a perspective on stages of maturity of analogue and digital information management ((Permission to reproduce extracts from British Standards is granted by BSI Standards Limited (BSI). No other use of this material is permitted.)*

Importantly, the stage of BIM Maturity is not related to 'dimensions' in line with the *n*D modelling philosophy[4]. The *n*D modelling philosophy assigns dimensions based on purpose, typically accepted as:

- 3D = 3 spatial dimensions
- 4D = Time. Attributes are added to allow construction sequencing etc
- 5D = Cost. Attributes are added to allow cost
- 6D = Facilities management (FM). Attributes are added to allow asset/facilities management

There is no real agreement beyond 5D. For example, 6D is sometimes 'sustainability' and sometimes 'FM'. Some companies state that they are working at Level 7 because some of their models are used for FM or sustainability purposes.

The Institution's BIM Panel do not recommend using *n*D modelling terms beyond 4D. Even cost (5D) is not really a 'dimension'.

The stage of BIM maturity is essentially a measure of how well each party's information is structured for use in federation by a collaborator without requiring significant remodelling for their process.

The stages of BIM maturity can be summarised as:

- **Stage 0:** Undefined
- **Stage 1:** Partially structured unfederated data. This can be achieved through National Standards of naming and layering standards, common origin points and orientations
- **Stage 2:** Structured federated information models. The parties are working in their own isolated BIM models and then sharing and coordinating information using a Common Data Environment (CDE) for federation. Based around the principles outlines in the BS EN ISO 19650[2] series of standards
- **Stage 3:** Server based object information models hosted on queryable database Common Data Environments. Companies claiming to be working at stage 3 are doing so before the formal definition has been agreed

Note the following:

- Just because a 3D model is being produced in a recognised BIM authoring package, it does not mean a party is working to stage 2 BIM. If the information within that 3D model is unstructured and difficult for collaborators to federate and use within their processes this is most likely stage 1 or below

Stage 3 is yet to be fully defined. There are currently pathfinder projects investigating stage 3, but no project in the UK has been delivered at stage 3

What constitutes working at BIM stage 2?

To work effectively at stage 2, the following requirements should be met:

- **Documentation can still be a contractual deliverable:** this could include 2D drawings, schedules, etc that originate from BIM authoring tools and supplementary information such as reports and specifications. To align with the requirements of stage 2, the deliverable should be in a consistent digital format that is ready to be federated with other models. The delivery format is recorded in the BIM Execution Plan
- **A 3D model is being issued as a deliverable:** this could include 3D models created in BIM-enabled software, eg a native file such as Revit, Tekla or ArchiCAD. It could also be a non-proprietary Industry Foundation Class (IFC) file containing the same information. The format and digital structure of this information is recorded in the BIM Execution Plan
- **Non-graphical data is issued as a separate deliverable:** this could include information that may be important for collaboration, co-ordination, future asset management or other activities. These non-graphical formats are defined in the BIM Execution Plan. One notable non-graphic format, COBie, is outlined in BS 1192-4[5]

These requirements should be transparent and consistent between team members. This greatly increases the ability for team members to exchange information and avoid duplication and remodelling. For this to work effectively the projects should use:

- Data standards
- Defined processes. The two most important documents are:

  - **Exchange Information Requirements (EIR):** this document defines the general information requirements and establishes the specific information management requirements. It is part of the tender document for the procurement of the design team and constructor
  - **BIM Execution Plan (BEP):** this document details how the team will manage the digital information throughout the project in compliance with the EIR

- Controlled data exchange: eg what information, what format and how often?
- Common Data Environment (CDE): the CDE is defined as a single source of information used to collect, manage and disseminate all project documents. At the basic level this could be achieved using an advanced project extranet site

	Stage 0	Stage 1	Stage 2	Stage 3
Contractual client demand for information		●	●	●
Common Data Environment (CDE)		●	●	●
Information rich, federated 3D models			●	●
Non-graphical information in agreed format		●	●	●
Standardised approach		●	●	●
Excecution plan / responsibility matrix		●	●	●
Checks / audit trail		●	●	●
Information exchanges		●	●	●
CDE as a database				●
Object based server information models				●
Non geometric information				●

Fig 2: *BIM stages compared (Credit: B Trojak)*

Most structural engineers will recognise that they can operate somewhere between stage 1 and stage 2 (see Figure 2).

References

[1] British Standards Institution (2013) *PAS 1192-2:2013 Specification for information management for the capital/ delivery phase of construction projects...* London: BSI [Now superseded and withdrawn]

[2] British Standards Institution (2019) *BS EN ISO 19650 Organization and digitization of information about buildings and civil engineering works, including building information modelling - Information management using building information modelling*, London: BSI

[3] HM Government (2015). *The Construction (Design and Management) Regulations 2015*, [online] available at: http://www.legislation.gov.uk/uksi/2015/51 [Accessed 15 April 2020]

[4] Lee A. et al (2005) "nD modelling road map: A vision for nDEnabled construction", [online] available at: https://tinyurl.com/yctwupz5 [Accessed 15 April 2020]

[5] British Standards Institution (2014) *PAS 1192-4:2014 Collaborative production of information. Fulfilling employer's information exchange requirements using COBie. Code of practice*, London: BSI

Section 2
The need for collaboration in BIM

The need for collaboration in BIM

The importance of collaboration

BIM stage 2 was intended to be a small step from current practices. This was so that it could be implemented without radically changing the construction sector's organisational structures, contracts and procurement routes.

However, BIM is fundamentally about sharing structured information and as such is optimally deployed within a collaborative framework. The need for more collaborative working with the construction industry is not new, and concluded by numerous industrial reports[1,2,3,4,5,6].

The 2011 Government Construction Strategy[7], heralded for launching the UK Government BIM Mandate, only mentions BIM in passing. A significant proportion of the report is given to the importance of collaboration, procurement and improving the effectiveness of the "Government as a client".

Challenges facing the sector from traditional ways of working

Traditional project delivery methods have failed the construction industry and its clients due to lack of confidence in shared data and incorrect assessments of how to minimise risk and liability. Yet the current mindset is to digitise existing traditional (document-centric) methods.

This will not solve the underlying issues facing the construction sector and wider built environment. The sector's systemic problems are likely to be manifestations of one or more of the following:

- Rudimentary exchanges of information by way of briefing, proposals and pricing
- Task and activity programming not commonly shared or consistent across team members
- Subjective decisions (design, project management, etc) based on information inferred from ambiguous, often partial, data that is ultimately unverifiable
- Cost data that is inconsistent across the project and not sufficiently transparent
- Failure to engage early with the parties who will subsequently operate the built assets
- Lack of commitment to timeframes and deadlines
- Late notification of problems without the necessary supporting data
- Inconsistent communication across the project (written or verbal instructions and feedback)
- Lack of a proper system of capturing and utilising 'lessons learned' from project to project

Any one or a combination of the above can undermine the efficiency of the asset during delivery, in-use and end-of-use phases. Using a BIM authoring tool in isolation will not address these issues. Structural engineers need to make improvements in information transformation and the underlying processes required for information flow.

This is why BS EN ISO 19650[8] defines BIM as the use of a shared digital representation of a built asset to facilitate design, construction and operation processes to form a reliable basis for decisions.

How to work collaboratively

Stage 2 BIM requires all parties to work together in a collaborative manner. Figure 1 represents a simplified workflow for a building structure and how the duties of architect, structural engineer and building services engineer interact.

