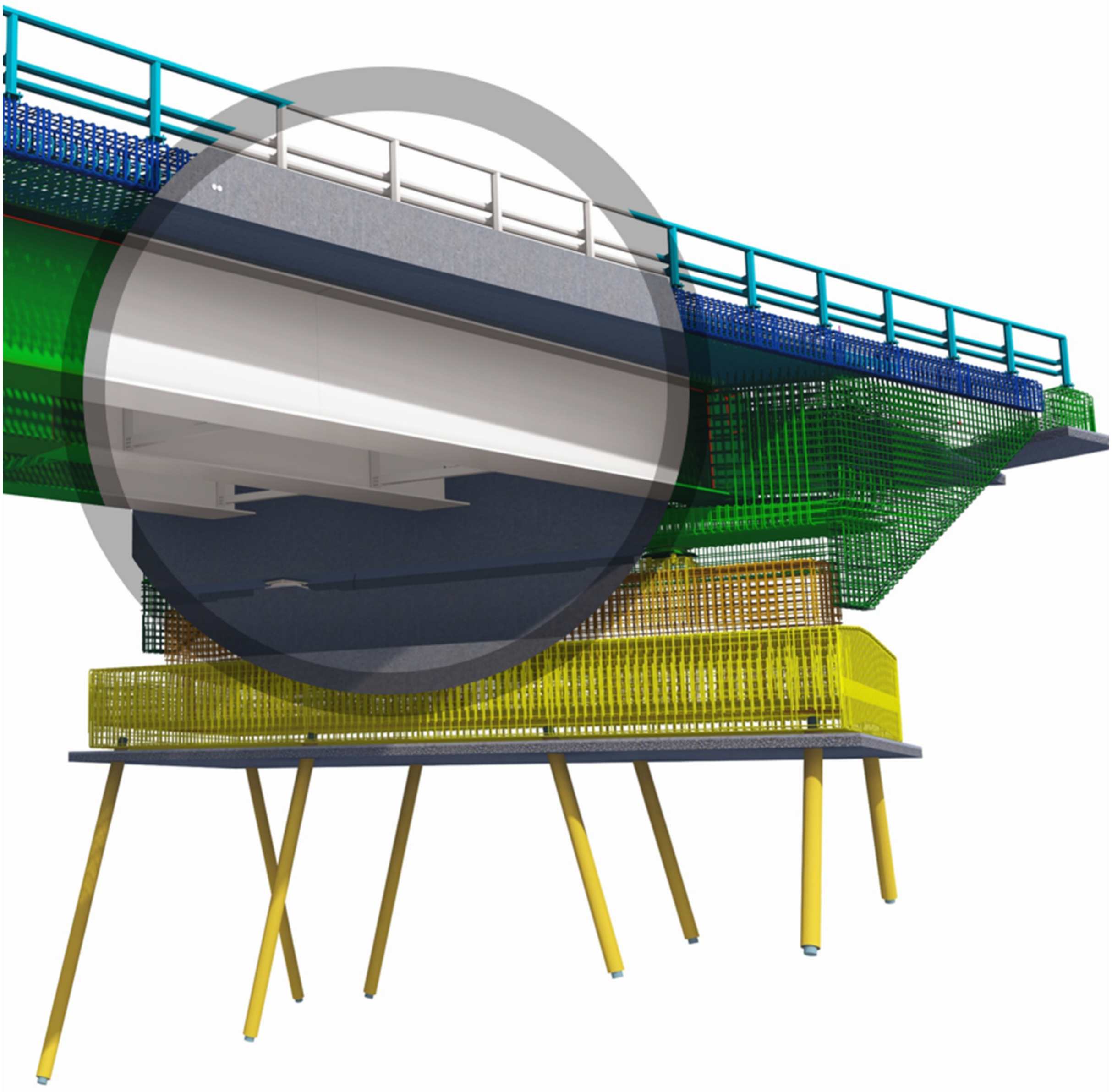
Standardization of Model-Based Deliveries in Norwegian Infrastructure Projects

Part 1: Needs Analysis

December 2023



FOREWORD

This report has been prepared by Sweco Norway AS in collaboration with the Norwegian Public Roads Administration and is part of the effort to increase standardization in model-based deliveries for transportation infrastructure. The work has been conducted based on a framework agreement between the Norwegian Public Roads Administration Directorate and Sweco Norway AS. A project group was set up, consisting of representatives from both parties. The project group included the following members:

- Kristine Tybring Lindtveit (Norwegian Public Roads Administration Directorate)
- Gaute Nordbotten (Norwegian Public Roads Administration Directorate)
- Marie Eliassen (Sweco Norway AS)
- Øystein Ulvestad (Sweco Norway AS)
- Christoffer Nergaard Mikalsen (Sweco Norway AS)
- Torhild Bjørkevoll Ersland (Sweco Norway AS)

A reference group with relevant industry stakeholders was also established.

This report is part one of the project and covers an analysis of the industry's needs and shortcomings regarding today's model-based deliveries. The second report, “Standardization of Model-Based Deliveries in Norwegian Infrastructure Projects – Part 2: Final Report” presents the project group's proposals for addressing the needs identified in this report.

In this report, the following English translations and abbreviations will be used:

Norwegian	English translation	Abbreviation
Statens vegvesen	Norwegian Public Roads Administration	NPRA
Statens vegvesen Vegdirektoratet	Norwegian Directorate of Public Roads	NDPR

The report has been translated to English by Øystein Ulvestad.

SUMMARY

In this report, the word "model" is used to describe a BIM model in IFC format in model-based projects.

Currently, there is significant variation in the design of model deliverables for infrastructure structures in Norway. This prevents the industry from fully utilizing the potential of model-based deliveries and creates unnecessary uncertainty in project timelines and costs. As a result, many people see the need to agree on standardized regulations. NDPR has therefore initiated the project "Standardization of Model-Based Deliveries in Norwegian Infrastructure projects." The following needs analysis has therefore been produced.

Feedback from the industry indicates that there is a need for improvement and standardization in several areas. There is a broad consensus that clearer and more detailed regulations should form the framework for this standardization. This will reduce uncertainties regarding resource needs and project timelines. All stakeholders also agree that the industry should adopt a common data structure for models, including properties and property sets. A common data structure is considered by many to be the most important success factor for standardization.

Many stakeholders want to utilize the potential of the IFC format in a better way. This includes a more deliberate use of IFC entities and the IFC Spatial Breakdown System. It is however commented that while the IFC4.3 format better supports bridges as a discipline, there are currently no commonly used modelling software that export IFC4.3 files in a satisfactory manner.

There is also a demand to improve model readability. Better methods and improved software need to be developed for easier access to model metadata and for acquiring measurements. Improved model readability could also include more deliberate use of objects colours or the use of digital annotations instead of symbols. Another suggestion for improvement is the use of predefined views with predefined dimensions and annotations, as well as software with improved filtering possibilities.

Additionally, proposals have been made to standardize various aspects of the BIM methodology. Examples include suggestions on how to divide models into sub models, how to create links in models to external documents, and how to communicate earthworks. Operators have also communicated a need for improved model usability from an IOM-perspective (Inspection, Operation, and Maintenance).

Although the needs vary somewhat among different stakeholders, they are all positive to a standardized framework for the design of infrastructure construction models. At the same time, stakeholders emphasize that regulations should not hinder innovation and creativity.

The engagement for this project has been significant, and stakeholders have demonstrated an impressive willingness to share knowledge and experience. Many people have made considerable efforts in the sharing process and have collaborated across organizations to agree on good solutions. This level of trust and willingness to share is unique internationally and is a major reason Norway holds a leading position in the use of BIM.

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1. INTRODUCTION

1.1. Project Description

Structure types listed in requirement 2.1 - 1 of the NPRA standard N400 Bridge Design (2023-01-01) must be reviewed by a third party and achieved «technical approval» before construction can commence. Historically, the review has been based on drawings where geometry and properties has been specified. Since 2016, NDPR has allowed for reviews to be based on either models or drawings. The guidelines for model design have been vague, with the aim of encouraging innovation from stakeholders. From 2016 to present, this has led to experimentation and rapid development and improvements. New challenges have arisen as models replace drawings, but designers have created methods to incorporate information regarding geometry, properties, and other relevant aspects into the models. Contractors and clients have refined this information and found ways to integrate models into their processes. The industry is now a world leader in model-based delivery for infrastructure structures. Model design and methodology does however vary from project to project, making it challenging to reuse methodology. In addition, the lack of clear and detailed regulations generates unnecessary uncertainty regarding progress and costs.

The industry has long recognized the need to standardize regulations for model design in model-based infrastructure projects. NDPR has therefore initiated the project "Standardization of Model-Based Deliveries in Norwegian Infrastructure Projects." As part of this scope, a needs analysis has been conducted. This report summarizes the results from the needs analysis. In addition, a final report will be published, presenting proposals for regulations ("Standardization of Model-Based Deliveries in Norwegian Infrastructure Projects – Part 2: Final Report."). This project outcome is intended to be used as a guideline for future requirements and recommendations for model design. It is not in the scope of this report to suggest which specific regulations the requirements and recommendations should be included in.

1.2. Purpose of Standardization

The primary goal of the project is to identify the needs and challenges posed by the current model-based deliveries for stakeholders. Another objective is to propose regulations concerning requirements and provide recommendations where standardized solutions could benefit the industry. It is crucial, however, to evaluate whether the relevant technology and software are sufficiently mature. Standardizing model design can lead to a reduction in the resources required to produce models, which in turn will decrease uncertainty regarding progress and costs. The resource requirements for using models on site and for operations will also be minimized. Methodologies will be easier to reuse, and the need for training at all stages will be diminished. This will also help reduce misunderstandings and misinterpretations of information. Furthermore, a standardized approach to model creation will encourage software vendors to develop better-suited digital tools, and it will simplify the process for stakeholders to create software "add-ins."

Standardization primarily mean that all models are structured the same way. However, it is important not to impose regulations that limits further innovation and creativity, as there will still be a future need for further development. The standardization should leave room to incorporating future innovation and improvements.

2. TERMINOLOGY EXPLANATION

The following definitions explain how different terms are used in this report:

Attribute
An attribute is linked to an IFC entity and provides specific information about the entity. Unlike properties, attributes are predefined in the IFC standard. An example of an attribute is "IfcElement.Length," which can be used to indicate the length of an object, such as part of a bridge.

BIM Title Block
"BIM Title Block" refers to objects or an object showing true north placed next to a construction. The BIM Title Block is intended to provide various pieces of information about the construction and/or links to external documents relevant to the construction (see also chapter 4.7.2).

