BIM FOR PRODUCTION: BENEFITS AND CHALLENGES FOR ITS APPLICATION IN A DESIGN-BID-BUILD PROJECT

Paula Mota, Fernanda Machado, Clarissa Biotto, Ricardo Mota, Bruno Mota
Design-Bid-Build Projects

Planned Design-Bid-Build

- Single-stage tender
- Design is completed before construction starts
- Consultant team develops detail design for client
- Contractor is appointed (usually) under a lump-sum contract

“Least risky approach” for client due to certainty in design, cost and duration

Contractor has no responsibility for design, but may suffer penalties for late completion
Building Information Modelling (BIM)

• BIM pulls a technological and procedural change that tends to affect everyone involved in the construction industry (Succar et al., 2007 cited in Guillermo et al. (2009))

• The implementation of BIM systems requires drastic changes in current business practices (Aouad and Arayici 2009)
Maturity at BIM Stages (Succar 2009)

**Stage 1**
Stakeholders deploy object-based 3D parametric software tools to generate single-disciplinary models.
Unsynchronised communication.

**Stage 2**
Stakeholders collaborate and exchange information with other disciplinary players.
Model-based collaboration may occur within one or between two stages of the product development: design-design stakeholders, or design-construction, etc.
Unsynchronised communication.
Requires some contractual arrangements.

**Stage 3**
Integration and collaboration of stakeholders across the project lifecycle phases.
Synchronised communication.
Complex analysis about constructability, operability and safety, and other nD modelling.
Requires reconsiderations of contractual relationships, risk-allocation and workflows.
The Case Study: BS Design Corporate Towers
BS Design Corporate Towers

- Fortaleza - Brazil
- 17 floors of commercial offices
- 4 floors for public use
- 5 floors of car parking
- Total area: 10,000m²

- Design started in 2012
In 2014, owner hired a BIM Manager company to 3D BIM modelling:
- clash detection,
- quantity take-offs,
- structural analysis,
- studies of lighting,
- manufacturing pre-casted elements, etc
In total, 18 disciplines were modelled
BS Design Corporate Towers

Planned Design-Bid-Build
- Design
- Tendering
- Construction

Actual Design-Bid-Build
- Design
- Tendering
- Construction
BIM Modelling Process

**INPUT**
- EIR

**PROCESS**
- DEVELOPMENT
  - 2D Design
- BIM Modelling for Design
  - Validation
- BIM Modelling for Production
  - Validation
- BIM Modelling for As-Built

**OUTPUT**
- 3D Detailing Drawings
- Clash Detection Reports
- Quantity Take-Off Spreadsheets
- Specification Spreadsheets
- Site and Construction Planning Animation

**STAKEHOLDERS**
- Owner
- Designers
- SIPRO
- Builder & Designers
- Builder & Contractor

**DESIGN PHASE** | **CONSTRUCTION PHASE**
Demands From Design

- **Lean process analysis**
- Spatial analysis
- Selection and Specification based on constructability analysis
- Visual communication
- Clash detection
- Quantity take-off
- Construction planning
- Construction logistics
Demands From Design

- Lean process analysis
- **Spatial analysis**
- Selection and Specification based on constructability analysis
- **Visual communication**
- Clash detection
- Quantity take-off
- Construction planning
- Construction logistics
Demands From Design

- Lean process analysis
- Spatial analysis
- Selection and Specification based on constructability analysis
- Visual communication
- Clash detection
- Quantity take-off
- Construction planning
- Construction logistics
Demands From Design

- Lean process analysis
- Spatial analysis
- Selection and Specification based on constructability analysis
- Visual communication
- Clash detection
- Quantity take-off
- Construction planning
- Construction logistics
Demands From Design

- Lean process analysis
- Spatial analysis
- Selection and Specification based on constructability analysis
- Visual communication
- Clash detection
- Quantity take-off
- Construction planning
- **Construction logistics**
Demands from Manufacturing

• Sheet Steel forming and site set-out based on constructability analysis

• 2800 mark-ups holes in steel beams saved R$1,128,000.00 ≈ £250,000.00
Demands from Construction

- Constructability analysis
- Quantity take-off
- Structural analysis
- Field BIM
- Construction planning
Demands from Construction

- Constructability analysis
- Quantity take-off
- Structural analysis
- Field BIM
- Construction planning
Demands from Construction

• Constructability analysis
• Quantity take-off
• Structural analysis
• Field BIM
• Construction planning
Demands from Construction

- Constructability analysis
- Quantity take-off
- Structural analysis
- Field BIM
- Construction planning
Results Analysis

• 29 design solutions divided in 7 categories:
  1. If the solution was part of the design process, or if it was requested as an extra information out of the design development;
  2. The nature of the solution: if it regarded the manufacturing, construction or design process;
  3. In which phase of the product development process the solution was generated: during design or construction;
  4. Who requested the development of the solution (builder, designers or SIPPRO);
  5. Who generated the solution (builder, designers, SIPPRO or manufacturer);
  6. Who validated the solution (builder, designers, SIPPRO, manufacturer or developer); and,
  7. If the effort to develop the solution was part of the contract between SIPPRO and the developer.
Solutions requested and developed out of the design phase.

Nature of solutions: manufacture, construction or design origin.

Phase when the solution was developed: design or construction.

RFI requester.

Solution developer.

Solution validator.
Solutions requested and developed out of the design phase.
Nature of solutions: manufacture, construction or design origin.
Solutions requested and developed out of the design phase. Nature of solutions: manufacture, construction or design origin. Phase when the solution was developed: design or construction.
Solutions requested and developed out of the design phase. Nature of solutions: manufacture, construction or design origin. Phase when the solution was developed: design or construction. RFI requester. Solution developer. Solution validator.
Solutions requested and developed out of the design phase.

Nature of solutions: manufacture, construction or design origin.

Phase when the solution was developed: design or construction.

Solutions requested and developed out of the design phase.

Nature of solutions: manufacture, construction or design origin.

Phase when the solution was developed: design or construction.

Nature of solution v.s. Phase it was requested.

Solutions part of the SIPPRO’s contract scope.
Conclusive Discussion

- Several demands from design, manufacturing and construction occurred due to the lack of detailed information in the drawings/models → high volume of design solutions developed during the construction phase.
- The main responsible for generating new design solutions for production was the consultant company SIPPRO.
  - new skilled player to generate the BIM for production models,
- The D-B-B stimulates Stage 1 of BIM Maturity, although the project achieved Stage 2.
- Other procurement routes that promote concurrent engineering should be adopted to implement BIM throughout the design and construction phases.
- AEC industry needs to overcome contractual issues, i.e., to predict an early contractor involvement to design the production system aligned to the product design.
Acknowledgements

• SIPPRO - Solutions for Production Planning

• BSPAR Developer and Construction

• Coordination for the Improvement of Higher Education Personnel - Brazil (CAPES)