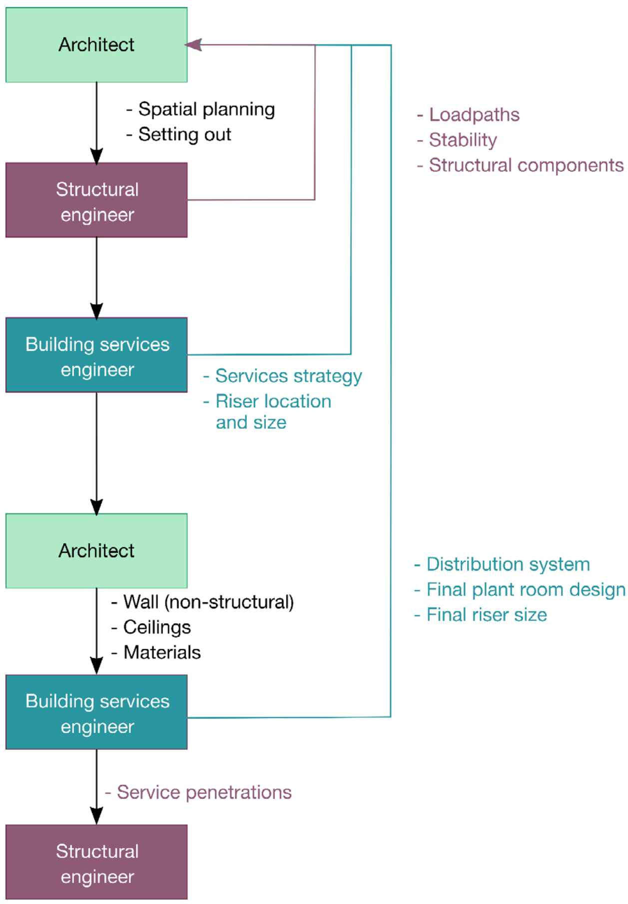

***Fig 1:** Simplified project workflow*

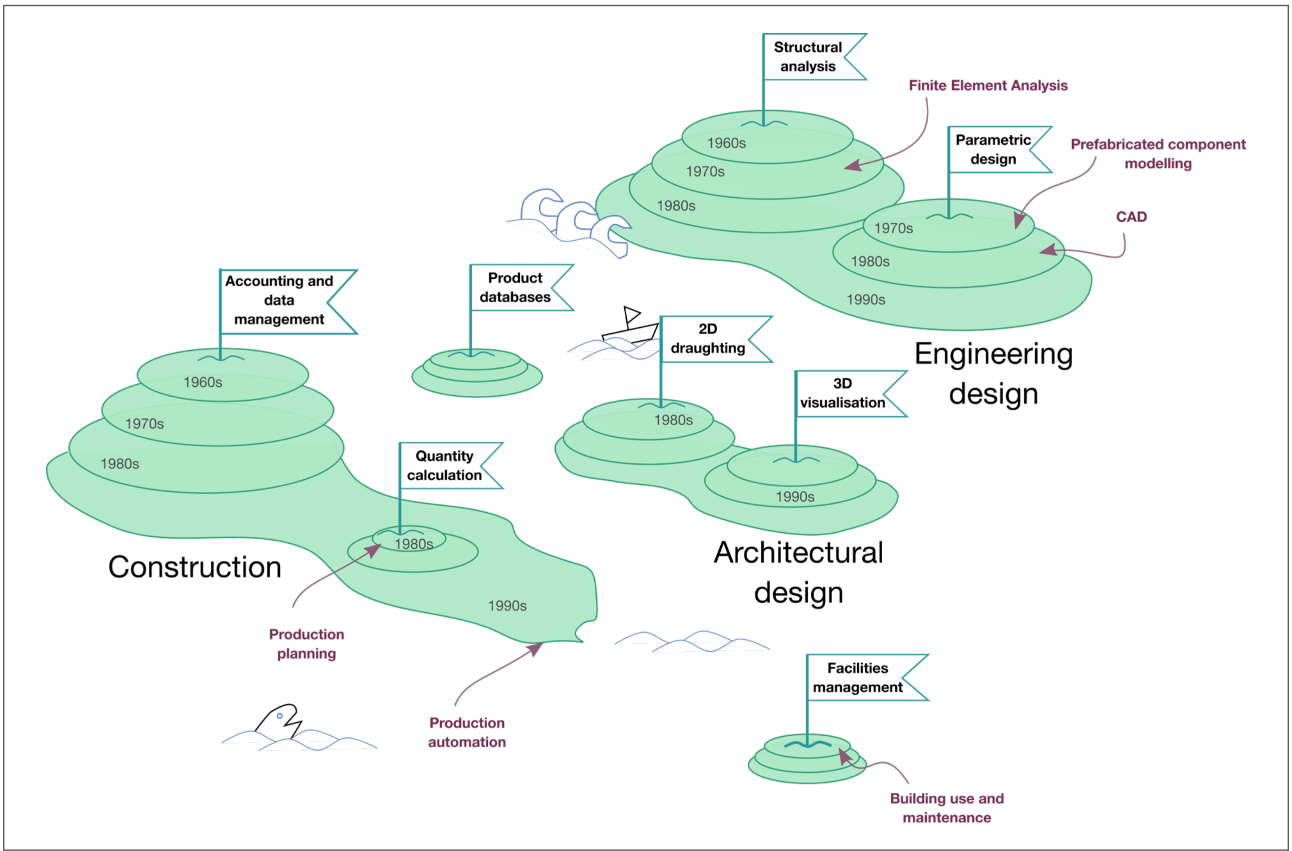

Fig 2: *Islands of Automation by Hannus (Credit: Matti Hannus, Hannu Penttilä & Per Silén)*

If any one party does not contribute to the workflow then the process breaks down. The BIM process requires two fundamental components:

- It needs to be clearly articulated what information is required by each participant. This is contained in the Exchange Information Requirements (EIR)
- The participants need to clearly articulate (and agree) how they will deliver information as needed. This is contained in the BIM Execution Plan (BEP)

The potential for BIM to improve productivity and reduce waste can only be reached if there are protocols for information exchange, standards of deliverables and procedures in place to ensure that the parties are contributing as required.

This is not a radical change from what structural engineers currently deliver. What is new is the rigorous and unambiguous scope and the structure of the information deliverable. The scope and deliverable for this requirement also needs to be a contractual requirement, in the same way that any traditional scope of deliverable needs to be contractual.

Without a coordinated approach between parties, the industry will retain islands of automation regardless of new technologies. See Figure 2.

The role of Employer's Information Manager

It is not enough for a client to express a desire for BIM on a project. A much deeper involvement is required from the client. This can be facilitated by employing someone to carry out the tasks required for successful BIM implementation. The Construction Industry Council (CIC) BIM Protocol[9] calls this role the 'Employer's Information Manager'. The duties of this role are set out in the CIC document 'Outline Scope of Services for the role of the Information Manager'[10].

Figure 3 shows how all members of the project team contribute to, and make use of, the Information Model.

The Employer's Information Manager is responsible for the information flow and exchange between project team members. There is much debate as to who is best placed to take on this role. Should it be the architect, contractor or structural engineer? The structural engineer has the opportunity to expand their role to encompass that of the Employer's Information Manager as they exhibit many of the core skills and competencies required.

