



APPLICATION OF THE IDS STANDARD AND bSDD IN BIM WORKFLOWS: A SYSTEMATIC LITERATURE REVIEW

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Abstract

This systematic literature review (SLR) examines the overview, benefits, and challenges associated with the use of the Information Delivery Specification standard and the buildingSMART Data Dictionary Service in the BIM workflow. It underscores how the combined application of IDS and bSDD can provide significant contributions to the workflow, such as improved efficiency and accuracy, while also highlighting the challenges related to fully addressing all aspects of use case analysis. This study seeks to encourage the academic community to propose solutions to mitigate these limitations and explore the integration of IDS and bSDD in the definition and validation of requirements.

Introduction

In a digital environment, the reliability of the entire project depends directly on the integrity of the BIM (Building Information modelling) model in terms of quality (Lino et al., 2024). Quality, as defined by ISO 9000, refers to the degree to which a set of inherent characteristics of an object fulfils requirements (ISO, 2015). In the process of ensuring the quality of a model, the management of information content and its quality is crucial, since the data quality directly affects the accuracy of any analysis performed with this data (Lino et al., 2024).

To understand the role of BIM in the project life cycle, it is essential to establish a clear definition of the concept. ISO 19650 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 (ISO, 2018). BIM implementation has reformulated the traditional business model of project development and collaboration, centralizing all information in a BIM model, including both physical characteristics and alphanumeric information (Lino et al., 2024).

Given the implementation of BIM in the Construction Industry, the topic of standardizing information and processes has gained prominence (Moura et al., 2024). To achieve reliability and accuracy, some care must be taken at all stages, including the model development and the choice of methods that will be used (ABDI, 2017). Thus, with a proper specification of elements and components, it is possible to obtain a solid foundation to represent multiple views of the project (ABDI, 2017).

To address challenges related to productivity loss and limited adaptability in data used in digital asset designs, the industry has sought a standardised digital collaboration strategy, which has led to the development of openBIM, a set of open standards for building data interoperability, through buildingSMART International (buildingSMART, 2024c). These standards adopt open, non-proprietary data formats, ensuring greater flexibility and accessibility of information across various platforms (Otranto et al., 2025).

Among these standards, the Industry Foundation Classes (IFC) stand out as a standardized data model that logically codifies the identity and semantics, characteristics or attributes, and relationships of objects, abstract concepts, processes, and people (buildingSMART, 2024e).

Given this scenario, the primary objective of this study is to conduct a Systematic Literature Review (SLR) of the most pertinent academic works concerning the application of the IDS standard and bSDD within the BIM workflow. The findings derived from the SLR serve to substantiate the identification of the existing research gap and to assist a research aimed at advancing the automation of model quality verification and control processes, utilizing the IDS standard and data dictionaries.

Basic Concepts

openBIM Workflow

The openBIM workflow is any process that incorporates bSI standards and solutions (buildingSMART, 2024b). An example can be structured as represented in Figure 1. There are some key points to be considered: no workflow is unique and universal, there is no need to use all standards in all workflows, different projects require different workflows, and specific needs generate specific workflows (buildingSMART, 2024b).

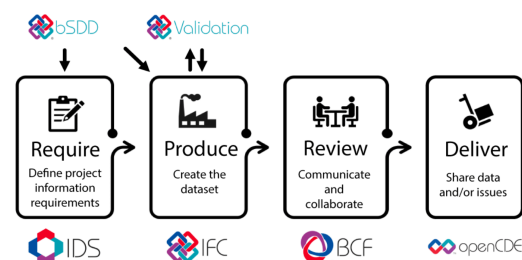


Figure 1: openBIM workflow (buildingSMART, 2024b)

The requirements for the data to be exchanged are captured in a specification (IDS). Design tools and human input generate a corresponding amount of information about the building, which is stored in a dataset (the IFC file). Both the requirements and the dataset are easily and formally interpretable thanks to references (bSDD), and the IFC file can be checked for conformity (validation). During the data exchange, which can be repeated, changes and additions are made by a tool that updates the dataset in a controlled way (BCF) and is managed in a secure and controlled digital environment (CDE) (buildingSMART, 2024c).