BSDD (BuildingSMART Data Dictionary)
BSDD is a standardized terminology database within the construction industry. Organizations can share property sets in this database to facilitate standardization work. BSDD supports multiple languages, enabling specifications independent of language. For example, IfcWall may have names like Vegg/Wall/Wand/Parete, etc.

Data Structure
Data structure refers to which properties and property sets are used and where in the IFC Spatial Breakdown System (IFC hierarchy) these are placed (see also "IFC Spatial Breakdown System").

IDS (Information Delivery Specification)
IDS is a method for validating IFC files. For example, it can check whether IFC files contain the correct IFC structure. IDS can also be used to verify that desired properties are filled in and that they contain "valid" values.

IFC (Industry Foundation Classes)
IFC is an open file format for modelling, widely used in the construction industry to facilitate data exchange and collaboration between different software applications.

IFC Bridge
There are several specific subclasses of IFC for different use cases. IFC Bridge is one of these subclasses. It is available from IFC version IFC4.3 and provides specific objects and attributes relevant to bridge design, bridge construction, and bridge management.

IFC2x3
IFC2x3 is a version of the IFC format released in 2006. IFC2x3 is still widely used, but naming and advanced functionalities are best suited for buildings.

IFC4.3
IFC4.3 is an evolution of IFC2x3. Examples of improvements include better support for non-geometric data and enhanced geometry handling. In IFC4.3, for instance, road lines can be represented using the object type IfcAlignment. IFC4.3 also includes the IFC Bridge subclass, which contains IFC entities relevant to bridge design, construction, and management. It should be noted that as of December 2023 there are no commonly used modelling software that export IFC4.3 files in a satisfactory manner.

IFC Schema
A collective term for all the functionality the IFC format possesses.

IFC Spatial Breakdown System
The IFC Spatial Breakdown System is a functionality within the IFC format. It defines multiple levels of information in a hierarchy, where elements lower in the hierarchy inherit properties from elements higher up. It also provides a way to organize elements like piles, foundations, abutments, and bridge railings according to spatial placement. The Spatial Breakdown System is available in both IFC2x3 and IFC4.3.

IFC Entity
All objects in an IFC file are classified as some type of IFC entity. Examples of IFC entities include IfcBeam, IfcBearing, and IfcColumn. IFC entities can encompass anything from basic geometric shapes and building parts to more complex things like floors, constructions, and subprojects. Each IFC entity type have a predefined set of attributes.

Information Object
An information object does not represent a physical object. The sole purpose of an information object is to carry information. Figures 2.1, 2.2, and 2.3 show examples of information objects.

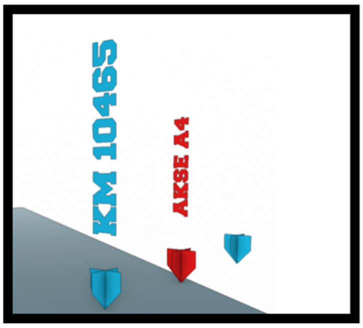

Figure 2.1 - Example of chainage information.

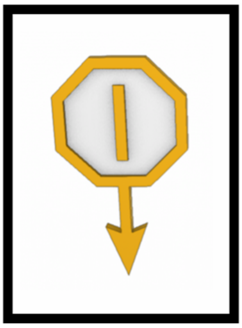
Figure 2.2 - Example of symbol (also known as information symbol).

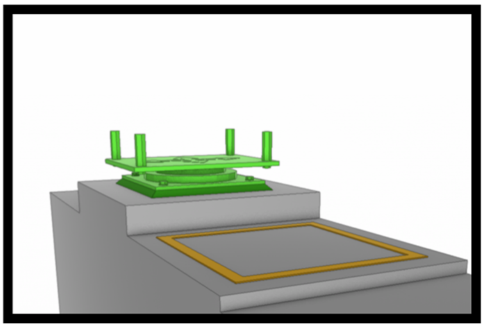
Figure 2.3 - Example of information about permitted jacking location at bearing.

Property
A property is associated with an IFC entity and provides specific information about the entity. Unlike attributes, properties are created and defined by the model creator and are not predefined in the IFC standard. An example of a property is "LOD." This property indicates the maturity of an object or model. See also chapter 4.5.3.

Property Set
A property set is a collection of properties. See also chapter 4.5.5.

Model
In this report, the term "model" is used to describe a IFC format BIM model.

Object
An object (also referred to as a volumetric object) is an IFC entity that cannot be broken down into smaller parts. The object can be assigned information in the form of properties and attributes.

Object Information
Object information is the information associated with an object through properties and attributes.

3. METHOD

In the work of identifying needs, NDPR formed a project group consisting of representatives from NDPR and Sweco. To gather feedback and input, a reference group was established, consisting of key individuals from various stakeholders in the industry. The reference group comprises a total of thirty-three people, including representatives from designers, contractors, clients, road owners, bridge managers, as well as other relevant actors.

This report is primarily based on responses to a feedback form that was distributed to the entire reference group. This feedback form consists of twelve questions, some of which are open-ended, while others focus more on specific details or areas. A complete form can be found in Appendix 1. Several separate meetings were also held with selected stakeholders to enhance the project group's understanding of certain specific topics.

A total of twenty-four responses were received, resulting in a response rate of 73%. Figure 3.1 shows the distribution of received responses by type of actor. The feedback has been systematically reviewed, and opinions, thoughts, and comments have been mapped. This was further used as the basis for categorizing the feedback. These categories are described in the results chapter.

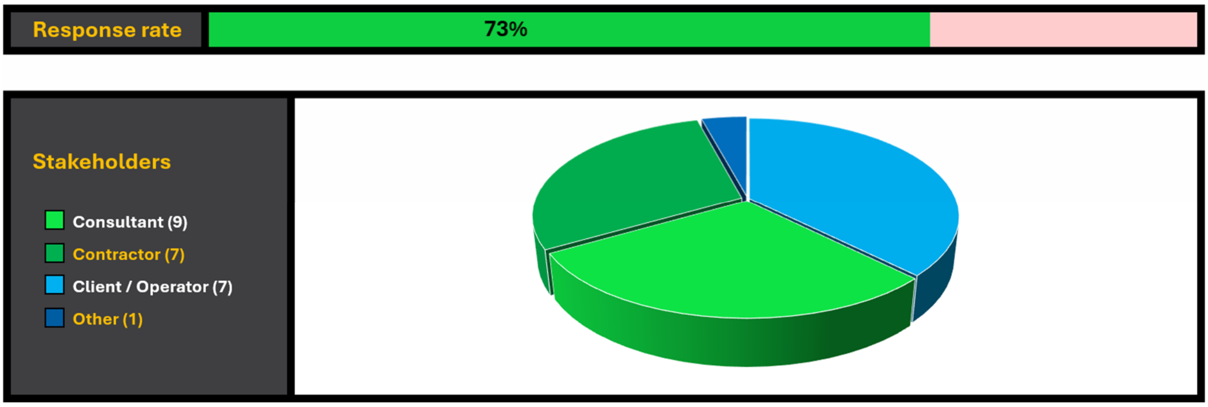

Figure 3.1 - Distribution of responses categorized by stakeholder.

4. RESULTS FROM FEEDBACK

4.1. Introduction

Based on the survey feedback, it is clear that the challenges faced by designers, contractors, and operators are different in many respects. This comes as no surprise as the different stakeholders work with the models at various stages of the project, resulting in different needs (see Figure 4.1). There are however areas where challenges overlap, with a consensus on the need for improvements and agreement on which solutions should be chosen.

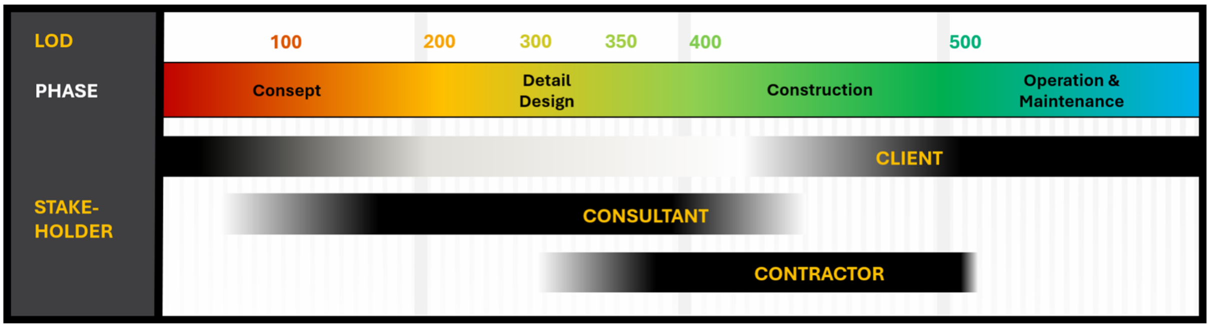

Figure 4.1 - Common project phases and typical stakeholders' involvement related to structures in infrastructure projects.

Based on the feedback, the needs analysis has been divided into six main categories. These categories are:

- Regulations
- Software
- IFC
- Properties
- Details and Design
- Methodology

These main categories are presented in the below chapters (see chapters 4.2 to 4.7).

4.2. Regulations

4.2.1. Introduction

Current regulations provide few detailed guidelines for the design of models for structures in infrastructure projects. This allows for significant experimentation and rapid development of models. At the same time, it is challenging to define which solutions meet the existing regulations and which do not. The following sections address key aspects related to the need for improvements in regulations.

4.2.2. Clearer Regulations

The NPRA standard «N400 Bridge Design» (2023-01-01) include some general requirements for model-based projects. It does for example require that gridlines and an object showing true north be incorporated into the model and that object information be logical, structured, and easy to access. There is however limited information on how these general requirements should be implemented. Additionally, many fundamental aspects of model design lack defined requirements. There are for example no model requirements defining sufficient level of detail for objects or which object clashes that are permitted.

As a result, many stakeholders have suggested that current regulations should be made clearer. Most feedback comes from designers who primarily want the requirements for model-based work to be more detailed and comprehensive. This will reduce the risk of design being deemed non-compliant due to controller preferences late in the design phase, thereby decreasing the resource needs for model production and reducing uncertainty regarding progress.

4.2.3. Designing for the Construction Phase

Designers primarily create models to be used by contractors during the construction phase (see Figure 4.2). Consequently, the most object properties are adapted for this phase. There are however stakeholders, particularly operators, who request that models and their object properties be better adapted to operator's needs. This could for example involve adding object properties for inspection.