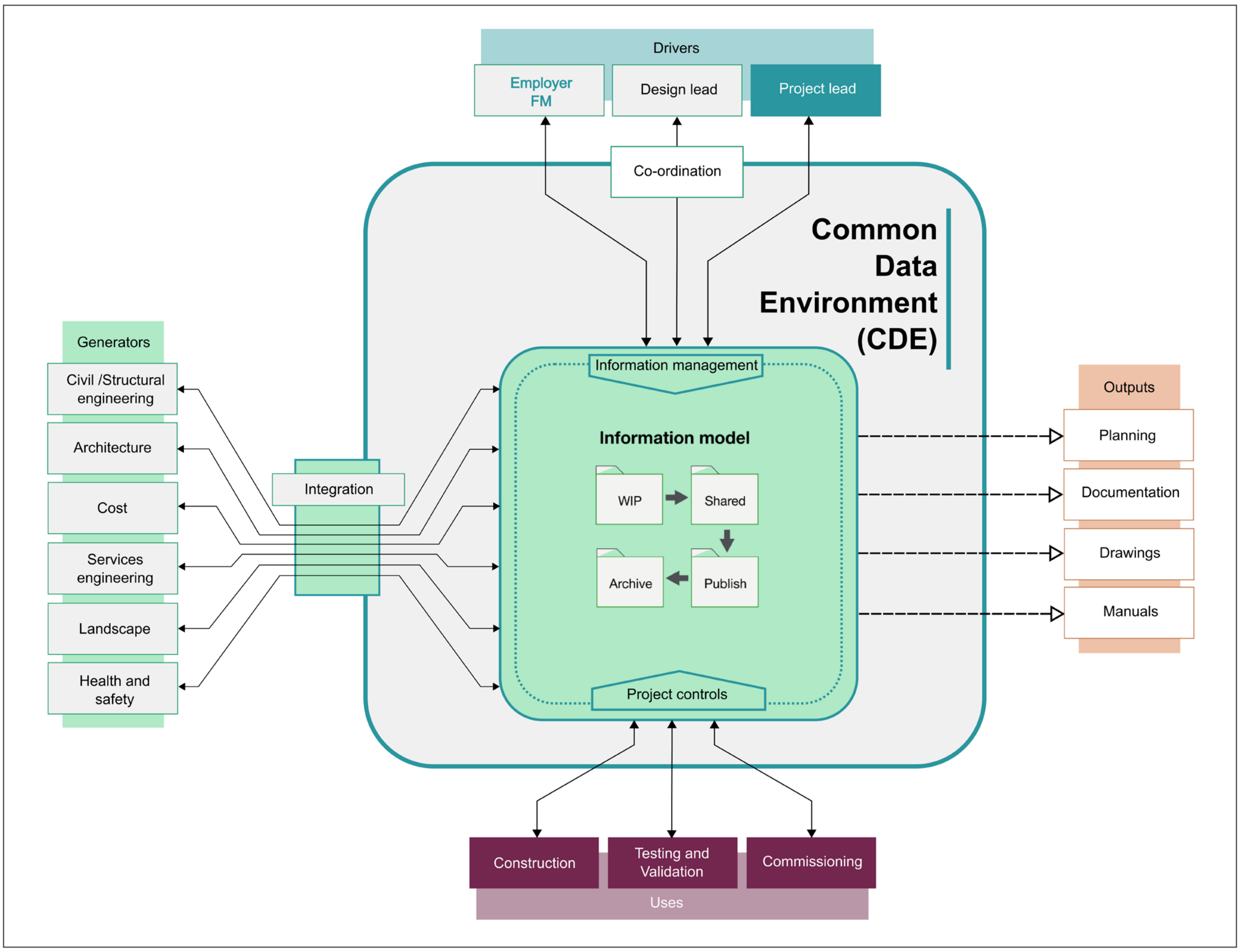

Fig 3: *The Information Model and the flow of information with project team members (Credit: Tony Broomhead, BL Consult)*

Sharing information through the Common Data Environment (CDE)

BS EN ISO 19650[8] suggests four states of information exchange:

- **Work in Progress (WIP):** this is a private area where project team members evolve the design within their own discipline. Often teams will be exploring several options and scenario testing but continuously sharing this with other team members is counter-productive. The WIP is often within the individual companies own IT infrastructure and not within the CDE

- **Shared:** this is the information that project team members need to share with each other to complete their tasks. The frequency and process of sharing should be stated in the BIM Execution Plan (BEP) and managed by the Employer's Information Manager. The frequency of information exchange can vary throughout the project lifecycle, within a project stage and between different disciplines. It is imperative that the format of the data exchanges is agreed and adhered to. This includes the version of software(s) that the team are using to complete their work, the format of the information exchange and the 'export options'. Changing software versions throughout a project should only be done by exception and needs to be agreed by all. This does not mean that all project team members must use the same software. Instead all team members must check that information required by others from them can flow unimpeded. This is often made easier by all using the same software. Some clients have mandated software and version. This is not the same as requiring the team work to BIM stage 2. It is entirely possible for project team members to all be using the same software and version, but each in a different way leading to the same incompatibility issues as if they all were using different software. Stage 2 is about how users' structure and share the information, not which software they use. Good practice is to continually check models for coordination throughout the 'Shared' phase and not wait until it is 'Published'

- **Published:** the published state is reached upon agreement among the project team to have reached a significant project milestone awaiting a decision from the appointing party (client) to continue. The appointing party's information need is typically specified in the Exchange Information Requirements (EIR) for each project milestone. To meet this milestone the project team will bring together all the discipline information models, produce a federated model and extract a subset of this information to meet the requirements outlined in the EIR. This subset of the federated model is known as Information Exchange aka 'data-drop'. Although there is no standard requirement a possible Information Exchange delivery format is COBie (Construction to Operation Building Information Exchange). COBie was originally devised to be used at the 'Handover Stage' only, however BS 1192-4[11] proposes this can be used at all stages. The requirements for the 'data-drop' and the format for the Information Exchange should be specified in the EIR and is effectively the scope for the contractual delivery of the digital asset information.

- **Archive:** as the project moves to the next milestone a copy of the federated information model is archived. This is just as important to digital deliverables as it was for 2D documentation and serves the same QA, audit and project control purposes. However, it is the recommendation of the BIM Panel that information is always stored in a neutral format (ie Industry Foundation Classes) as well as native formats due to the issue of longevity of data. It is difficult to open native file formats from even five years ago, but built environment assets are expected to last at least an order of magnitude longer than this. This means that neutral formats should be required at the 'Published' stage and checked for adequacy. Common bad practice is to exchange information in native formats which everyone checks and an 'IFC' version which no one has checked

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[1] Ministry of Works (1962) *Survey of Problems Before the Construction Industries*, HMSO [online] available at: https://archive.org/details/op1265587-1001 [Accessed 15 April 2020]

[2] Banwell C.H., (1964) *The Placing and Management of Contracts for Building and Civil Engineering Work*, HMSO [online] available at: https://archive.org/details/op1265594-1001 [Accessed 15 April 2020]

[3] EDCs for Building and Civil Engineering (1975) *The Public Client and the Construction Industries (The Wood Report)*, HMSO

[4] Latham M, (1994) *Constructing the Team*, HMSO [online] available at: http://constructingexcellence.org.uk/wp-content/uploads/2014/10/Constructing-the-team-The-Latham-Report.pdf [Accessed 15 April 2020]

[5] Construction Task Force (1998) *Rethinking Construction*, HMSO [online] available at: http://constructingexcellence.org.uk/wp-content/uploads/2014/10/rethinking_construction_report.pdf [Accessed 15 April 2020]

[6] Constructing Excellence (2009) *Never Waste A Good Crisis*, [online] available at: https://constructingexcellence.org.uk/resources/never-waste-a-good-crisis/ [Accessed 15 April 2020]

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[8] British Standards Institution (2019) BS EN ISO 19650 *Organization and digitization of information about buildings and civil engineering works, including building information modelling - Information management using building information modelling*, London: BSI

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[10] Construction Industry Council (2013) *Outline Scope of Services for the Role of Information Management*, 1st Edition, London: CIC [online] available at: http://cic.org.uk/download.php?f=outline-scope-of-services-for-the-role-of-information-managment.pdf [Accessed 15 April 2020]

[11] British Standards Institution (2014) BS 1192-4:2014 *Collaborative production of information. Fulfilling employer's information exchange requirements using COBie. Code of practice*, London: BSI

Section 3
BIM: Level of definition and digital plan of work

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BIM emphasises the need for clarity. It makes us ask:

- *What* level of information needs to be provided by each role?
- *Who* will provide it?
- *When* will it be provided and how?