IDS

Information Delivery Specification (IDS) is a buildingSMART standard for defining information requirements in a computer interpretable format. With the IDS, it is possible to specify on a project level which semantic information should be attached to which objects in BIM model at particular phase of a project (Cerovsek and Omar, 2024). The IDS specification connects an XML language structure to the bSDD, i.e., it relates and verifies information based on the standard structure developed for the IFC (Garlet et al., 2023).

Every specification has three main parts: description, applicability and requirements. They are highly structured so that computer software may automatically and accurately check information requirements with no ambiguity (buildingSMART, 2024d).

bSDD

To mitigate issues related to the loss or misinterpretation of information during the exchange of specific data, data dictionaries are utilized. These are defined as centralized repositories containing information about data, including its meaning, relationships to other data, origin, usage, and format (ISO, 2020). bSDD is a service to facilitate the distribution of data dictionaries published by independent organisations. The bSDD's mission is to elevate BIM data quality and consistency, reduce misunderstandings, and enable more effective collaboration in the construction industry (buildingSMART, 2024a). Each dictionary consists of Classes and Properties, which could be related to each other or with other dictionaries. Both IFC and bSDD contain definitions of data structures. While the IFC is a standard, the bSDD is a service for distributing definitions that can be used in IFC models (extend IFC) (buildingSMART, 2024e).

Experiment

To identify existing studies in the field and acquire new insights for the research, a Systematic Literature Review (SLR) was conducted. This method, based on secondary data, was carried out in a systematic and structured manner. To ensure rigor, the primary steps proposed by Okoli (2015) were followed, as outlined in Figure 2.

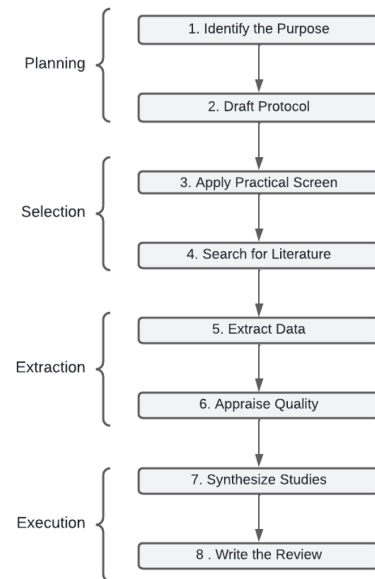


Figure 2: A systematic guide to Literature Review development

The primary objective of the SLR is to investigate the application of the IDS standard and the data dictionaries within the bSDD in the BIM workflow, as well as to examine the associated challenges and advantages. To achieve this objective, the adopted protocol was designed to address the following research questions:

- Q1: What are the contributions of utilizing the IDS standard and/or data dictionaries in workflows for quality control and verification of models?
- Q2: What are the primary challenges associated with the utilization of IDS?
- Q3: What are the main tools employed for development of IDS and for model verification?
- Q4: What functions are supported by the use of IDS and/or bSDD?
- Q5: For which BIM Model uses are IDS and/or bSDD utilized?
- Q6: What standards are most frequently cited in the preparation of the selected articles?

The search process was conducted using the title/abstract/keywords field with three keywords blocks:

- (1) BIM: (BIM OR (Building AND Information AND Model*)); AND
- (2) IDS: (IDS OR (Information AND Delivery AND Specification*)); OR
- (3) bSDD: (Data AND Dictionary) OR bSDD)).