How model metadata relevant to operators should be applied and updated needs to be considered.

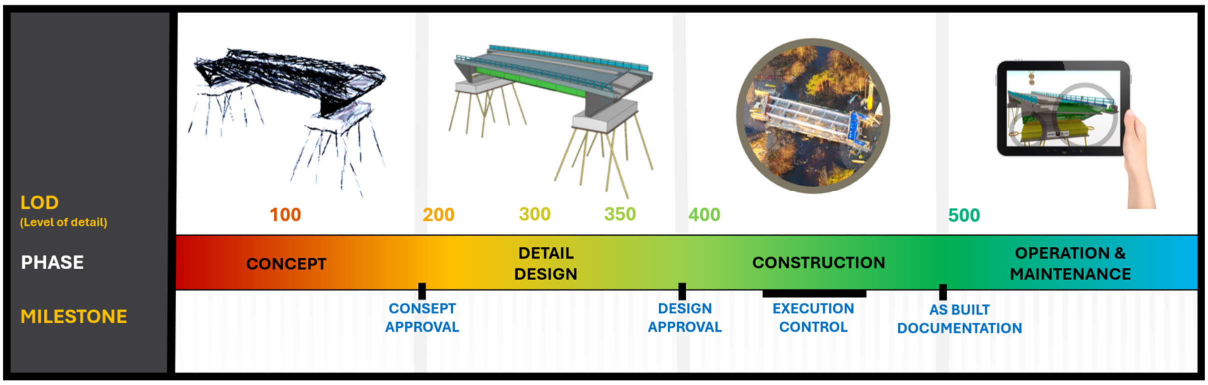

Figure 4.2 - Common milestones related to structures in infrastructure projects.

4.3. Software

4.3.1. Introduction

Software is essential for producing and using models effectively. Software that is well-adapted to the needs of the industry can save time, reduce errors, and enable the use of models in multiple processes. Current software is however often better suited for use in building and industrial projects rather than for infrastructure projects. Many stakeholders therefore see a need for improvements in current software to better exploit the potential of model-based deliverables. The following sections address key aspects related to the need for software improvements. It should be noted that comments are based on the use of IFC2x3 models.

4.3.2. Model dimensions

Both designers, contractors, and managers have pointed out that it can be time-consuming and challenging to manually acquire measurements from models. A common example is the challenge faced when acquiring measurements to surfaces that are not planar. Difficulties in acquiring precise measurements make both the control process and the construction processes challenging. Many stakeholders have therefore request improved useability for manually acquiring measurements. There is also a demand for easy ways of producing predefined sections in the model that include dimension lines. It should be noted that some software already has this ability (see Figure 4.3).

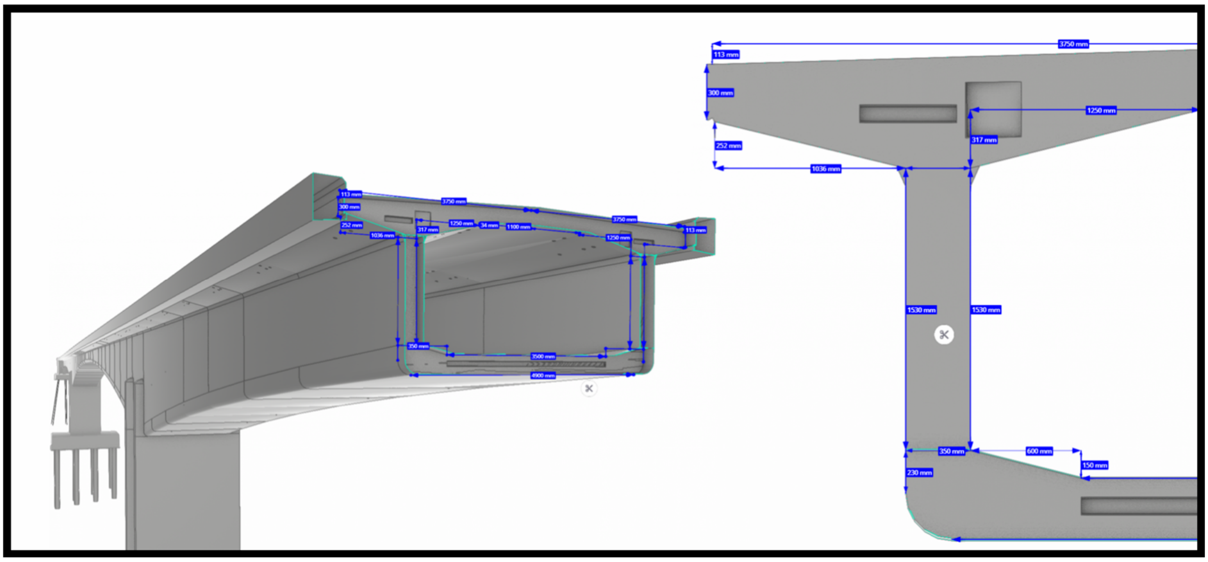

Figure 4.3 - Examples of predefined sections that include dimension lines in Trimble Connect. (Model: Cowi)

4.3.3. Software Impacts on Data Structure and Appearance

Many stakeholders find it challenging that displayed object colour in a model varies depending on the software being used. Another challenge is object metadata being displayed differently from one software to another. Software such as AutoCAD Civil, OpenRoads, and Gemini are known to change object colour and users have experienced that important object information have been lost when importing IFC files.

At construction sites, models are primarily utilized by using handheld devices such as tablets and mobile phones. Due to limited screen size and challenges of scrolling, the appearance of the model and the placement of metadata are crucial for contractors to use the models effectively. To facilitate the use of models on construction sites, careful planning should be done to ensure that non-essential data can be easily filtered out. Additionally, the most relevant metadata should be made easily accessible at the top of each property tab (see also chapter 4.5.5).

4.3.4. File Sizes and Stability

In model-based projects it is crucial that model sizes are adapted to the relevant software used at site. The users should be able to open the models quickly, and relevant metadata should be easy to filter and retrieve. Additionally, file sizes should be small enough for the software to function satisfactorily. Not all software manages large data volumes well, and some contractors have experienced stability issues on tablets when the amount of metadata in the models becomes too large. Some contractors have therefore expressed a desire for the models to be divided in a way that limits file sizes.

4.4. IFC

4.4.1. Introduction

According to the NPRA standard «N400 Bridge Design» (2023-01-01), model-based project deliverables must be based on open BIM standards and formats. In practice, this means that all model deliverables for transport infrastructure projects must be provided as IFC files. IFC2x3 is the most common IFC format used in Norwegian infrastructure projects.

The IFC format, especially IFC4.3, includes multiple functionality that can be utilized in infrastructure projects. Few current projects fully exploit this.

Several stakeholders wish to utilize more of the capabilities offered by the IFC format. The following sections address key aspects related to the use of the IFC format.

4.4.2. IFC4.3 and IFC Bridge

IFC can be used in many disciplines, and specific IFC subclasses have already been developed for several of them. IFC Bridge is one of these subclasses. IFC Bridge is available from IFC version IFC4.3 and offers specific entities and attributes relevant to transport infrastructure projects. For example, a bridge bearing can be modelled as the entity type "IfcBearing." This provides a standardized way to structure bridge models, which simplifies data extraction from the models and makes it easier to develop advanced software solutions. IFC4.3 also has other advantages compared to IFC2x3, such as better support for non-geometric data that can replace many of the information objects used in current models. The version also features improved ways to display certain types of geometry. An example is road alignments, which can be represented using the entity type IfcAlignment instead of using volumetric objects.

For these reasons, several stakeholders want requirements for using IFC4.3 and IFC Bridge to be considered. It is important to note that commonly used modelling software like Revit and Tekla still lack the ability to export IFC4.3 files in a satisfactory manner.

4.4.3. IFC Spatial Breakdown System

The IFC Spatial Breakdown System is a feature of the IFC format and is available for both IFC2x3 and IFC4.3. The IFC Spatial Breakdown System defines multiple levels of information, a hierarchy, where elements lower in the hierarchy inherit the properties and attributes placed higher up in the hierarchy. This is explained in more detail in chapter 4.7.2. The system also allows for the organization of elements such as piles, foundations, land pits, and bridge railings according to spatial placement (see Figure 4.4).

Using the Spatial Breakdown System provides a standardized way of structuring bridge models, which simplifies data extraction from the models and reduces file sizes. Therefore, several stakeholders suggest that the IFC Spatial Breakdown System should be used more consciously. A proposed use case is described in chapter 4.7.2.

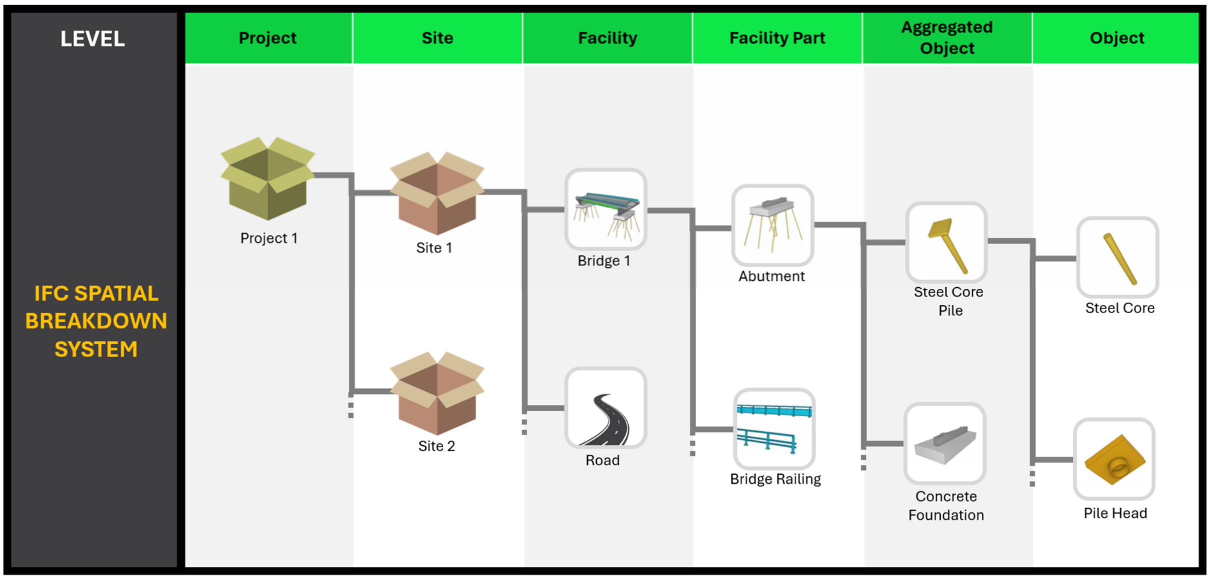

Figure 4.4 - Levels in the "IFC Spatial Breakdown System" hierarchy.

