BUILDING INFORMATION MODELLING IN USE OF SUSTAINABLE BUILDING CONSTRUCTION PROJECT

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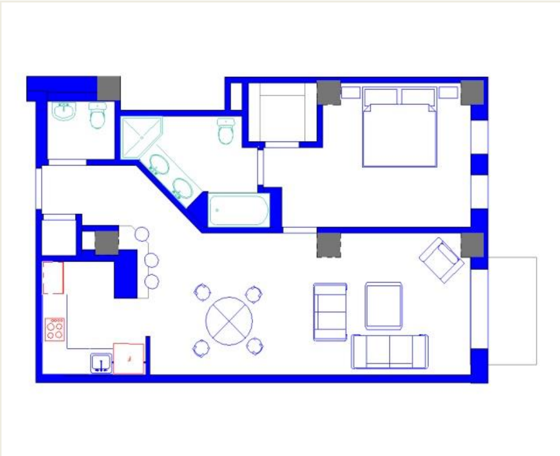
Abstract
The construction industry has its own quality of day today construction project work. This factor make the construction industry different from other industry because of the change and development of technology, production and other business have changed their process leaving behind construction industry. The main problem is still remained labour involving a lot of work construction industry in most of the countries including India. The mainly construction industry is still following same traditional process of generating drawing by architects or designers and building erection by the contractors. At the time of contract is set between architects, designers and contractors, the relation begins between them. The more difficulty are change in plan takes long time to correct because of lengthy process involved which adversely affects the productivity and efficiency of the construction industry.

Introduction
Since the early 2000s, the Architecture, Engineering, Construction and Operating (AECO) industry experiences a radical development growth due to the digitization [1]. In the Building Information Modelling (BIM) research field, an exponential increase can be observed in published research since 2010 [2]. By that, it is not a surprise that BIM is increasingly applied by the AECO Industry [3,4]. Even BIM implementation strongly vary on international base due to several challenges and, thus, utilization overall is still low [1], [5]. Especially during the early design process, BIM can improve the building energy performance by design optimizations.

Early design decisions have a high impact on building energy performance and the total building lifecycle compared to its initial costs [5,6]. But it is still common, due to interoperability challenges and the high level of knowledge needed, that building energy optimization is not taking part in the earliest stages of the design process. While interoperability, i.e. the ability to exchange information between two tools is one issue, the correct provision of information within the BIM tool and post-processing is another [8].

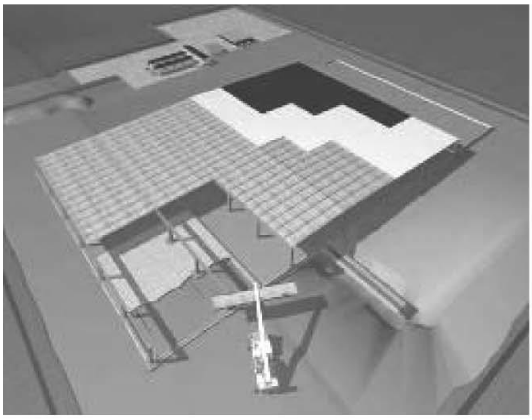
In this work, also a synopsis of literature and reports on BIM workflows are reviewed. Most of there viewed studies are scientometric based literature reviews, which are an objective method to analyze and validate the interests of research for a specific domain [9]. Based on tags and catch phrases, scientometric tools like Citespace [10] analyze publications of a certain topic. Clusters can be presented in form of consistently recurring tags, and temporal trends can be visualized on a timeline [9]. These validations represent the most relevant topics in science research. Based on the results of scientometric studies in the field of BIM [9],[2],[11],[12], it becomes remarkably clear that interoperability is nowadays a highly relevant theme in the context of digitalization of the AECO industry. Other subjects in common with interoperability are collaboration, collaborative design, and energy performance analysis [9]. Recurrent inconsistency and lack of semantic, as well as missing exchange data standards are pointed out as the most common reasons for interoperability problems. Interoperability issues and challenges are also seen as a main driving motivation for a fully utilization of BIM [12]. Common solutions for interoperability challenges are presented in chapter 3.4 to chapter 3.7 of this work.