This review selected three databases: SCOPUS, Web of Science (WoS) and Directory of Open Access Journals (DOAJ). Additionally, searches were conducted on Google Scholar and within the proceedings of the CIBW78 Conference 2024 due to their relevance to the subject matter. Several criteria were applied in the SLR conducted for this study. First, the analysis was restricted to publications in English. Second, materials such as theses, monographs, dissertations, books, and guides were excluded from the study sample. Third, the time frame considered was between 2014 and 2024, focusing on articles available in electronic format for consultation. At first, a total of 117 papers were retrieved from the selected databases. Figure 3 provides a summary of the distribution of articles across the databases.

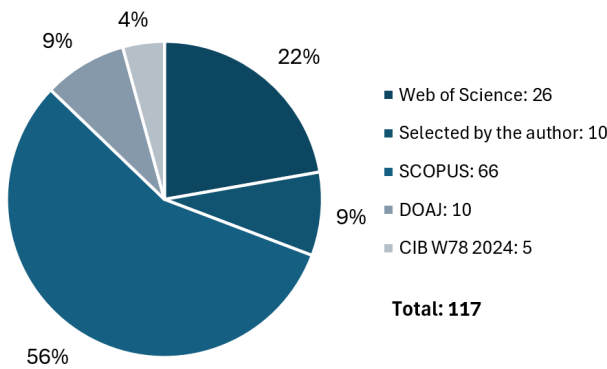


Figure 3: Distribution of articles across databases

For content analysis, inclusion criteria (IC) and exclusion criteria (EC) were established. The inclusion criteria encompassed studies addressing aspects related to IDS or data dictionaries within the BIM context. The exclusion criteria involved the removal of duplicate studies (36 articles excluded), studies outside the engineering domain (6 articles excluded) or studies that did not address IDS or bSDD (49 articles excluded).

Subsequently, the quality of the remaining papers was assessed through a detailed review of the 26 articles. The evaluation was conducted using quality questions (QQ), presented below, to determine the presence of relevant contributions in addressing the research questions formulated during the planning phase.

- QQ1: Does the study provide a description of the tools employed in the research?
- QQ2: Does the study discuss the advantages and limitations associated with the use of IDS and/or bSDD?
- QQ3: Does the study specify the BIM use cases that were analyzed?
- QQ4: Does the study address any aspects related to budgeting or cost control?
- QQ5: Does the study establish a connection between data dictionaries and IDS?

- QQ6: Does the study reference any aspects of verification/control in public works?

The responses to the questions were categorized as follows: Yes, Partially or No, corresponding to weights of 1, 0.5 and 0, respectively. This resulted in a total score ranging from 0 and 6 for each article. Only those articles that obtained scores above 3 in the quality assessment were selected for further analysis, yielding a total of 18 articles for study (Table 1).

Table 1: Quality Assessment of papers selected at SLR

Score	References
5.0	Marco et al. (2024)
4.5	Pérez-García et al. (2024)
4.0	Cerovsek and Omar (2024); Tomczak et al. (2022); Fischer et al. (2024); Garlet et al. (2023)
3.5	Bigai and Santos (2024); Garlet et al. (2024)
3.0	Mendonça and Ferreira (2024); Argasinski and Tomczak (2024); Lino et al. (2024); Scandurra and di Luggo (2023); Scandurra et al. (2024); Owerko et al. (2024); Mellenthin Filardo et al. (2024); Kremer and Beetz (2023); Tomczak et al. (2022); Trani et al. (2024)

Discussion and result analysis

Table 2 presents the distribution of selected articles. It illustrates a notable increase in research interest pertaining to the topic from 2022 onwards.

Table 2: Selected articles by year

Year	Number of articles
2022	1
2023	3
2024	14

The bSDD service experienced a substantial transformation in 2020, when it moved away from one centrally authored data dictionary curated by buildingSMART experts in favour of a distribution platform for independent dictionaries that can be mapped together by relations (buildingSMART, 2024a). In addition, version 1.0 of IDS standard was officially approved in June 2024 (buildingSMART, 2024f). Combining these advances, it can be inferred that technological progress, coupled with the increasing demand for interoperability, has contributed to the rise in scientific publications pertaining to the topic.