4.4.4. IFC Entities

All objects in an IFC file are classified as some type of IFC entity. Examples of IFC entities include IfcBeam (often representing a beam) and IfcColumn (often representing a column). IFC4.3 offers more entity types than IFC2x3, many of which are relevant for infrastructure constructions. Most designers do not consciously consider which entity types are chosen to represent an object. For operators, sorting entity types is however a valuable tool for extracting information from models. Some stakeholders therefore want to standardize how IFC entities should be used.

4.5. Properties

4.5.1. Introduction

Except geometry, most transfer of information in model-based projects is done through meta-data in the form of properties. Properties are therefore an essential part of this methodology. Many consulting companies have their own standardized properties and property sets. However, the lack of a common Norwegian industry standardization makes it difficult for software developers, contractors, controllers, and operators to develop systems and methodologies that can be reused across the industry. All involved stakeholders have therefore expressed a desire for the standardization of properties and property sets, considering this as crucial for the further development of model-based projects. The following sections address key aspects related to properties.

4.5.2. Aggregated objects

Before settling on common properties and property sets, it is necessary to consider how properties are intended to be used. Whether to allow objects to be aggregated or not is one of the things that need to be decided. An aggregated object is a unit consisting of one or several objects (see "Option 2" in Figure 4.5). In this example, the objects have properties at the "object level," and the aggregated object have additional properties at the "aggregated object level."

Many stakeholders have asked that aggregated objects (as shown in "Option 2" in Figure 4.5) not be used, as they have led to misunderstanding and caused errors at construction sites. The stakeholders prefer that all object properties be assigned at "object level" only. Alternative way to do this are shown in "Option 1A" and "Option 1B" in Figure 4.5.

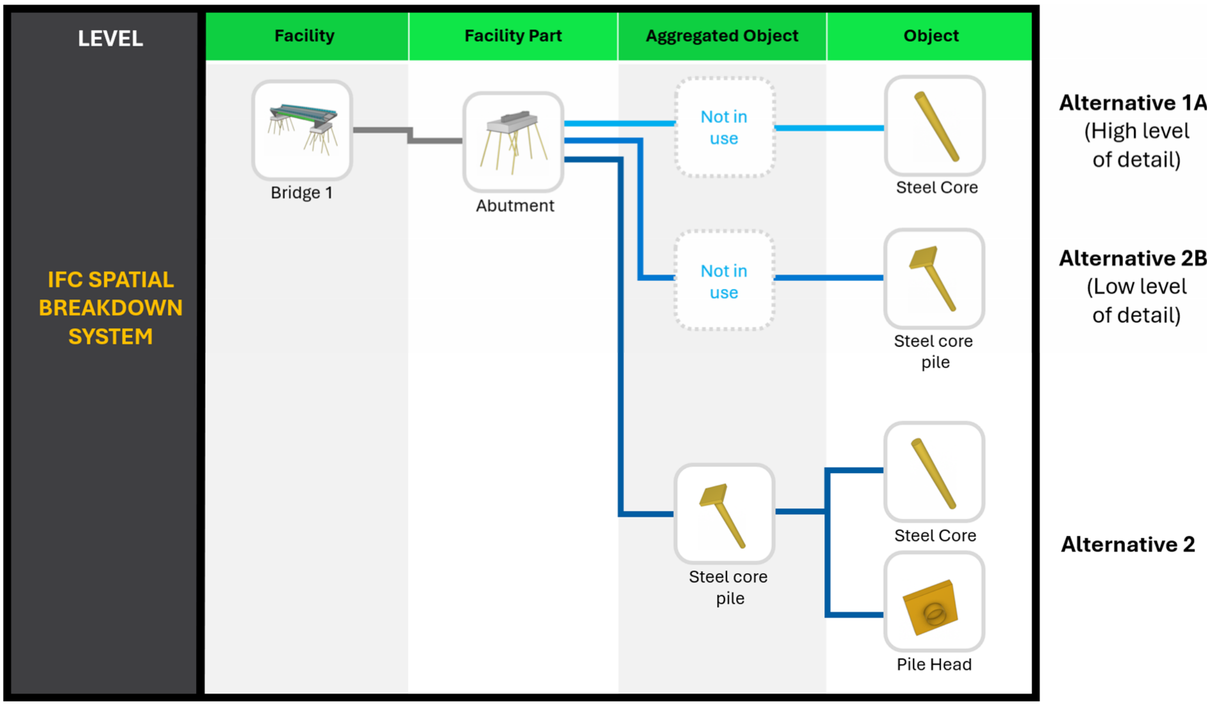

Figure 4.5 – Alternative ways of aggregating objects in the "IFC Spatial Breakdown System" hierarchy.

Using a steel core pile as an example, the steel core, the mortar, the casing pipe, and the pile head should not be used as four different objects and then combined into the aggregated object called steel core pile. The objects should either be labelled steel core, mortar, casing pipe and pile head, or all the elements combined into an object called steel core pile.

4.5.3. Properties

A property is data normally associated with an object, providing information such as location, material, or LOD status. Other properties might be project related and can potentially be placed higher in the IFC hierarchy where it is not connected to an object.

In model-based projects, it is common to use several "open" properties. These are properties used to transfer information that is difficult to categorize. Examples of such information are shown below:

- **Object 1:**
  Open property 1: The hatch must be lockable.
- **Object 2:**
  Open property 1: The plate is attached with four M8 bolts.

This method provides designers a lot of flexibility in defining the information associated with an object and minimizes the number of necessary properties needed for each object. It is however challenging to capture, structure and sort meta-data given in this way.

Across Norwegian projects identical properties are named differently from model to model. In one model, the property describing rebar diameter might be labelled "diameter," while in another model, the same property might be labelled "bar diameter." This variation makes comparing data across different models difficult and hinders the reuse of methodologies. As a result, all stakeholders in the industry see advantages in standardize properties.

When selecting which properties to standardize, it is important to note that each new property introduced increases the resources needed for model production. Duplicate properties (multiple properties conveying nearly the same information) should therefore be avoided. In addition, duplicate properties increase the risk of errors and misunderstandings. Standardization of properties for Norwegian infrastructure structures should when possible be aligned with other standardization initiatives.

4.5.4. Property Values

NPRA have currently no standardized list of accepted property values. As an example, the property value for LOD (Level of detail) may be listed as "LOD400" in some models and "400" in others, even though the information is essentially identical. When developing a methodology and compiling data from multiple models, it is essential that identical information be provided in the same manner across all models. It will therefore be greatly beneficial for the industry if accepted values for selected properties is standardized. Examples of such properties are LOD status, material, and object name.

To verify that metadata in models only contain accepted property values, Information Delivery Specifications (IDS) can be utilized. This is a machine-based method for checking whether properties have been added and if metadata consists of accepted values. IDS can also be used to verify that IFC files have the correct data structure (see chapter 4.4.3).

4.5.5. Property Sets

A property set is a collection of properties. A property set can, for example, contain properties based on function, product type, or information relevant only in specific project phases (such as “casting stage”). An example of a property set with associated properties is shown in Figure 4.6. Currently, there is no standardized way of organizing properties into property sets.

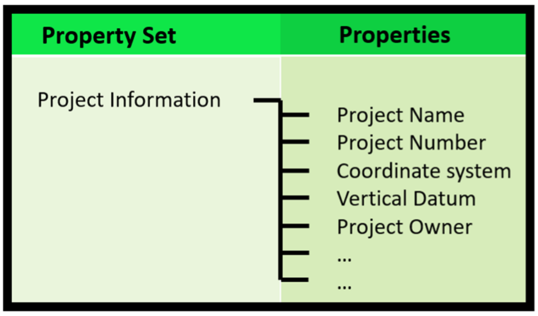

Figure 4.6 – The Property Set «Project Information» consists of multiple properties.

Currently most models divide properties into multiple property sets. In most software, each property set is displayed in its own tab. As a result, properties can be categorized, and the number of rows in each tab is reduced. This can be an advantage at construction site since commonly used handheld devices often have limited ability to scroll through many rows of data.

An alternative approach is to place all properties in a sole property set. The model consequently gets a simpler data structure, and in most software, all properties will then be displayed in one tab. This single tab will contain more rows, and the need for scrolling will typically increase. The user will on the other hand have access to all relevant information in one place.

It is important to note that the display of properties and data structures varies significantly between different software (see Chapter 4.3.3.)

All stakeholders have expressed the need for standardization of property sets and how they are named. This, combined with standardized properties, is considered essential for future development of model-based workflows.

4.6. Detail and Design

4.6.1. Introduction

Currently the level of detail and design philosophy varies significantly from model to model. As an example, the number of unsolved object clashes varies significantly between models. Gridlines are also represented in different ways, and object colours are not standardized. Many stakeholders advocate for more uniform model design as this would reduce the risk of misunderstandings and simplify the use and reuse of models. The following sections address the main aspects related to level of detail and design philosophy.

4.6.2. Details and Concepts

The NPRA standard N400 Bridge Design (2023-01-01) specifies that project deliverables either be delivered model-based or as drawings. In model-based projects, there are however certain types of design solutions that are difficult to represent clearly and unambiguously as objects in a model. Very thin objects, such as membranes over joints in concrete (see Figure 4.7) is one example. Designed solutions for such areas are often easier to comprehend when shown in drawings as elements can be scaled up without losing information (see Figure 4.8). One of the drawbacks of using drawings in a model-based project is however the need to make a reference in the model to the relevant drawing. In addition, both the references link, and the drawings has to be kept up to date.