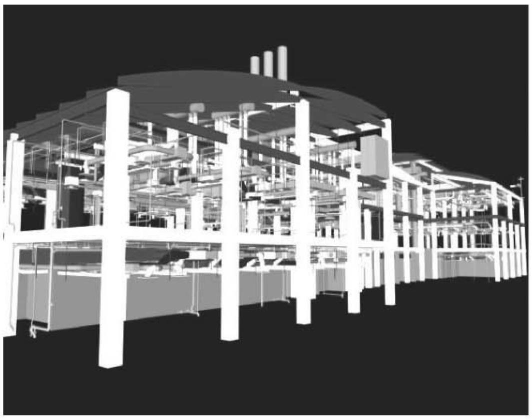
2D Building Plan **3D Building Plan**

Integration of BIM based BEM in AECO industries seems to be useful and crucial but requires professional experience, thus it is not fully integrated so far and typically realized with several challenges. Tackling such challenges can result in an increase of BIM applications, particularly in connection with BEM. Implementation and utilization of BIM increases the benefits up to 33% in cost reduction, 50% time reduction, 50% greenhouse reduction and a 50% reduction of material usage for a case study focused on a nationwide of UK as reported in [13].

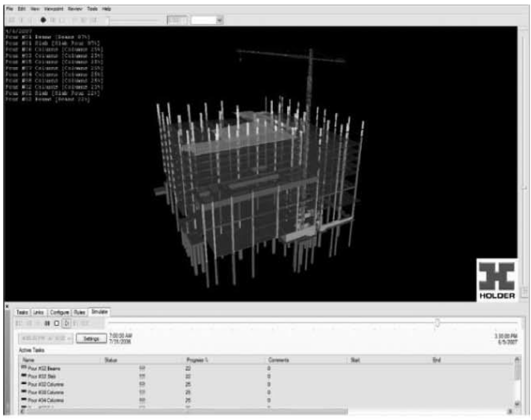
Due to literature research and AECO industry feedback, interoperability was a key challenge for the BIM India Light project [14]. Herein, the goal was to develop a BIM 2BEM framework, using Autodesk Revit (BIM) and DALEC (Day- and artificial light with energy calculation [15]). A combination of property standardization using the Austrian Standards International (ASI) property server and Industry Foundation Classes (IFC), as an open-source, international standard (ISO 16739-1:2018), was highlighted as a key approach for BIM2IndiLight. DALEC, which is principally a web-based simulation tool, runs a combined thermal, day and artificial light calculations [15]. To enable time-efficient calculations while considering complex system configurations, pre-calculations are the core of the DALEC tool concept, that performs a hourly-based, full year simulation run per room in less than a second. BIM2IndiLight aims to implement DALEC into a BIM2BEM, IFC-based approach to target building performance optimization in the early stage of design. With an integration of standardized properties, interoperability on the semantic level can be reached (see chapter 3.3) and will be applicable as a generous framework also for other tool work flows. In particular, the early implementation of standardized exchange properties herein is seen by the BIM2IndiLight project participants as a fundamental step for interoperability. The EN ISO 19650-1:2018 provides a guideline for the BIM working process [16], in which standardizing the BIM process, information description and exchange of information are the main topics. The uniform description of the processes and information during the BIM process are seen as the key values for a successful project. Since DALEC calculation encompasses the control aspects of façade and lighting, day light availability, artificial light and energy efficiency, the work on standardization for all four fields was conducted. The open access of the standardized exchange properties on the ASI property server is essential for interoperability and making the results and framework useable.