A clear plan of work is also essential. The most generally used plan in the UK is the RIBA Digital Plan of Work. In the USA the AIA schema (B101-2017 family of documents and G202-2013 BIM Protocol) is used.

This guidance provides a description of the actions, outcomes and deliverables (including level of definition of information) normally associated with each of the seven stages of the 2013 RIBA Digital Plan of Work. Figure one shows the general comparison with the AIA schema and Level of Development Specification.

RIBA (2013)			AIA (2007)	
Stage		Default LOD	Stage	Default LOD
1	Preparation and brief	1		
2	Concept design	2	Schematic design	100
3	Developed design	3	Design development	200
4	Technical design (Only in UK for complex or critical elements)	4	Construction documents	300 350
5	Construction	5	Construction phase	400
6	Handover close out	6	Project completion	500
7	In use	6		

***Figure one** RIBA Plan of Work compared to AIA Schema*

Each project will have its own requirements for level of definition of information at each stage. This is dependent on the complexity, risk profile and procurement approach. These need to be defined early in the project programme. Having a normalised approach gives clarity to how specific project requirements differ from this norm.

What is the difference between level of detail and level of definition?

It is very important to avoid confusion between level of detail and level of definition (development in the US):

- **Level of definition** is a collective term used for (and including) 'level of model detail' and the 'level of information detail'
- **Level of model detail** is a description of graphical content of models at each of the stages defined. Essentially this is how much detail is included in the model element
- **Level of model information** is a description of non-graphical content of models at each of the stages defined. This is the degree to which the detail and attached information has been thought through, ie the degree to which project team members may rely on the information when using the model
- **Information model** is a model comprised of documentation, graphical and non-graphical information

The actions, team deliverables and structural engineer deliverables for each RIBA stage

The structural engineer's contract needs a clear scope of services defining the 'what, when and how' of the role. And, because BIM is about integration, the scope of services needs to define "who" the other parties are. It should also define the "what, when and how" of their roles. Things to consider include:

- Project stages for the creation and refinement of information and defining standards for information
- What is the extent of the structural engineer's design responsibilities? Which systems is the structural engineer responsible for and to what stage of refinement? This may be best shown in component responsibility matrices
- What is the extent of the structural engineer's management and integration responsibilities?
- What information is expected at each stage from the structural engineer (extent and level of definition)?
- What information is expected from others at each stage (extent and level of definition)?
- In what format is the information to be delivered to others?
- What are the responsibilities of other parties? Critically, who is responsible for co-ordination and information/ model management?
- What are the obligations for reviewing information delivered to the structural engineer by others? This includes the further development of the structural engineering by other parties

The following tables suggest the actions, team deliverables and structural engineer deliverables for each RIBA stage. This is not to be confused with stages of BIM maturity according to BS EN ISO 19650. Team deliverables and structural engineer deliverables are given in separate columns. Any differences are highlighted in bold black text.

Stage 1 – Preparation and brief

Actions	Team deliverables	Structural engineer deliverables
Establish the Project Objectives, Business Case, Employer priorities and aspirations for project needs, performance and external influences, with benchmarking against previous relevant projects	The project brief defining: the project needs: definition of function(s), operation, quality, benefit, value and time	**Information in support of** defining the project needs
Describe the performance requirements and acceptance criteria, including: • Function • Mix of uses • Scale • Location • Quality • Cost (Opex and Capex) • Value • Time • Risk • Health and safety • Carbon (embodied and in use) • Environment and sustainability	The performance requirements, which cover priorities and aspirations, determine acceptance criteria for: • Function • Mix of uses • Scale • Location • Quality • Cost (Capex and Opex) • Value • Time • Health and safety • Carbon (embodied and in use) • Energy and resource needs • Commissioning, testing and validation • Design life and decommissioning	
Employer management systems for information and decision making	• The management systems and approval policies	
Site, operational and legal constraints	• Site, operational and legal constraints	
Safety, cost, contract and risk constraints	• Approach to allocation of risk and risk management • Procurement constraints	
Outcome		
Employer approval of the project brief, setting out the Stage 1 definition information and forming the basis for the development of the Stage 2 concept definition for the project		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		

Stage 2 – Concept design

Actions	Team deliverables	Structural engineer deliverables
Establish the refined project brief and approved concept: scope, scale, form and budget for the project, including obtaining site studies and construction and specialist advice Update feedback from previous relevant projects Carrying out technical strategy studies and determine the primary design criteria, design options, cost estimates, and selection of the preferred design option Confidence level appropriate to a design contingency of 20 to 25%	Integrated concept for the **project** setting scope, scale, form and primary design criteria:	Integrated concept for the **structure** setting scope, scale, form, function and primary design criteria, **integrated with**:
	• Architectural form and spatial arrangements	Architectural form, spatial arrangements
	• Structural/civil philosophy and spatial arrangements, technical strategy studies	Technical strategy studies
	• Services philosophy and spatial arrangements, technical strategy studies	Services philosophy and spatial arrangements, technical strategy studies
	• Commissioning philosophy	Commissioning philosophy
	• Preliminary assessment of energy use and carbon (embodied and in use)	
	• Strategies for: - - Access and egress - Acoustics - Fire resistance - Thermal performance - **Glazing, daylight and illumination** - Ground movements - **Control systems** - **Systems resilience** - Carbon - Energy and natural resource use - In-use performance - Procurement	• **Information in support of** strategies for: - Access and egress - Acoustics (vibration and structure borne noise) - Fire resistance - Thermal performance - Ground movements - Carbon - Energy and natural resource use - In-use performance - Procurement
	Strategies to address interface issues on and off-site	Strategies to address interface issues on and off-site
	Construction requirements and compatibility with site constraints	Construction requirements and compatibility with site constraints
		Input into:
	Capital cost plan	• Capital cost plan
	Maintenance cost plan	• Maintenance cost plan
	Outline design and construction programme	• Outline design and construction programme
	Health and safety risk management strategy	• Health and safety risk management strategy
	Value management strategy	• Value management strategy
Outcome		
Employer approval of the Stage 2 Concept Report; graphic and technical information setting out the integrated concept for the project demonstrating how the project brief is achieved and forming the basis for development of the Stage 3 design		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		