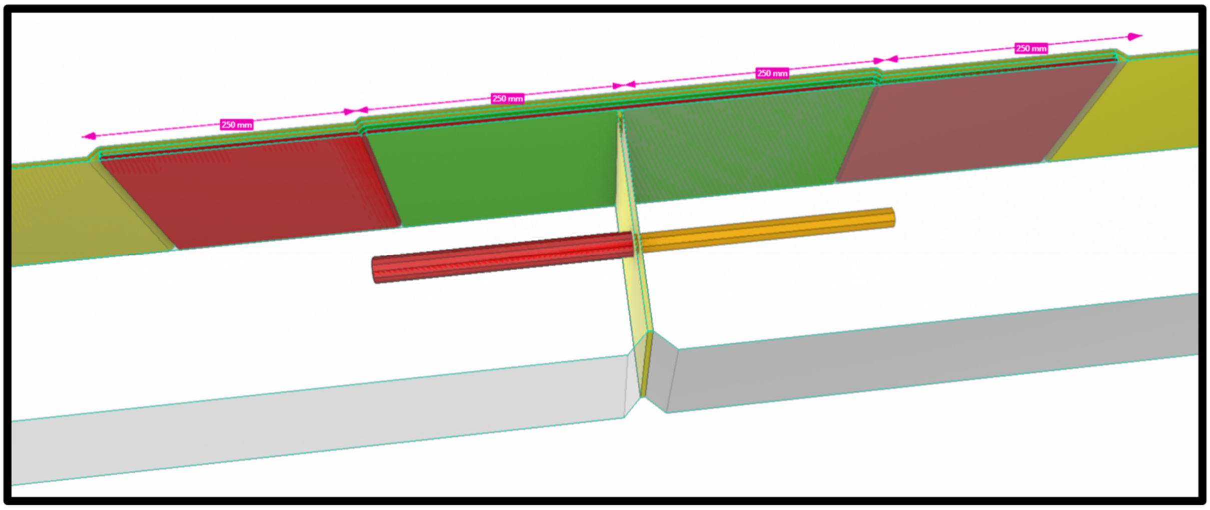

Figure 4.7 – Membrane covering of a concrete joint shown in a model. Thin layers are hard to model in an unambiguous way.

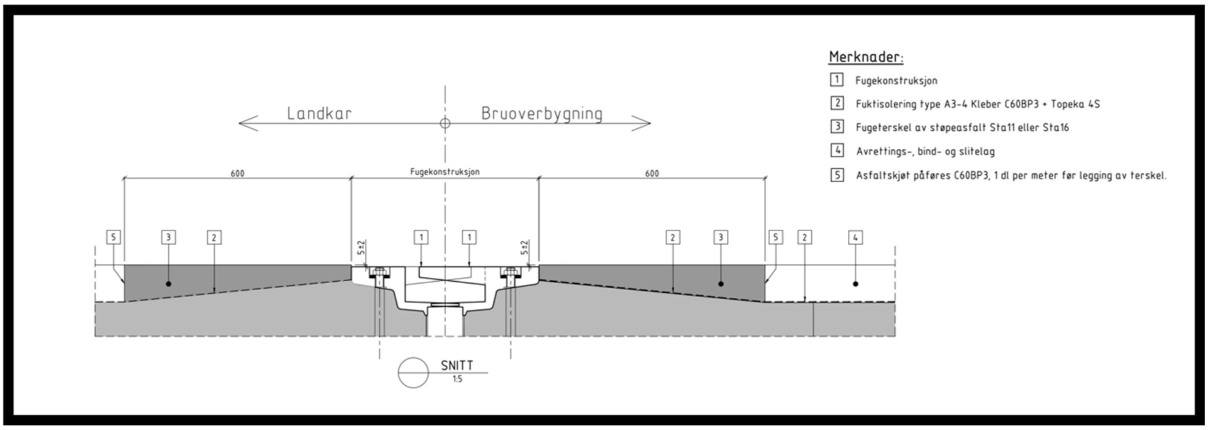

Figure 4.8 - Membrane covering of a concrete joint shown in a drawing.

As an alternative to making references in the model to external project drawings, experiments have been made to utilize 3D detail directly in the model (see Figure 4.9). The disadvantage of this approach is that the principle of linking information only to the object being constructed is compromised. Additionally, a reference to the 3D detail must be created, and it has to be placed in a sensible location. Another suggested alternative are drawings integrated into the model (see Figure 4.10), though this solution has not yet been tested. A third option is to produce a standardized set of drawings that can more easily be referred to when needed.

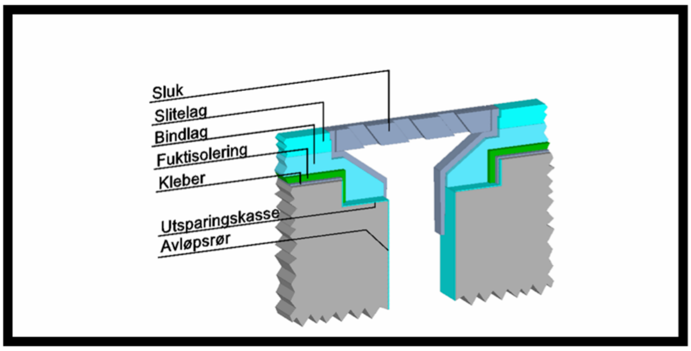

Figure 4.9 – *Example of how a detail can be extracted and shown in a model as objects.*

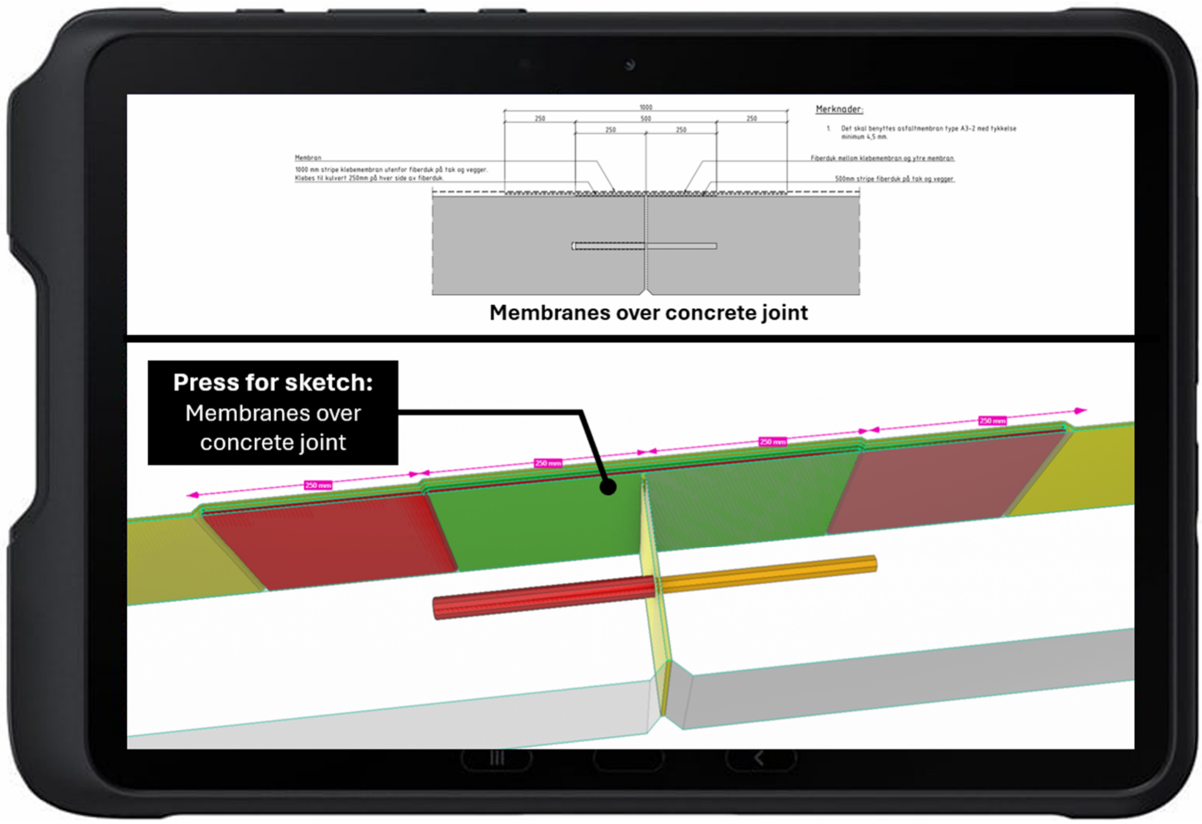

Figure 4.10 - Suggestion for how a drawing reference can be integrated into a model. (The figure is not taken from any existing software but have been made manually).

Some contractors are positive to using 3D details in the model (see Figure 4.9). A majority of designers are however negative to this suggestion. Almost all stakeholders feel positively towards using drawings to convey information about certain types of design solutions. If this is to be implemented, requirements from NPRA standard N400 Bridge Design (2023-01-01) needs to be reconsidered.

4.6.3. Level of Detail

Section 1.4.1-4 in NPRA standard N400 Bridge Design (2023-01-01) requires deliverables to be produced at a level of detail that ensures correct execution and also provides necessary documentation for operators. This requirement allows for significant interpretation, and the level of detail in current models varies from project to project. Particularly so for objects representing third-party products. In real life these third-party products are often highly detailed. To what degree the object representation of the third-party products is simplified varies significantly.

A model with a high level of detail does not always add extra value for anyone. An example is the model representation of a snow proof panel. A snow proof panel with a high level of detail (see Figure 4.12) does not necessarily add any extra value compared to a snow proof panel with a lower level of detail (see Figure 4.11) as long as the object metadata for the panel is sufficient. A high level of detail can however make the model file size unnecessarily large without adding significant value.

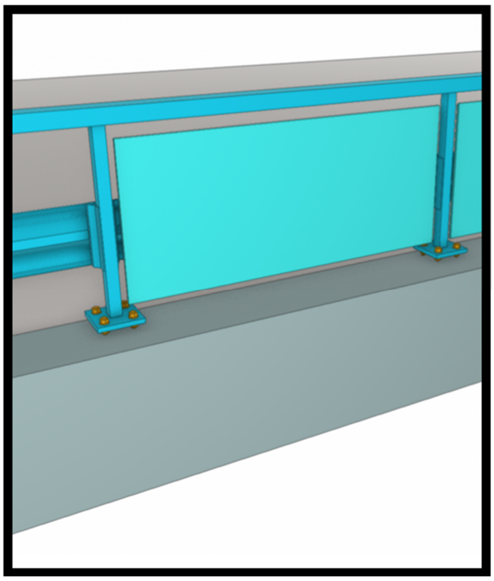

Figure 4.11 – Snow proof railing panel modelled with a low level of details.

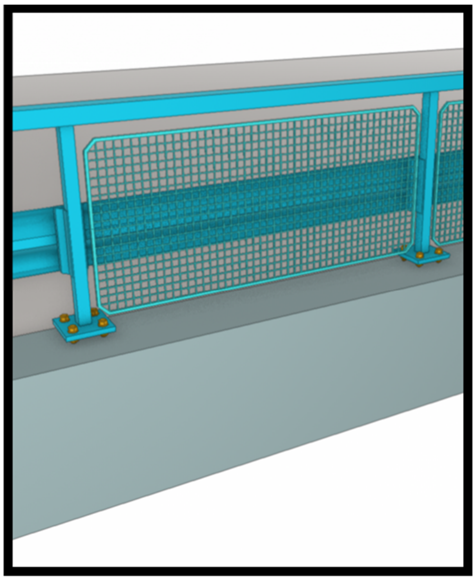

Figure 4.12 – Snow proof railing panel modelled with a high level of details.