From the quality assessment, the first three quality criteria emerged as the most frequently cited. Among the selected articles, all of them present some advantages or limitations regarding the use of IDS and/or bSDD, as well as addressing the analyzed BIM uses, directly or indirectly. Furthermore, 16 of the 18 articles detail the tools employed. Concerning the joint use of data dictionaries and IDS, Marco et al. (2024) state that the use of IDS in conjunction with other buildingSMART tools to enrich the process, such as bSDD and BCF, can facilitate communication.

In response to quality criterion QQ5, only Pérez-García et al. (2024), Marco et al. (2024) e Fischer et al. (2024) address the use of IDS in public works for various purposes. Regarding QQ4, which pertains to the topic of budgeting or cost control in the articles, no article explicitly mentions the use of BIM for cost estimation. Only Pérez-García et al. (2024) references the use of BIM related to budgeting as a suggestion for future work, highlighting a notable gap for further exploration. After the selection and extraction of study data, this analysis stage aims to answer the research questions previously defined for the execution of the SLR.

Q1 - What are the contributions of utilizing the IDS standard and/or data dictionaries in workflows for quality control and verification of models?

The main contributions identified in the following works taught are listed below:

- **Increasing information management efficiency through collaboration and interoperability:** Based on a SWOT analysis related to the development of IDS, Cerovsek and Omar (2024) highlight that one of its strengths is that the use of IDS enhances trust, collaboration leverage, and the power of consistent models. The results of the study developed by Bigai and Santos (2024) indicate that employing open BIM standards like IDS enhances information management efficiency throughout BIM project workflows, promoting more reliable data exchange and coordination. The use of open BIM standards facilitates effective data integration at various stages of construction and operation, leading to improved project management, reduced errors, better coordination between stakeholders, and ultimately, time and cost savings (Owerko et al., 2024). Concerning the use of bSDD, Scandurra and di Luggo (2023) and Scandurra et al. (2024) assert that the use of data dictionaries promotes collaboration

among various professionals by systematizing information that can be shared and interpreted within the IFC.

- **Automation of model verification and agility in the verification process:** The concept of integrated quality assessment/quality control methodology has the potential to transform the collaboration process and the management of deliverables (Lino et al., 2024). Through experiments, Owerko et al. (2024) demonstrated the feasibility of automatically generating IDS files based on data provided by the requesting party, a feature that can streamline the model verification process and enable rapid adjustment of the level of information output table structure without requiring manual intervention. Additionally, IDS was identified by Tomczak et al. (2022) as the most advantageous method for automated compliance and validation verification of alphanumeric information requirements, as it supports requirements creation and offers users with a range of options for specifying what can be required from models.

- **Precise definition of information requirements between appointing and appointed parties:** The analysis of BIM models based on client-established information requirements is a means of producing higher quality models (Pérez-García et al., 2024). To address this need, IDS has the potential to provide the exact definition of information requirements for communication between appointing and appointed parties for each major milestone (Cerovsek and Omar, 2024). Furthermore, as identified by Cerovsek and Omar (2024) in their SWOT analysis, one notable opportunity is the chance to make templates for IDS use for specific projects or/and BIM uses, which can bring as an advantage the elaboration of future more detailed and less typological projects (Trani et al., 2024).

- **Validation of information within the IFC model:** Marco et al. (2024) explore the potential for real-time compliance verification, offering immediate feedback to designers during the model development process. They also highlight that the integration of IDS with the IFC schema can enhance workflow efficiency by seamlessly combining the design process with the validation of information requirements.

- **Using bSDD to define information requirements:** Standardisation and accuracy of generated datasets are of paramount importance. (Argasinski and Tomczak, 2024). In this context, Marco et al. (2024) emphasize the role of bSDD in standardizing information, improving clarity and accuracy in the exchange of project details across disciplines. Additionally, when evaluating methods for specifying information requirements, Tomczak et al. (2022) suggest that data dictionaries can indirectly be used as a reference when defining requirements in other methods to specify information requirements to provide a shared understanding.