Stage 3 – Developed design

Actions	Team deliverables	Structural engineer deliverables
Developing in detail the approved Concept to provide a co-ordinated Developed Design; establishing the detailed form, character, function and cost plan, defining all components in terms of overall size, typical detail, performance and outline specification Technical studies in support of the Developed Design Confidence level for information appropriate to a design contingency of 10 to 15%	**Co-ordinated** Developed Design for the **project** setting:	**Integrated** Developed Design for the **structure** setting:
	• Detailed form, function, cost plan	• Detailed form, function
	• Defining all components in terms of: - Overall size - Typical detail - Performance and outline specification	• Defining all components in terms of: - Overall size - Typical detail - Performance and outline specification
	• Primary geometry frozen	• Primary geometry frozen
	• Builder's work strategy for significant interfaces	• Builder's work strategy for significant interfaces
	• **Room information sheets**	
	Assessments for:	**Information in support of** assessments for:
	- Access and egress - Acoustics - - Fire resistance - Thermal performance - **Glazing, daylight and illumination** - Ground movements - **Control systems** - **Systems resilience** - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing	- Access and egress - Acoustics (**vibration and structure borne noise**) - Fire resistance - Thermal performance - Ground movements - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing
		Input into:
	Commissioning, testing and validation plan	• Commissioning, testing and validation plan
	Maintenance plan and cost plan	• Maintenance plan and cost plan
	Procurement plan and pricing schedule	• Procurement plan and pricing schedule
	Detailed design and construction programme	• Detailed design and construction programme
	Detailed construction methodology	• Detailed construction methodology
	Health and safety risk management	• Health and safety risk management
	Risk management plan	• Risk management plan
	Value management plan	• Value management plan
Outcome		
Employer approval of the co-ordinated Developed Design, graphic and technical information demonstrating how the project brief is achieved and forming the basis for the development of production information		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		

Stage 4 – Technical design

Actions	Team deliverables	Structural engineer deliverables
Producing the detailing, sizing, positioning, performance definition, specification and operation and maintenance requirements of all systems and elements Confidence level appropriate to a design contingency of 5 to 10%.	Integrated production information for the **project** setting:	Integrated production information for the **structure** setting:
	• Specific element design and specification	• Specific element design and specification **(excluding temporary works, formwork, reinforcement detailing and schedules)**
	• Performance, quality, operation and maintenance requirements	• Performance, quality, operation and maintenance requirements
	System co-ordination	**Structural** system co-ordination
	Builders work for significant interfaces	Builders work for significant interfaces
	Refined assessments for:	**Information in support** of refined assessments for:
	- Access and egress - Acoustics - - Fire performance - Thermal performance - **Glazing, daylight and illumination** - Ground movements - **Control systems** - **Systems resilience** - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing	- Access and egress - Acoustics (**vibration and structure borne noise**) - Fire performance - Thermal performance - Ground movements - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing
		Input into:
	Commissioning, testing and validation plan	• Commissioning, testing and validation plan
	Maintenance plan	• Maintenance plan
	Procurement plan	• Procurement plan
	Capital pricing schedule	• Capital pricing schedule
	Maintenance cost plan	• Maintenance cost plan
	Detailed construction programme	• Detailed construction programme
	Detailed construction methodology	• Detailed construction methodology
	Health and safety risk management	• Health and safety risk management
	Risk management plan	• Risk management plan
	Initial submissions to statutory authorities	• Initial submissions to statutory authorities
	Design stage environmental accreditation certification	• Design stage environmental accreditation certification
Outcome		
Completion of integrated production information (graphic and technical) enabling either construction (where the contractor is able to build directly from the information prepared), or the production of fabrication, manufacturing and installation information for construction		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		

Stage 5 Review – Construction

Actions	Team deliverables	Structural engineer deliverables
Reviewing the Stage 5 fabrication, installation and construction (F&C) information prepared by others for general conformity with design intent of the production information / CCRs Review updated F&C Information incorporating As-constructed Information	Acceptance of the fabrication, installation and construction information including:	Acceptance of the **structural** fabrication, installation and construction information including:
	• Complete fabrication and manufacturing details	• Complete fabrication and manufacturing details
	• System and component verification including commissioning	• System and component verification including commissioning
	• Operation and maintenance information	• Operation and maintenance information
	• Completed component **co-ordination**	• Completed component **integration**
	• **Integrated system commissioning**	
	• Final assessments for: - **Access and egress** - Acoustics - Thermal performance - **Glazing, daylight and illumination** - Ground movements - **Control systems** - **Systems resilience** - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing	• **Input into** final assessments for: - Acoustics (**vibration and structure borne noise**) - Thermal performance - Ground movements - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing
	• Maintenance plan and maintenance procurement plan	• Maintenance plan and maintenance procurement plan
	• Maintenance cost plan	• Maintenance cost plan
	• Detailed construction programme	• Detailed construction programme
	• Detailed construction methodology	• Detailed construction methodology
	• Health and safety risk management	• Health and safety risk management
	• Risk management plan	• Risk management plan
Outcome		
Employer acceptance of the fabrication, installation and construction information		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		

Stage 6 Review – Handover close out

Actions	Team deliverables	Structural engineer deliverables
Review of As-constructed Information and asset information Assist with implementation of Handover Strategy	Acceptance of the As-constructed Information and asset information including:	Acceptance of the **structural** As-constructed Information and asset information including:
	• As-constructed element, component and system information and verification including commissioning	• As-constructed element, component and system information and verification including commissioning
	• Integrated system commissioning	• Integrated system commissioning
	• Asset information	• Asset information
		Input into:
	Project logbook	• Project logbook
	Technical guide for facilities management[c]	• Technical guide for facilities management[c]
	User guide[c]	• User guide[c]
	Assistance in handover	• Assistance in handover
	Post-project review	• Post-project review
	Environmental/sustainability certification (unless post-occupancy certification required)	• Environmental/sustainability certification (unless post-occupancy certification required)

Outcome

Handover of project

Table notes:

a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650

b) Bold text highlights differences between team deliverables and structural engineer deliverables

c) Refer to Michelle Agha-Hossein (2018), Soft landings framework 2018: Six phases for better buildings (BG 54/2018), Bracknell: BSRIA

Stage 7 – In use

<table>
<tr><th>Actions</th><th>Team deliverables</th><th>Structural engineer deliverables</th></tr>
<tr><td rowspan="2">Collect feedback on the in-use performance and the process through stages 1 to 6

Update as-built information

Optional:
Implement initial aftercare and extended aftercare[b] (Occupier to ensure FM team properly resourced)</td><td>Input into review of process through Stages 1 to 6 and in-use performance</td><td>Input into review of process through Stages 1 to 6 and in-use performance</td></tr>
<tr><td>Duration of Stage 7 Services to be agreed</td><td>Duration of Stage 7 Services to be agreed</td></tr>
<tr><th colspan="3">Outcome</th></tr>
<tr><td colspan="3">Feedback on design and construction process and initial in-use performance of project
Duration of Stage 7 Services to be agreed</td></tr>
<tr><th colspan="3">Table notes:</th></tr>
<tr><td colspan="3">a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650</td></tr>
<tr><td colspan="3">b) In accordance with: Michelle Agha-Hossein (2018), Soft landings framework 2018: Six phases for better buildings (BG 54/2018), Bracknell: BSRIA</td></tr>
</table>

Section 4
BIM: Design and detailing

BIM: Design and detailing

The process of developing a BIM Information Model is a progression through design into detailing where:

- Design is creation of the system, the type and size of components and the elements
- Detailing is the dimensioning of elements and components, size and geometry of connections to other elements, and method of manufacture

Guidance in this suite on 'BIM: Level of definition and digital plan of work' describes the Stages and the level of definition at those Stages. Design and detailing are both part of the level of definition, with more design content in the early stages moving to detailing content in Stage 5. There can be no clear boundary as a component design may rely on decisions about, or knowledge of, the detailing (timber construction being an obvious example).