Deciding on an appropriate level of detail is often a matter of cost versus benefit for designers and contractors. As part of clarifying the regulations for model-based deliveries, many stakeholders therefore want a minimum level of detail to be defined. Some stakeholders have also called for a maximum level of detail to be defined to avoid model file sizes getting unnecessarily large.

4.6.4. Clashes Between Objects in Model

In a large model with thousands of objects, clashes between some of these objects are common.

Essentially a clash in the model represents an unresolved issue. It can create uncertainty on how executions should be performed at site and the clash can also be difficult or impossible to resolve in real life. Objects clashing in the model can additionally cause uncertainty in interpreting as built solutions at an operating phase. It is however important to note that a clash free design does not necessarily improve the model quality. Furthermore, making a model free of clashes can be extremely resource intensive. Therefore, the extent to which a clash in the model constitutes a problem should be considered in relation to the type of clash it represents.

In this report, common types of clashes are grouped as follows:

- **Type 1:** Reinforcement clashing with prestressing (see Figures 4.13 and 4.14)
- **Type 2:** Reinforcement clashing with embedded elements (see Figure 4.15)
- **Type 3:** Reinforcement clashing with reinforcement (see Figures 4.16 and 4.17)
- **Type 4:** Clashes between fabrics, membranes, and other thin objects (see Figure 4.18)

Clash Type 1: Reinforcement clashing with prestressing

Prestressing cables that need to be channelled through layers of reinforcement often causes model clashes (see Figure 4.13). The positions and dimensions of the prestressing cables are often hard to revise, while adjusting the position of the reinforcement is generally easier. In Figure 4.14, model reinforcement has been adjusted to avoid clashes between rebars and prestressing cables. Adjusting the model to avoid clashes is however time consuming. Additionally, adjusting the rebars effects the automated information on rebar cc-distances. Adjusting the model rebars can therefore create challenges for rebar fixers when trying to interpret correct rebar cc-distance. In Figure 4.13, reinforcement bars clash with prestressing. This solution is less time-consuming to produce in a model and additionally provides clear information about the intentional rebar cc-distance. The drawback of this solution is that information on which object group (prestressing cables or rebars) have priority when clashing.

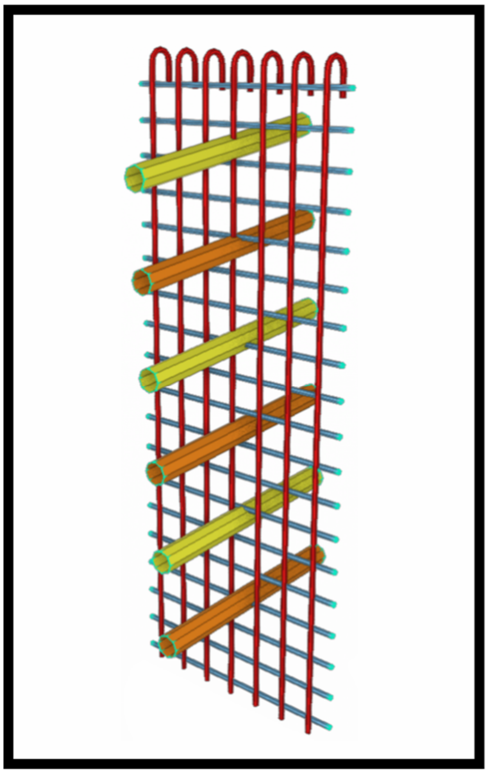

*Figure 4.13 – Example where rebars clash with prestressing. Automated metadata on rebar cc-distance is consistent. (Example: 7*150)*

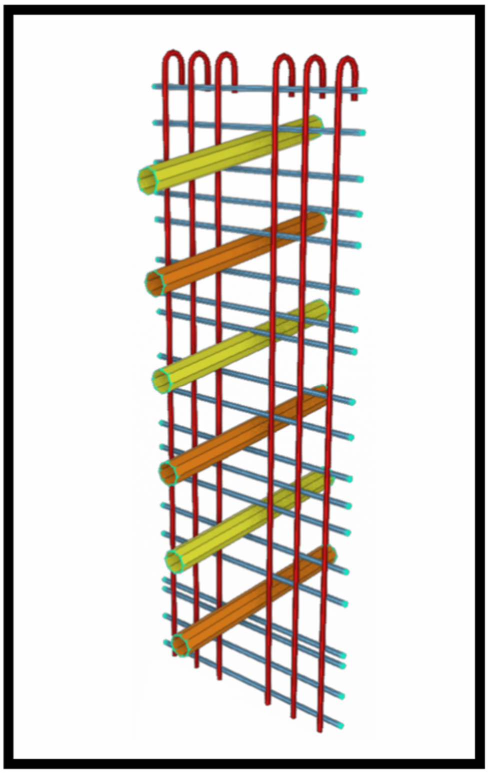

Figure 4.14 – Example where rebars have been adjusted to avoid clashes with prestressing. Automated metadata on rebar cc-distance is not consistent. (Example: 150, 130, 340, 130, 150)

Clash Type 2: Reinforcement clashing with embedded elements

A common type of model clashes are rebars clashing with embedded elements. Figure 4.15 shows a clash between reinforcement and an embedded group of bolts. Many clashes of this type can easily be resolved at site as long as information is provided on which object should be prioritized when clashing.

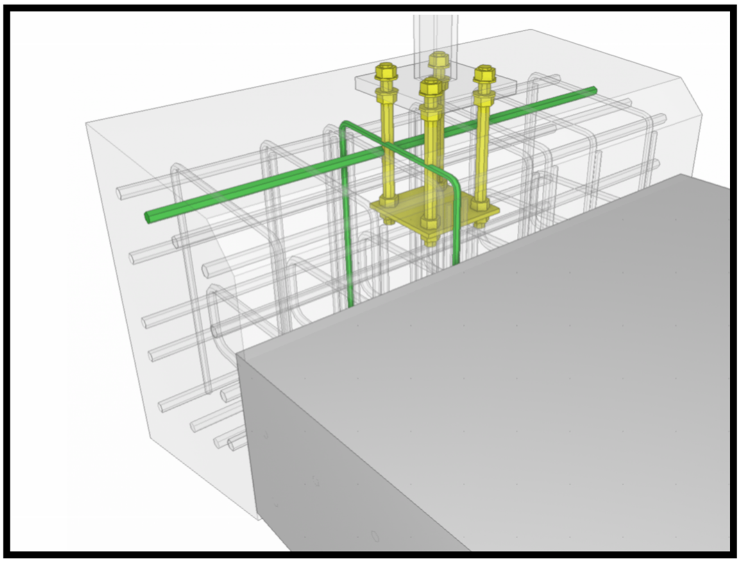

Figure 4.15 - Example of reinforcement colliding with an embedded group of bolts.

Clash Type 3: Reinforcement clashing with reinforcement

Another common type of model clashes is reinforcement clashing with other reinforcement. In some cases, these types of clashes are very challenging to resolve by doing on-site adjustments (see Figure 4.16). Other examples of clashes are parallel groups of reinforcements with different cc-distances clashing with each other at certain intervals (see Figure 4.17). Clashes of this type are generally easy to resolve by doing on-site adjustments. They are however very time consuming to avoid in models.

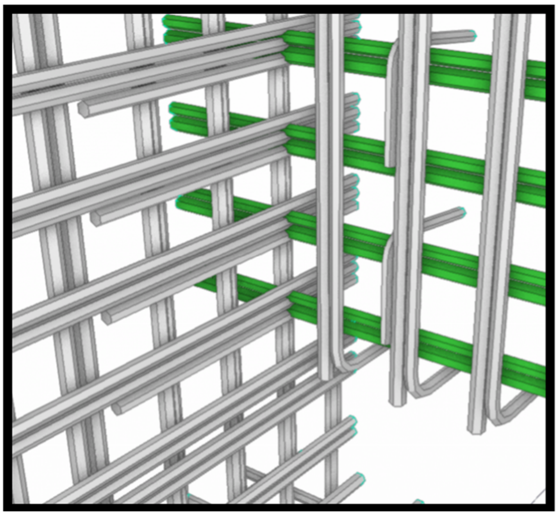

Figure 4.16 – Molde example where reinforcement clashes with reinforcement. This type of clash will be particularly challenging to resolved on-site.

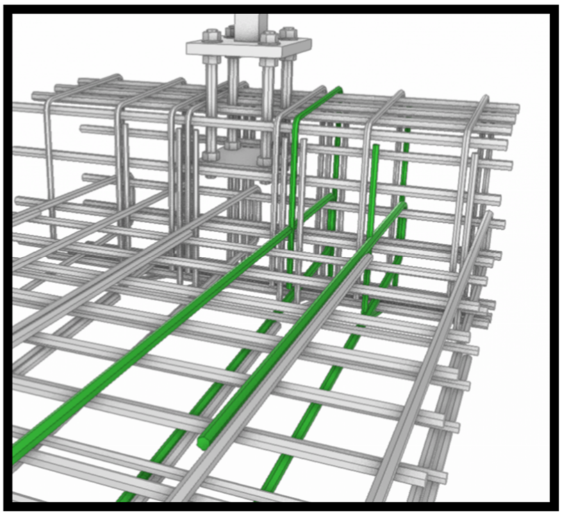

Figure 4.17 – Model example where reinforcement clashes with reinforcement. This type of clash can often be resolved on-site.

Clash Type 4: Clashes between fabrics, membranes, and other thin objects

Very thin objects such as fabrics, membranes, and other thin products are often challenging to represent in a model in an unambiguous way. Specially when they appear in layers (see *Figure 4.18)*. This often results in model clashes near joints or in areas where the objects are intended to be layered. In Figure 4.18, a fibre mat, and a membrane clash in an area where they are meant to overlap. These model clashes are difficult to avoid, but when left unsolved can create uncertainty about the correct installation sequence at site.