Q2 - What are the primary challenges associated with the utilization of IDS?

The primary limitation reported regarding the use of IDS

is its focus on alphanumeric information, which does not support geometric formats or spatial verifications. This limitation makes it difficult to fully automate the verification of certain types of BIM data, such as detailed geometric relationships and spatial configurations (Owerko et al., 2024).

In their studies, Cerovsek and Omar (2024) cite that IDS cannot be equipped to handle domain-specific requirements that involve complex interdependencies between elements. This limitation means that IDS cannot be solely relied upon for comprehensive model validation, especially for projects with stringent regulatory or design requirements.

The lack of generally applicable requirements for the additional functions, their implementation, and their use leads to a very individual application (Kremer and Beetz, 2023). To overcome these challenges, some studies suggest the use of the proposed extension of IDS facets to verify information that is initially not verifiable using XLINK, a markup language designed to create links between resources in XML documents (Kremer and Beetz, 2023; Fischer et al., 2024). Thus, it can be concluded that neither the IDS nor any other single method for specifying information requirements covers all aspects of use case analysis, as each method has a different objective, despite overlaps, and selection should be made consciously based on a purpose (Tomczak et al., 2022).

Additionally, other limitations and challenges associated with the use of IDS are cited, such as:

- The current lack of support for authoring environments, as noted by Cerovsek and Omar (2024) and Owerko et al. (2024);
- The lack of standardization of IDS generating tools: Identical instructions given to two different tools resulted in divergent syntax and spellings, leading to different readings and results by the verification software (Mendonça and Ferreira, 2024);
- Incompatibility between the platforms used for creating and validating IDS, as cited by Bigai and Santos (2024);
- Incompatibility between different versions of IFC and IDS, which may become a significant challenge over time, is a concern raised by Cerovsek and Omar (2024);
- Properties not listed in the IFC could not be verified (Garlet et al., 2024), emphasizing the importance of specific data dictionaries for certain validations.

Finally, the limited recognition of the standard outside academic circles and among a select group of pioneering companies emphasizes the need for a cultural shift in compliance-checking methodologies (Marco et al., 2024), highlighting the importance of raising awareness and training professionals to adopt new practices and technologies.

Q3 - What are the main tools employed for development of IDS and for model verification?

Initially, it is essential to distinguish the types of tools employed during the IDS development and utilization process, which were referenced in the articles. These include

modelling tools (Revit and Archicad), IDS standard development tools (us-BIM.IDS, IDS Converter, and Sublime-Text), model checking tools using IDS (Blender, Blender-BIM + IFCTester, Solibri and Plannerly), and other associated tools (usBIM.bSDD, BIM Collab, XLINK, ifcopenshell and Excel).

Among the software utilized for the development of IDS, the most frequently cited are usBIM.IDS (ACCA, 2023) and IDS Converter (Dias, 2024). Bigai and Santos (2024) explain that the selection of usBIM.IDS was driven by two primary factors: its ability to create XML files in a clear and organized manner, which minimizes errors and simplifies comprehension during the development process; and its status as a freely accessible platform, enabling users to download it at no additional cost.

The use of IDS Converter in the study by Mendonça and Ferreira (2024) was justified by its easy correlation between the information exchange requirements and IDS, in addition to its more flexible manipulation capabilities.

For verification purposes, Blender, along with Blender-BIM, currently known as Bonsai (Blender, 2024), with the IFCTester add-on, the most widely used tool. According to Pérez-García et al. (2024), BlenderBIM serves as a complete BIM authoring and auditing platform. It also states that IFCTester is able to read both IFC and IDS files, and performs an iterative check of the elements according to the information requirements. Some authors mention the development of additional add-ons using the ifcopenshell programming language.

Q4 - What functions are supported by the use of IDS and/or bSDD?