An information model includes both temporary and permanent works until construction is complete. Then the temporary works which are not incorporated into the permanent works are removed. For both permanent works and temporary works, the design and the detailing of the structural systems, components and elements are the responsibility of the structural engineer, but the party performing this role will vary:

- For permanent works, there is a progression from what is conventionally described as consultant design to contractor or specialist design
- Temporary works, design and detailing would usually be the responsibility of the contractor or a specialist designer

At the outset of a project preliminary decisions will be taken about the extent and level of definition of information to be prepared at each stage and the responsibilities of the various parties for this. Only in the simplest of projects will these decisions not require some degree of amendment. A review at the end of each stage would be normal. Generally, for permanent works, the detailing of components and elements will be carried out in Stage 5, and for temporary works, both design and detailing will be carried out in Stage 5.

In more complex projects it may be necessary to progress both detailing of permanent components and design of temporary works in early stages. This means information required for Stage 4 may be at LOD 5.

The responsibilities for producing the information need to be defined. As responsibility for completion of a design or the detailing may shift from one party to another any responsibilities for review and acceptance must also be defined. As detailing is more usually carried out by a different party to the one carrying out the design, the basis of the design, performance and specification must be clearly defined and recorded and included in the information model.

The following tables give comparative responsibilities for production of information at Stage 5 and the relevant review responsibilities for the permanent works information. Note that this stage refers to model completion as per RIBA and is not to be confused with stages of BIM maturity according to BS EN ISO 19650. Team deliverables and structural engineer deliverables are given in separate columns with any differences highlighted by bold black text. Distinctions between the two tables are highlighted by green text.

Stage 5: Construction – Information to be defined

Actions:	Team deliverables:	Structural engineer deliverables:
Defining the fabrication, manufacturing, installation and construction (F&C) information for all components, including all temporary works, connection details and builder's work Selecting proprietary equipment and components Verification testing of components and systems and the creation of operation and maintenance information Confidence level appropriate to a design contingency of 2 to 5%	Integrated fabrication, installation and construction information including:	Integrated **structural** fabrication, installation and construction information including:
	• Complete fabrication and manufacturing details	• Complete fabrication and manufacturing details, **for permanent and temporary works**
	• System and component verification including commissioning	• System and component verification including commissioning
	• Operation and maintenance information	• Operation and maintenance information
	• Completed component **co-ordination**	• Completed component **integration**
	• **Integrated system commissioning**	
	• Final assessments for:	• **Input into** final assessments for:
	- **Access and egress** - Acoustics - Thermal performance - **Glazing, daylight and illumination** - Ground movements - **Control systems** - **Systems resilience** - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing	- Acoustics (**vibration and structure borne noise**) - Thermal performance - Ground movements - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing
	• Maintenance plan and maintenance procurement plan	• Maintenance plan and maintenance procurement plan
	• Maintenance cost plan	• Maintenance cost plan
	• Detailed construction programme	• Detailed construction programme
	• Detailed construction methodology	• Detailed construction methodology
	• Health and safety risk management	• Health and safety risk management
	• Risk management plan	• Risk management plan
Outcome		
Employer acceptance of the fabrication, installation and construction information		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		
c) Green text highlights differences between this table (information to be defined) and the next table (review of information defined by others)		

Stage 5 Review: Construction – Review of information defined by others

Actions	Team deliverables	Structural engineer deliverables
Reviewing the Stage 5 fabrication, installation and construction (F&C) information for the permanent works prepared by others for general conformity with design intent of the production information / CCRs Review updated F&C Information incorporating As-constructed Information	Acceptance of the fabrication, installation and construction information for the permanent works including:	Acceptance of the **structural** fabrication, installation and construction information for the permanent works including:
	• Complete fabrication and manufacturing details	• Complete fabrication and manufacturing details
	• System and component verification including commissioning	• System and component verification including commissioning
	• Operation and maintenance information	• Operation and maintenance information
	• Completed component **co-ordination**	• Completed component **integration**
	• **Integrated system commissioning**	
	• Final assessments for:	• **Input into** final assessments for:
	- **Access and egress** - Acoustics - Thermal performance - **Glazing, daylight and illumination** - Ground movements - **Control systems** - **Systems resilience** - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing	- Acoustics (**vibration and structure borne noise**) - Thermal performance - Ground movements - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing
	• Maintenance plan and maintenance procurement plan	• Maintenance plan and maintenance procurement plan
	• Maintenance cost plan	• Maintenance cost plan
	• Detailed construction programme	• Detailed construction programme
	• Detailed construction methodology	• Detailed construction methodology
	• Health and safety risk management	• Health and safety risk management
	• Risk management plan	• Risk management plan
Outcome		
Employer acceptance of the fabrication, installation and construction information		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		
c) Green text highlights differences between this table (review of information defined by others) and the previous table (information to be defined)		

Section 5
BIM: Fabrication, construction and sub-contractors

BIM: Fabrication, construction and sub-contractors

An information model and the BIM process live throughout the life of a project. From inception, through design and construction, to use, future modification and eventual decommissioning. The stages of the 2013 RIBA Digital Plan of Work (PoW) take a project through to initial use ('soft landings'). However, there is benefit in continuing to update the information model through the life of a project.

It is fundamental that the fabrication and construction stage information is captured within the model from commissioning to handover (Stages 5 and 6 of the PoW). For these Stages of a project, the responsibility for the structural information will usually move from the structural consultant to a contractor and/or specialist sub-contractor. These parties have taken over the role of structural engineer for the latter stages of the project.

Contractors and sub-contractors prepare this structural information:

- The complete fabrication and manufacturing details
- System and element verification
- System and element operational information
- Temporary works
- The progressive capture of as constructed information
- The final handover information

Much of this information is based on the information produced in earlier stages and generally by others. This means there must be clarity of that basis ie it's Level of Definition (LOD) including the supporting information.

Examples include:

- Strategies for ground movements
- Movements and tolerances
- Thermal performance
- Interfaces
- Carbon
- Maintenance

A contractor or sub-contractor producing fabrication and construction information at Stage 5 will use the structural information within the information model at the end of Stage 4 as the basis for their work. Similarly, a specialist contractor may take on the responsibility for the structural information for a structural system, eg piling, a fabric roof, or standard timber components at Stage 3 or earlier.

This transfer of information highlights the importance and potential benefits of having a well planned and managed common data environment. From the outset of the project, care and effort should be invested, particularly by the employer, to ensure compatibility of data from the different parties (the roles of architecture, structural engineering, services engineering, cost, etc.).

As with other stages of the project, it is important that the responsibilities for structural information are defined. There may also be a responsibility for the party producing the information that forms the basis of fabrication and construction information to review or give acceptance for the permanent works aspects of this structural information. An example would be the structural consultant reviewing information produced by a contractor or sub-contractor.

The following tables give actions, outcomes and deliverables for both the production of information and review at Stages 5 and 6. Note that these stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650. Team deliverables and structural engineer deliverables are given in separate columns with any differences highlighted by bold black text. Distinctions between tables for the same Stage are highlighted by green text.

Similar tables could be used for review at RIBA Stage 4 and 3 if there is an earlier transfer of structural information to a specialist.