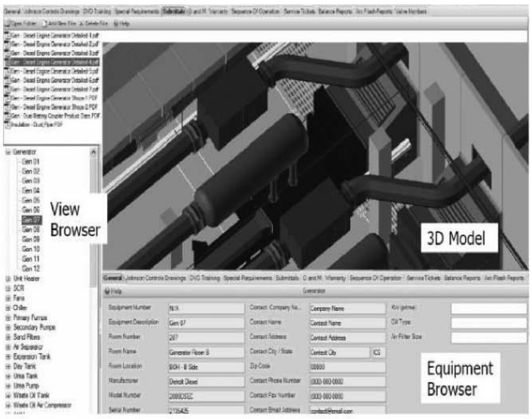
(a) Site Logistic Planning Model



(b) Integrated Structural & MEP Model



(c) Construction Sequencing Model



(d) Facility Information Model

Different components of BIM in different phases of project

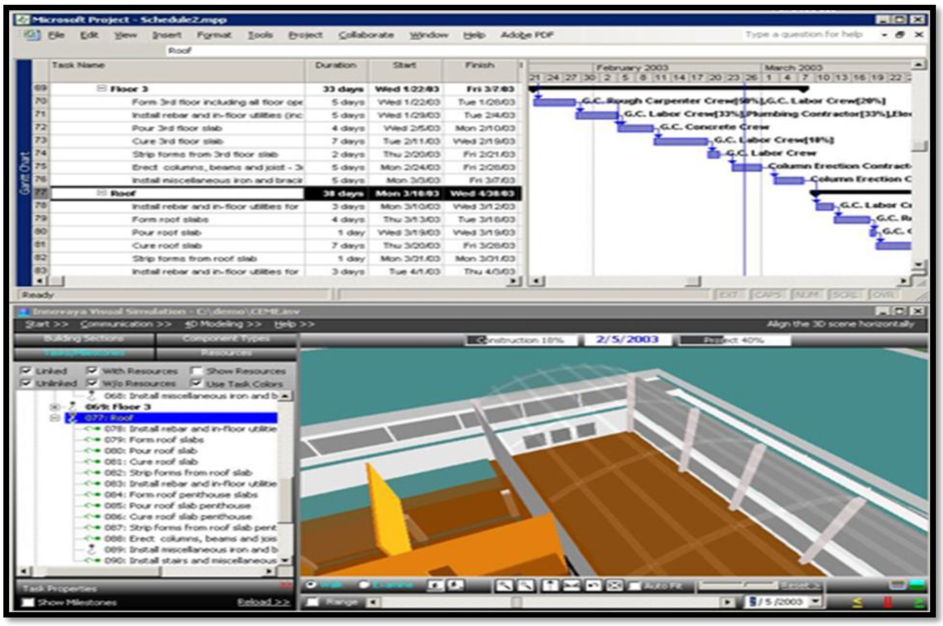
Herein, the main research question for this studies is therefore: Can open accessible and standardized properties assess in tackling the interoperability challenges? In order to address this question, this work provides a general overview on the interoperability approaches in BIM2BEM research. Besides, an in-house approach is developed within the BIM2IndiLight project and the results are presented and discussed.

BIM-based BEM

For BIM applications and utilization, it is important to distinguish between building information model, which is defined as a digital representation of an asset for supporting decision making between all stakeholders (ENISO19650 1:2019), and building information modelling, which is the process of creating and using this representation to exchange model information between different tools and stakeholders. BIM can be used as a basis for time estimation, construction costs and quantities, stress analysis, energy simulations and more.

The integrated approach of a BIM process, which encompasses a complete building lifecycle. In the core the digital asset can be observed, which is used by all project participants to communicate and to exchange information between different project participants and tools to improve design coordination, building simulation, building construction and building control [17]. Compared to the total number of companies from the AECO industry, BIM is relatively rarely applied, but due to its benefits BIM is expected to be an integral part of the industry in the future [18][19]. The utilization of the digital asset as an input for energy simulation tools is then called BIM2BEM or BIM2BEPS (building energy performance simulation). Building energy performance simulations (BEPSs) are performed by an energy simulation tool, in best case capable of using the BIM data directly or indirectly (Conversion work flow for data formats and complement information). Especially during the design stage, building energy performance can be optimized and energy demand reduced, also control strategies can be simulated and optimized for building operation [20]. For both cases, energy modelling and life cycle analysis, the digital asset is an important and central part, holding all needed information for next steps. The BIM2BEM workflow is an energy optimization process, which is taking part in the conceptual design phase, in best case, and is getting more detailed and precise during every step of the design phase. Each optimization process can be seen as an individual loop in the developing project. With each step, the building energy simulation gets closer to the operating building performance.

To secure a consistent and stable exchange of information (building object properties, geometry and topology), during the BIM2BEM workflow, interoperability is an essential requirement. Interoperability is the capability of two or more tools to exchange, understand and use data in a bidirectional flow and it is the key factor for a consistent exchange. Based on these requirements three interoperability levels can be defined [21]:
- File and syntax level: the ability of two tools to exchange files without parsing errors
- Visualization level: the ability to visualize the model being exchanged between two tools
- Semantic level: the ability to have a common understanding of a model being exchanged between two tools.