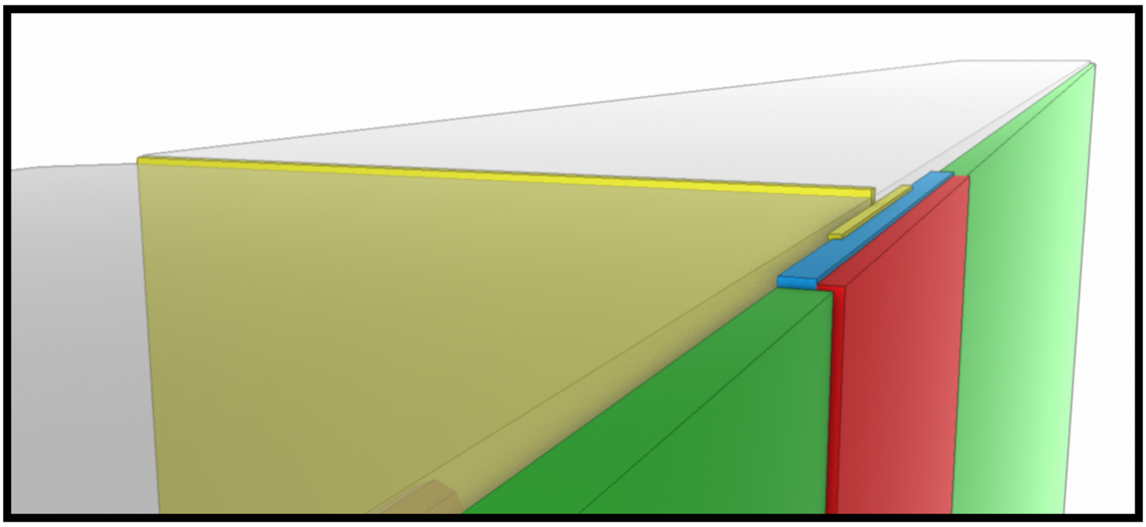

Figure 4.18 - Example of model clashes between thin layers near a concrete joint.

As part of request for clearer and more detailed regulations on model-based deliverables, many stakeholders seek definitions specifying the types of model clashes that are acceptable.

4.6.5. Product Neutral Components

Elements like bridge railings, prestressing tendons, and bearings often need to be incorporated into a model before the final product is determined. Several stakeholders have expressed a desire to develop product-neutral standard components for use in models until the final product is chosen.

4.6.6. Welds, Bolts and Cutouts

In the design of steel structures, welds, bolts, and bolt holes are crucial for the end result (see Figure 4.19). Requirements in NPRA standard N400 Bridge Design (2023-01-01) states that bolts and welds must be modelled.

Steel components are often produced by specialized manufacturers who prefer to base their production on drawings. In cases where these drawings are not derived from the model, contractor and designers would like more freedom when considering cost versus benefit for modelling details for welds, bolts, and bolt holes.

For large steel structures some contractors have also commented on challenges identifying unique details in models with a lot of repetition.

Operators and clients are supportive of modelling welds, bolts, and bolt holes as it consolidates as much information as possible in the model.

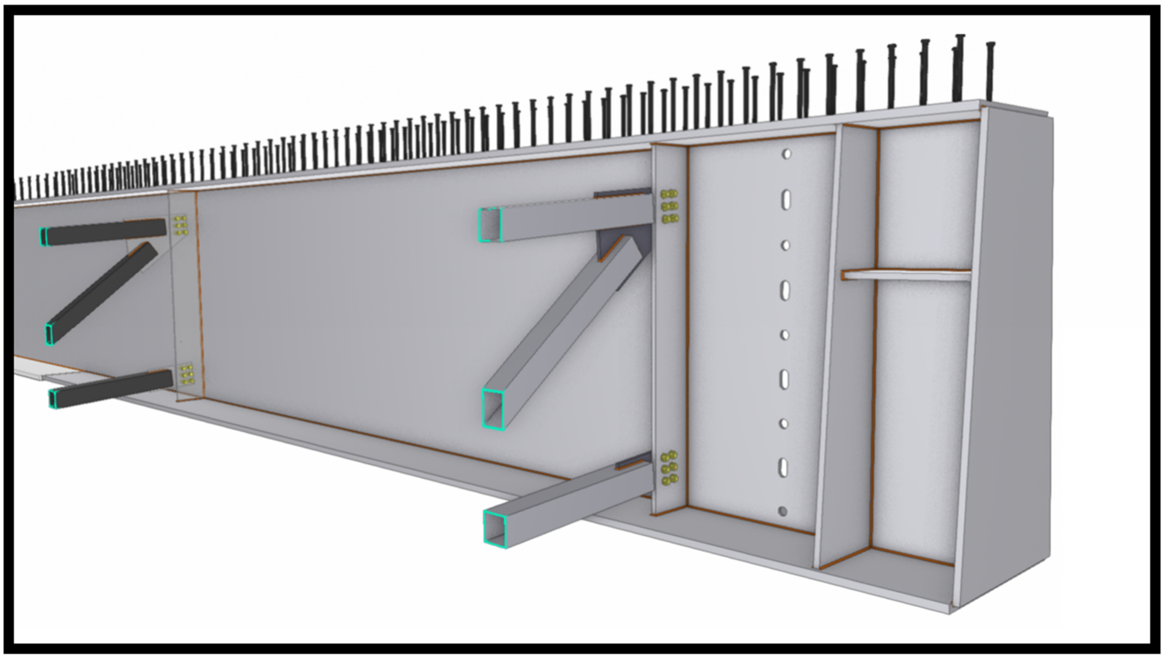

Figure 4.19 - Model with welds and bolts included.

For voids in concrete (e.g., for drainage), most stakeholders are positive to using void objects (see Figure 4.21). For the void object to have value, it needs to include metadata on the building sequence when the void is to be made.

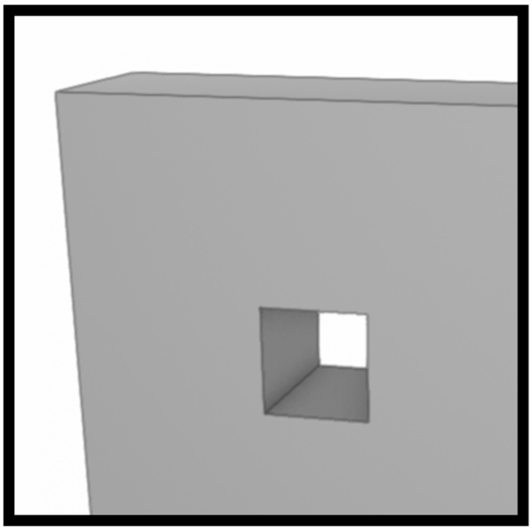

Figure 4.20 – Example of a void without avoid object.

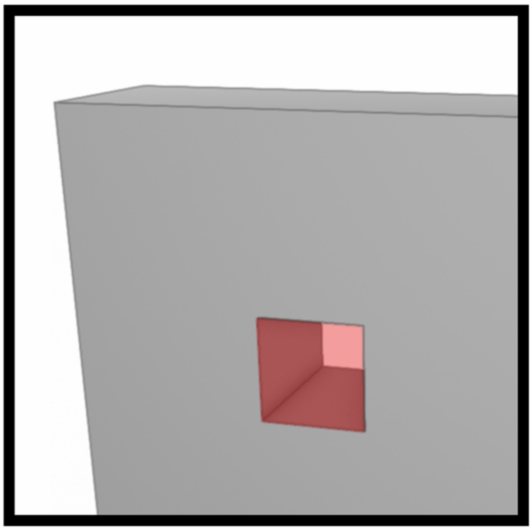

Figure 4.21 – Example of a void with a void object.

4.6.7. Colours

Object colour is a powerful tool to make models more user-friendly and intuitive. Using bright colours for small objects while applying grey tones to large surfaces like concrete (see Figure 4.23) can enhance visibility of smaller objects. Colour can also convey information about different pouring stages. Most designers, contractors, and operators support the standardization of colour used in models as long as universal design is used where possible. Rendering of colours may however vary between software. Another challenge is that some modelling software automatically creates object colours based on object material.

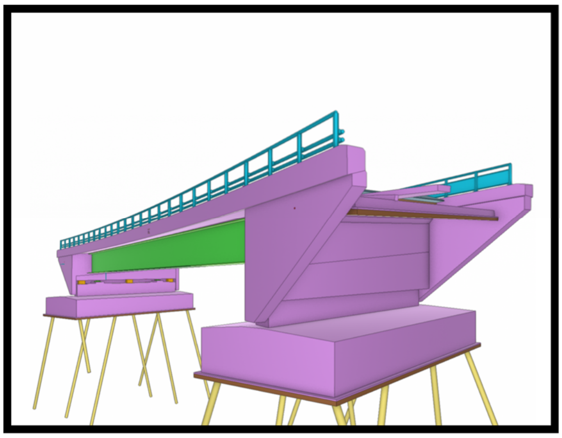

Figure 4.22 – Concrete shown in a strong purple colour makes it difficult to see smaller objects.

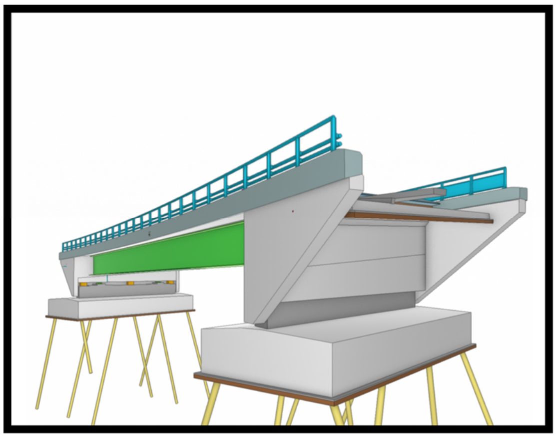

Figure 4.23 – Concrete shown in shades of grey makes it easier to see smaller objects.

4.6.8. Gridlines

Currently, there are no standardized way of representing gridlines in models. In some models, gridlines are represented as IfcGrid elements (see Figure 4.24), while in others they are represented as volume objects (see Figure 4.25).

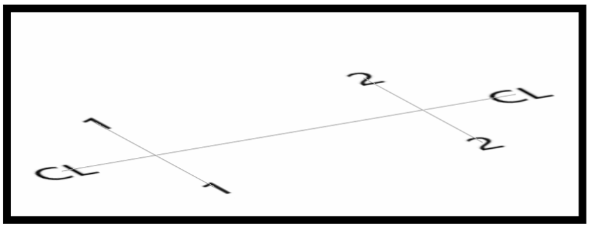

Figure 4.24 – Gridlines represented as IfcGrid elements.