In general, the idea of using IDS and its use in the construction process is presented in Figure 4.

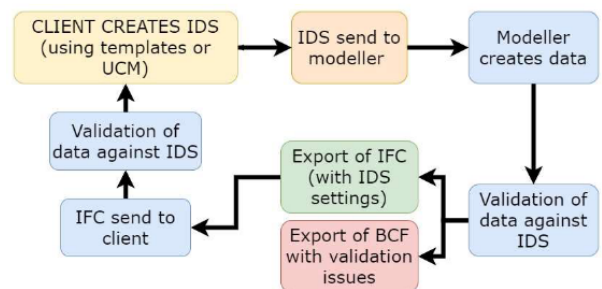


Figure 4: Information Delivery Specification operation diagram (Owerko et al., 2024)

Some functions were presented concurrently across the articles. Among the potential functions for IDS, the most frequently cited are requirements definition and quality verification. This aligns with the concept of IDS and the openBIM workflow (Figure 1), which emphasizes interoperability and efficient exchange of information among various platforms and project stakeholders. However, these two functions do not encompass the full range of IDS applications. Other functions mentioned include:

- **Model enrichment:** Marco et al. (2024) developed a tool that, among other functionalities, enables the enrichment

of BIM models through bSDD by incorporating standardized metadata for utility and compliance using IDS. Garlet et al. (2024) proposed an approach for creating data dictionaries that can serve as a foundation for enriching models and classifying the information required for the specific domain under their studies.

• **Quality control throughout the modelling process:** Mellenthin Filardo et al. (2024) proposed a procedural change that involves utilizing information requirements not only for verification but also during the modelling phase. This approach would, by default, generate Exchange Information Requirements (EIR)-compliant project deliverables. This change could significantly reduce iterations within the information delivery process, in which the project deliverables, e.g., BIM models, are sent back and forth for rework until they pass the formal conformity check (Mellenthin Filardo et al., 2024).

• **Others:** Other functionalities for the use of bSDD are presented in the works of Scandurra and di Luggo (2023), Argasinski and Tomczak (2024) and Scandurra et al. (2024), who demonstrated the application of data dictionaries for documentation purposes related to the preservation of historical heritage.

Q5 - For which BIM Model uses are IDS and/or bSDD utilized?

From reading the articles selected in the SLR, the main uses reported below are:

• **Capture existing conditions and author design model:** In their article, Owerko et al. (2024) examine the modelling of a railway station based on requirements formulated in Excel. Similarly, Cerovsek and Omar (2024) address the modelling of the architectural phase of a building, while Trani et al. (2024) focus on the modelling of infrastructure PropertySets. Additionally, Bigai and Santos (2024) employ IDS to define requirements for the creation of BIM objects, considering various model uses.

• **Review design models:** To achieve effective automated verification, models should be enriched with relevant information without excess (Mendonça and Ferreira, 2024). In this regard, both studies ((Mendonça and Ferreira, 2024; Fischer et al., 2024) address the verification of code compliance during project reviews. The former focuses on accessibility regulations, while the latter is concerned with verification related to fire safety standards.

• **Analyze Energy Performance:** Garlet et al. (2024) discuss the enrichment of models for energy simulation through the creation of data dictionaries, while Garlet et al. (2023) and Kremer and Beetz (2023) explore the use of IDS for model checking in the context of energy analysis.

• **Analyze other engineering:** Marco et al. (2024) focus on the modelling and analysis of requirements for the use case of mechanical installations in the article. Additionally, Tomczak et al. (2022) address the circular economy model within the built environment.

• **Compile Record Model:** Specifically for the asset operation phase, the articles by Scandurra and di Luggo

(2023), Argasinski and Tomczak (2024) and Scandurra et al. (2024) employ bSDD to insert specific information regarding the condition of preservation of works of art and decorative elements, in order to support the conservation, prevention, maintenance, and restoration of historical and artistic heritage.