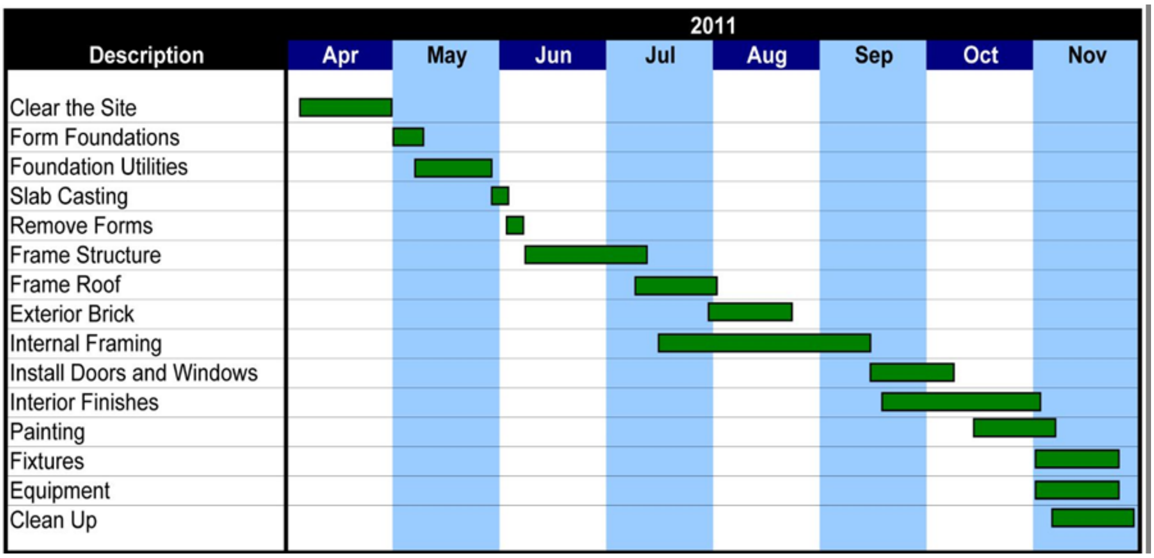
Scheduling in BIM

BIM2BEM Interoperability

In the field of BIM research, various approaches have been developed to solve interoperability problems in data exchange in the BIM process. Figure3 gives an overview of the different approaches, which are described in detail in this chapter.

In Gao et al. (2019) [16] and Farzaneh et al. (2019)[16], the BIM-based BEM process is investigated during their review papers and concluded three general approaches to reach interoperability, technology based, process based and combined approach. In this regard, 56% of these approaches are technology based. That means that they work on information exchange based on programs and interfaces (Figure3). The technology-based approach can be split into three model integration methods [22]:

1. Integrated approach: the energy simulation program is implemented as a plug in inside the BIM tool. Communication runs via the application programming interface (API). This approach runs the most stable and has the least issues with geometry translation. Disadvantages are that it is not interoperable and forces the user to use specific tools.
2. Central approach: BIM tool and BEM tool exchange information via an interface like IFC and gbXML. This approach is the most common and flexible one, it is also interoperable. Disadvantages are that both tools need to support the interface. The exchange can be in best case directly, i.e. without any converting, not compatible (if there is no way of exchange possible) or indirectly compatible, which means it must be converted.
3. Distributed model integration approach: Information between BIM and BEM are exchanged via a middleware. The middleware can be a third-party interface (TPI) like SketchUp, that performs a data schema translation (e.g. Revit to SketchUp to IDF (EnergyPlus - Information Delivery Format) or a visual programming language(VPL). In this context, typical VPLs are Rhino Grasshopper or Revit Dynamo and others. Revit can be loaded into Rhino Grasshopper (or vice versa through RhinoInside) and energy simulations are performed by simulation engines like Energy Plus, Radiance or Daysim.



Traditional scheduling

Conclusion

Besides technical solutions, it was highly desirable to develop a reproducible workflow, defining and using standardized properties for the day-and artificial light, sun shading and controlling sector. In this way, future projects can use that database for defining their project exchange information requirements on a standardized base. Software companies and different AECO companies can use the ASI property server properties instead of each defining their individual requirements. This highlights how interoperability can be achieved on the property definition layer. However, with respect to the research question of whether standardized and openly accessible properties are the solution to interoperability, it must be said that this is only part of the solution. Based on research and through the BIM2IndiLight project work, it became clear that standardized properties are essential for future interoperability challenges, but due to software companies not using these standardized properties, users of BIM tools have to integrate them manually. This process was complicated and not very common even among AECO industry professionals. Although standardized properties are available for different scenarios, the selection and integration of these properties into a BIM tool is poor due to the lack of software solutions.

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