Stage 5: Construction – Information to be defined

<table>
<tr><th>Actions</th><th>Team deliverables</th><th>Structural engineer deliverables</th></tr>
<tr><td rowspan="14">Defining the fabrication, manufacturing, installation and construction (F&C) information for all components, including all temporary works, connection details and builder’s work

Selecting proprietary equipment and components

Verification testing of components and systems and the creation of operation and maintenance information

Confidence level appropriate to a design contingency of 2 to 5%</td><td>Integrated fabrication, installation and construction information including:</td><td>Integrated structural fabrication, installation and construction information including:</td></tr>
<tr><td>• Complete fabrication and manufacturing details</td><td>• Complete fabrication and manufacturing details, for permanent and temporary works</td></tr>
<tr><td>• System and component verification including commissioning</td><td>• System and component verification including commissioning</td></tr>
<tr><td>• Operation and maintenance information</td><td>• Operation and maintenance information</td></tr>
<tr><td>• Completed component co-ordination</td><td>• Completed component integration</td></tr>
<tr><td>• Integrated system commissioning</td><td></td></tr>
<tr><td>• Final assessments for:</td><td>• Input into final assessments for:</td></tr>
<tr><td>- Access and egress
- Acoustics
- Thermal performance
- Glazing, daylight and illumination
- Ground movements
- Control systems
- Systems resilience
- Carbon (embodied and in-use)
- Energy and natural resource use
- In-use performance
- Whole life costing</td><td>- Acoustics (vibration and structure borne noise)
- Thermal performance
- Ground movements
- Carbon (embodied and in-use)
- Energy and natural resource use
- In-use performance
- Whole life costing</td></tr>
<tr><td>• Maintenance plan and maintenance procurement plan</td><td>• Maintenance plan and maintenance procurement plan</td></tr>
<tr><td>• Maintenance cost plan</td><td>• Maintenance cost plan</td></tr>
<tr><td>• Detailed construction programme</td><td>• Detailed construction programme</td></tr>
<tr><td>• Detailed construction methodology</td><td>• Detailed construction methodology</td></tr>
<tr><td>• Health and safety risk management</td><td>• Health and safety risk management</td></tr>
<tr><td>• Risk management plan</td><td>• Risk management plan</td></tr>
<tr><th colspan="3">Outcome</th></tr>
<tr><td colspan="3">Employer acceptance of the fabrication, installation and construction information</td></tr>
<tr><th colspan="3">Table notes:</th></tr>
<tr><td colspan="3">a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650</td></tr>
<tr><td colspan="3">b) Bold text highlights differences between team deliverables and structural engineer deliverables</td></tr>
<tr><td colspan="3">c) Green text highlights differences between this table (information to be defined) and the next table (review of information defined by others)</td></tr>
</table>

Stage 5 Review: Construction review of information defined by others

Actions	Team deliverables	Structural engineer deliverables
Reviewing the Stage 5 fabrication, installation and construction (F&C) information for the permanent works prepared by others for general conformity with design intent of the production information / CCRs Review updated F&C Information incorporating As-constructed Information	Acceptance of the fabrication, installation and construction information for the permanent works including:	Acceptance of the **structural** fabrication, installation and construction information for the permanent works including:
	• Complete fabrication and manufacturing details	• Complete fabrication and manufacturing details
	• System and component verification including commissioning	• System and component verification including commissioning
	• Operation and maintenance information	• Operation and maintenance information
	• Completed component **co-ordination**	• Completed component **integration**
	• **Integrated system commissioning**	
	• Final assessments for:	• Input into final assessments for:
	- **Access and egress** - Acoustics - Thermal performance - **Glazing, daylight and illumination** - Ground movements - **Control systems** - **Systems resilience** - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing	- Acoustics (**vibration and structure borne noise**) - Thermal performance - Ground movements - Carbon (embodied and in-use) - Energy and natural resource use - In-use performance - Whole life costing
	• Maintenance plan and maintenance procurement plan	• Maintenance plan and maintenance procurement plan
	• Maintenance cost plan	• Maintenance cost plan
	• Detailed construction programme	• Detailed construction programme
	• Detailed construction methodology	• Detailed construction methodology
	• Health and safety risk management	• Health and safety risk management
	• Risk management plan	• Risk management plan
Outcome		
Employer acceptance of the fabrication, installation and construction information		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		
c) Green text highlights differences between this table (review of information defined by others) and the previous table (information to be defined)		

Stage 6 – Handover close out

Actions:	Team deliverables:	Structural engineer deliverables:
Preparation of As-constructed Information and asset information Assist with implementation of Handover Strategy	Preparation of the As-constructed Information and asset information including:	Preparation of the **structural** As-constructed Information and asset information including:
	• As-constructed element, component and system information and verification including commissioning	• As-constructed element, component and system information and verification including commissioning
	• Integrated system commissioning	• Integrated system commissioning
	• Asset information	• Asset information
		Input into:
	Project logbook	• Project logbook
	Technical guide for facilities management[d]	• Technical guide for facilities management[d]
	User guide[d]	• User guide[d]
	Assistance in handover	• Assistance in handover
	Post-project review	• Post-project review
	Environmental / sustainability certification (unless post-occupancy certification required)	• Environmental/sustainability certification (unless post-occupancy certification required)
Outcome		
Handover of project		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		
c) Green text highlights differences between this table (Stage 6) and the next table (Stage 6 review)		
d) Refer to Michelle Agha-Hossein (2018), Soft landings framework 2018: Six phases for better buildings (BG 54/2018), Bracknell: BSRIA		

Stage 6 Review – Handover close out

Actions:	Team deliverables:	Structural engineer deliverables:
Review of As-constructed Information and asset information Assist with implementation of Handover Strategy	Acceptance of the As-constructed Information and asset information including:	Acceptance of the **structural** As-constructed Information and asset information including:
	• As-constructed element, component and system information and verification including commissioning	• As-constructed element, component and system information and verification including commissioning
	• Integrated system commissioning	• Integrated system commissioning
	• Asset information	• Asset information
		Input into:
	Project log book	• Project log book
	Technical guide for facilities management[d]	• Technical guide for facilities management[d]
	User guide[d]	• User guide[d]
	Assistance in handover	• Assistance in handover
	Post-project review	• Post-project review
	Environmental / sustainability certification (unless post-occupancy certification required)	• Environmental/sustainability certification (unless post-occupancy certification required)
Outcome		
Handover of project		
Table notes:		
a) Stages refer to model completion as per RIBA and are not to be confused with stages of BIM maturity according to BS EN ISO 19650		
b) Bold text highlights differences between team deliverables and structural engineer deliverables		
c) Green text highlights differences between this table (Stage 6 review) and the previous table (Stage 6)		
d) Refer to Michelle Agha-Hossein (2018), Soft landings framework 2018: Six phases for better buildings (BG 54/2018), Bracknell: BSRIA		

Section 6
BIM: existing structures, alteration and addition

BIM: existing structures, alteration and addition

Introduction

This high-level guidance outlines what needs to be considered when looking at using BIM for existing structures. Guidance on the approach to appraisal of existing structures can be found in existing industry documentation.

Using BIM for existing structures still requires collecting data about the existing asset. There are also new ways to obtain data, different data to process and the ability to collate it all in a model environment.

A key consideration is how much of the existing building should be modelled. There is no fixed answer to this. It depends on a balance of:

- Project requirements
- Required certainty
- Cost
- Nature and length of the proposed works

Restricting the modelling to what the structural engineer is changing is perhaps short sighted if other disciplines are modifying other areas and therefore coordinating with other elements of the structure.