In general, Pérez-García et al. (2024) highlight that the application of BIM information requirements at various stages of an asset's life cycle in public procurement, such as cost estimation, planning, and regulatory code validation, represents a compelling area for further exploration. Additionally, Tomczak et al. (2022) propose conducting research across different case studies and utilizing testing requirements on real project data to provide deeper insights into the definition of requirements.

Q6 - What standards are most frequently cited in the preparation of the selected articles?

Among the standards referenced in two or more articles, the following are listed:

- ISO 12006 (Building construction - Organization of information about construction works), cited 7 times;
- ISO 19650 (Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) - Information management using building information modelling), cited 6 times;
- ISO 29481-1:2016 (Building information models - Information delivery manual), cited 5 times;
- ISO 23386:2020 (Building information modelling and other digital processes used in construction - Methodology to describe, author and maintain properties in interconnected data dictionaries), cited 4 times.

Figure 5 presents the co-occurrence network of the most frequently referenced technical standards identified in the reviewed literature, emphasizing the principal clusters and recurrent interconnections among them. Node size and color intensity represent citation frequency, and edges indicate joint citation within the same publication.

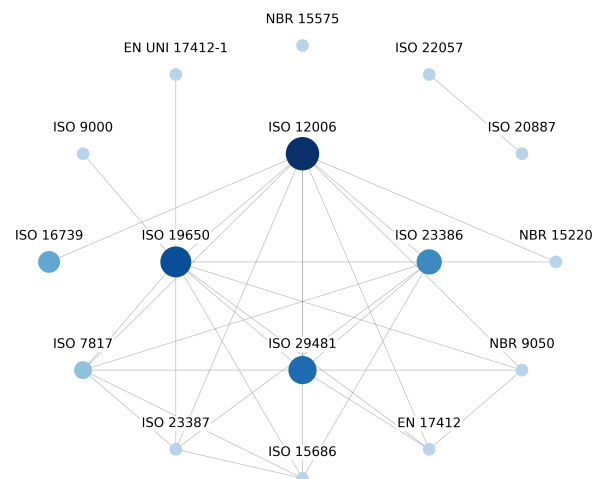


Figure 5: Co-occurrence graph of standards cited in the analyzed articles

An analysis of the standards cited in the articles selected for the SLR allows for an evaluation of the relevance of these regulations to the topic, as well as an understanding of the standards and methodologies being examined in conjunction with the IDS. This analysis is essential for identifying trends, gaps and best practices currently being adopted in the integration of IDS with other tools and processes.

Conclusions

This study conducted a systematic literature review that encompassed works on the application of IDS and bSDD within the BIM workflow, with the aim of analyzing their usage, as well as their associated challenges and advantages. After reviewing the selected articles, it was determined that the use of data dictionaries and the IDS standard significantly contributes to the workflow within the BIM context. However, challenges persist, particularly regarding limitations in supporting the inclusion of geometric information or specific requirements. Consequently, it was concluded that IDS cannot fully address all aspects of use case analysis.

Among the advantages identified, the most prominent include enhanced efficiency of information management through collaboration and interoperability, facilitated by the precise definition of information requirements, the automation of model verification, and the resultant acceleration of the verification process. Additionally, real-time validation of information within the model offers significant benefits to designers. Regarding the tools employed, it is concluded that the most commonly used for creating the IDS was usBIM.IDS.

Therefore, the principal contribution of this article lies in encouraging the academic community to propose solutions to overcome the challenges identified in the literature, while also exploring the integration of IDS and bSDD for the definition and validation of requirements. This would expand their application to other BIM use cases, such as quantity surveying and planning.

Future research will further investigate the technical aspects underlying the potential integration of IDS and the bSDD service. With particular emphasis on budgeting for public works, it aims to classify and apply the solutions identified in the reviewed literature to overcome current challenges and to develop an integrated IDS–bSDD workflow for model quality control and verification.

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