The level of detail and confidence in modelled items also needs to be considered. Items which are changing require modelling in more detail than those which are just for coordination. It is important to convey the accuracy of the information presented in the model. Also, it is important to be aware of the difference between re-creating design intent (eg for analysis or documentation) and documenting actual conditions (affects precision).

Using existing information – potential sources

Potential sources of existing information include:

- Initial sketches
- Record 2D drawings
- Record 3D design model
- As constructed model (point cloud, either at completion or retrospective)

Data capture

Capturing information about existing assets requires consideration of the following points:

- Different tools and techniques and the pros and cons of each, including:
  - Point cloud
  - Lidar
  - Photogrammetry
  - Drone
- Limitations of data capture, both in terms of how the data can be captured, the accuracy of the data and the ability to use the data:
  - Access
  - Time restrictions
  - Dimensional accuracy (eg flange thicknesses, hidden detail)
  - Model size and manipulation
  - File storage, archival and transmittal
- Time to acquire and process data and limitations

Detailed guidance is readily available from suppliers of the relevant equipment and services and from other professional bodies and standards bodies.

How the information is processed

Data will require post processing to a greater or lesser extent. Key considerations are:

- Who models existing buildings: surveyor? Each professional modelling their own discipline? Architect modelling everything? Should this vary by design stage?
- How is the accuracy captured (plan accuracy, dimensional accuracy, verticality, etc)? Where does this risk lie?
- How are assumptions and rationalisations captured if turned into a 3D graphical environment?

Other matters to consider

- How to model underground structures, survey techniques and recording accuracy/tolerance? Level of development is irrelevant for an existing asset as it is already developed. The level of accuracy/confidence is required. This could be categorised as: assumed, based on existing documentation, field verified by survey and laser scan model
- What about precision? Steel columns all slightly different for the same serial size. Age/material affects this. How much granularity is it necessary to consider for the required purpose?
- How to make sure that the level of design development is suitably annotated to avoid it 'looking better than it is'
- How to identify what is not known as well as what is known? Eg the existing structural model from record drawings may not cover steel connections, end plates etc.
- How to identify updates as more knowledge becomes available?
- How to tackle data attached to the model? Eg materials testing associated with testing of structural elements

Section 7
BIM: Contractual implications

BIM: Contractual implications

How does a BIM project differ from a non-BIM project from a contractual perspective?

Superficially it does not. The structural information is created and refined in stages and used to manufacture or construct the asset. It is also used by other disciplines to inform their development and refinement of the information.

However, the way information is produced and shared, and the responsibilities for sharing, reviewing and updating that information is different. Also, as BIM projects are intended to continue beyond completion through to handover and in-use stages, the structural information needs to be updated to incorporate the as-constructed information and modifications thereafter.

The need for clarity

BIM projects need clearly set out:

- Procedures for information exchange; formats etc (information management role)
- Responsibilities through all stages including 'in-use' and the allocation of those responsibilities to the various parties involved (consultants, specialists, contractors, facility managers and the employer)

With BIM:

- Co-ordination should improve, but who is responsible?
- Expectations for the accuracy of information in a BIM model will tend to be higher as it is digital, not just a line on paper

BIM emphasises the need for clarity over what level of information is to be provided both when and how. It will expose any weaknesses in this. 90% of all claims against design consultants have 'lack of clarity in the scope of services' as the root cause. BIM, if not addressed carefully, will make this worse. But the rigour of BIM has the potential to improve the situation.

What are the risks?

Perhaps the greatest risks come from:

- The meaning of BIM being ill-defined: a structured BS EN ISO 19650[1] approach with Execution Plan and BIM Protocol? Or just an informal collaborative approach?
- Obligations to deliver information in a format that is unfamiliar or requires software to be purchased
- Copyright licenses and ownership of information: maintaining the normal approach of granting licences for use of information and avoiding assigning rights
- Integrity of data: reliability and interoperability of software are likely to be beyond the control of the structural engineer, so they should avoid taking on such responsibility
- Reliability of information relating to existing structures and temporary works

BIM also increases the risks from:

- Misaligned scopes of services requiring well defined structural information in advance of other disciplines: giving the potential for significant reworking and change as others catch up
- The potential responsibility for updating structural information to reflect what has been constructed, and later alterations

Scope of services

The structural engineer's contract needs a clear scope of services defining the "what and when" of the role. And, because BIM is about integration, the scope of services needs to define "who" the other parties are and the "what and when" of their roles:

- Project stages for the creation and refinement information, and defining standards for information?
- What is the extent of the structural engineer's design responsibilities? Which systems is the structural engineer responsible for and to what stage of refinement? This may be best shown in component responsibility matrices
- What is the extent of the structural engineer's management and integration responsibilities?
- What information is expected at each stage from the structural engineer (extent and level of detail)?
- What information is expected from others at each stage (extent and level of detail)?
- In what format is the information to be delivered to others?
- What are the responsibilities of other parties? Critically, who is responsible for co-ordination and information/ model management?
- What are the obligations for reviewing information delivered to the structural engineer by others, including the further development of the structural engineering by other parties?

The more complex a project the more detailed the scope of services should be.

Handing over information to specialists and contractors

In most projects, the structural engineer will hand over information to specialists or contractors for them to complete the information for construction. The structural engineer's contract and that of the receiving party need to define:

- What information is to be handed over
- Its level of detail
- What further development is required
- Responsibilities for review

Using standard contracts

The standard forms of construction contract have generally side-stepped BIM by simply proposing the addition of a BIM Protocol, which sets out procedures and duties. Care is needed here as the protocol may not be sufficiently detailed or cover sharing of information outside the model, eg reports and calculations.

If this is your first BIM project, contact your insurers and have your draft contract reviewed by them.

References

[1] British Standards Institution (2019) *BS EN ISO 19650 Organization and digitization of information about buildings and civil engineering works, including building information modelling - Information management using building information modelling*, London: BSI

Background reading

CIC (2018) *Building Information Modelling (BIM) Protocol* – 2nd Edition, London: CIC, [online] available at: http://cic.org.uk/admin/resources/bim-protocol2nd-edition-1.pdf [Accessed: 15 April 2020]

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BIM: Legal implications

This guidance must be read in conjunction with that on BIM: Contractual implications

Legal authority and insurers are consistent in the view that stage 2 BIM does not materially alter the legal or insurance framework that structural engineers are used to working with.

What issues do contracts need to address?

Contracts need to address these new issues:

- Models and what information they contain
- Model hosting, storage and security
- Accuracy of digital data
- Interoperability of systems, clash detection and checking
- Copyright licences and ownership of information
- Risk allocation and clarity of roles and responsibilities
- Reliability of historic BIM information
- Tiered dispute resolution
- Is the model considered as goods or products subject to statutory implied terms of fitness for purpose?

Most standard forms of construction contract have generally side-stepped BIM by simply proposing the addition of a BIM Protocol, setting out procedures and duties. Care is needed here as the Protocol may not be sufficiently detailed or cover the above issues.

Bespoke contracts may seek to address the issues by pushing liability away from the employer without adequately addressing how liability and risks are apportioned across the project.

Whilst the legal framework has not changed, BIM projects have the potential to increase liability through:

- Lack of clarity about responsibilities
- The imposition of onerous responsibilities that the structural engineer may not be familiar with

Useful references

CIC (2013) *Best Practice Guide for Professional Indemnity Insurance when using Building Information Models*, London: CIC [online] available at: http://cic.org.uk/download.php?f=best-practice-guide-for-professional-indemnity-insurance-when-using-bim.pdf [Accessed: 15 April 2020]

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