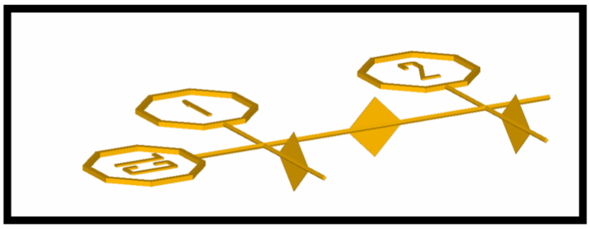

Figure 4.25 – Gridlines represented as volumetric objects.

The advantage of using IfcGrid elements is that they are part of the IFC schema and will be “pre-standardized” according to the IFC format, other disciplines, and most software. Using IfcGrid instead of volumetric objects will also make it easier for software vendors to create built-in functionality like automatic section cuts in gridlines. It is however difficult to display IfcGrid gridlines effectively in some software. Additionally, it is challenging to snap to IfcGrid gridlines in most software when acquiring measurements.

Gridlines represented as volumetric objects are currently easier to snap to when acquiring measurements. The majority of both designers and contractors therefore prefer to use volumetric objects to represent gridlines.

4.7. Methodology

4.7.1. Introduction

The concept of BIM does not only include BIM models but also the processes and solutions surrounding their use. Examples are how models reference to external documents and how the main model is divided into sub-models. It can also involve how project information is communicated, how model revisions are managed, and how information on earthworks is communicated.

Currently, there are significant variations in this methodology from project to project. The lack of a standardization creates challenges for reuse and prevents the industry from fully exploiting the potential of model-based deliveries. Many stakeholders therefore wish for more of the methodology used in model-based deliveries to be standardized. The following sections address key aspects related to methodology.

4.7.2. Alternatives to "BIM Title Block"

Most models currently contain an object showing true north or symbols placed over the construction, commonly referred to as a BIM Title Block. The BIM Title Block includes general information about the project and the construction, as well as links to relevant documents (see Figure 4.26).

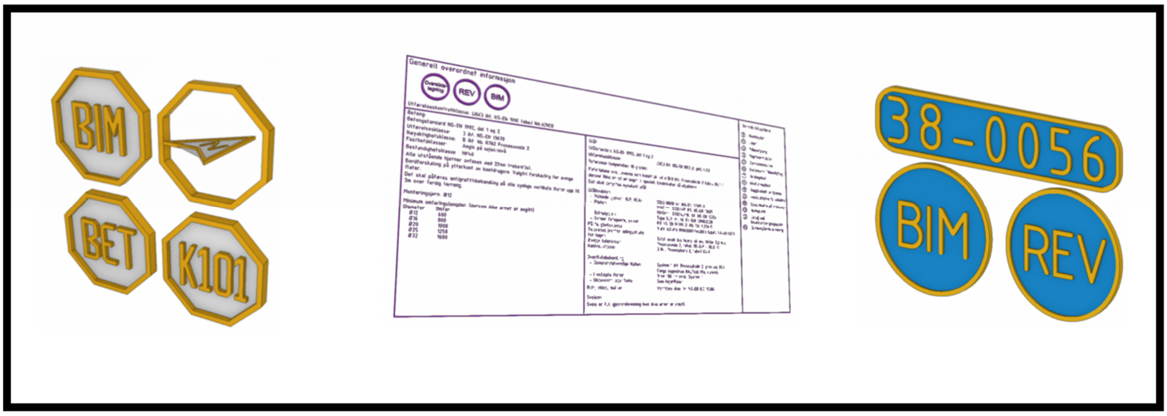

Figure 4.26 – Alternative examples of BIM Title Blocks.

In this methodology, general project and construction information is linked only to the BIM Title Block (see Figure 4.27). However, when it is necessary to compare data from multiple models, having general information embedded in all objects within a model is highly beneficial. Some models address this by applying the same general project and construction information to all objects. While this approach solves the problem, it unnecessarily increases the amount of data in the model and poses a risk of some objects containing incorrect information. Therefore, it would be advantageous to utilize the functionality of the IFC hierarchy to ensure the information is stored in one location within the model, while still making it valid for all objects.

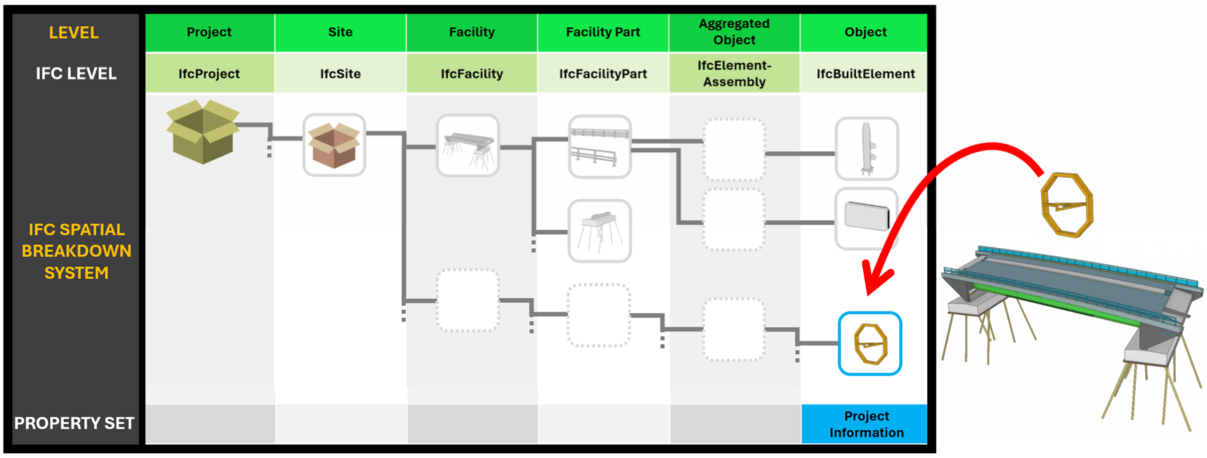

Figure 4.27 - Metadata applied to a BIM Title Block will not be "inherited" by all other objects in the model.

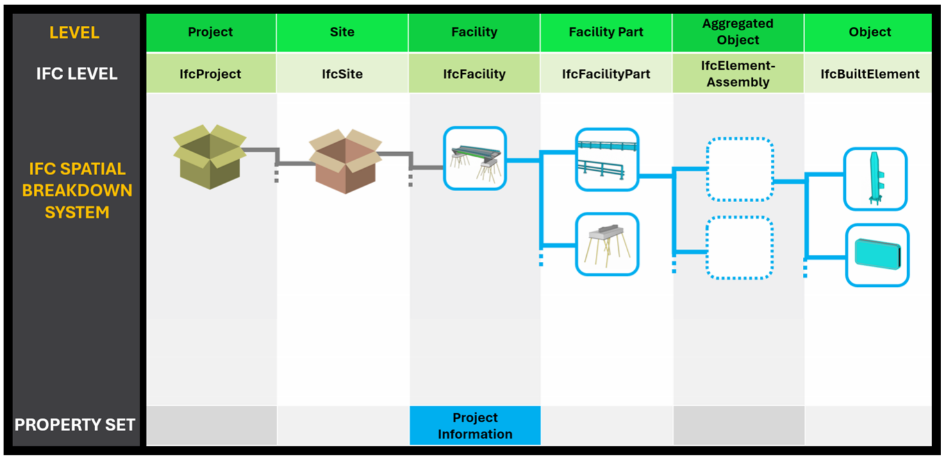

Figure 4.28 - If metadata (for example property sets with general project information) is placed at higher levels in the IFC hierarchy, all objects in the model will "inherit" the information.

Several stakeholders therefore want to place general information regarding the project and the construction in property sets located at higher level in the IFC hierarchy, suggesting IfcFacility level as ideal. That way general information regarding the project and the construction will be "inherited" by all objects in the model (see Figure 4.28). This solution is dependent on using the IFC Spatial Breakdown System.

Various software will display property sets at IfcFacility level differently. Figures 4.29, 4.30, and 4.31. show a custom-made property set at IfcFacility level called "TEST-FANE" in Trimble Connect, Solibri and BIMvision.

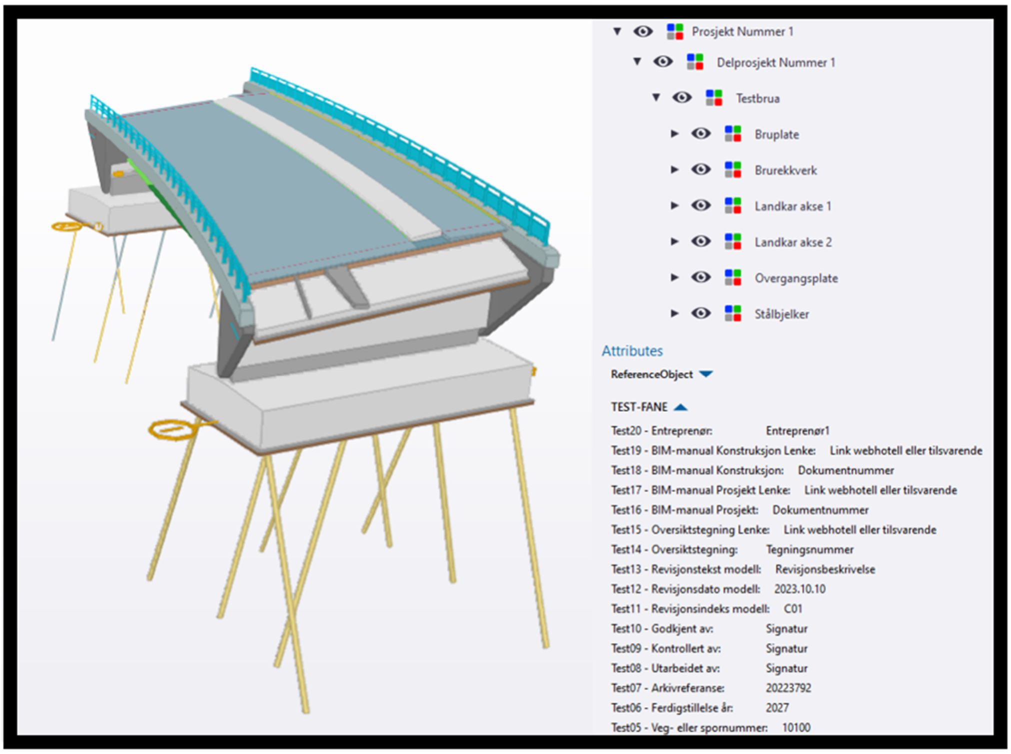

Figure 4.29 - Model and data structure with a custom-made property set at IfcFacility level called "TEST-FANE" shown in Trimble Connect.

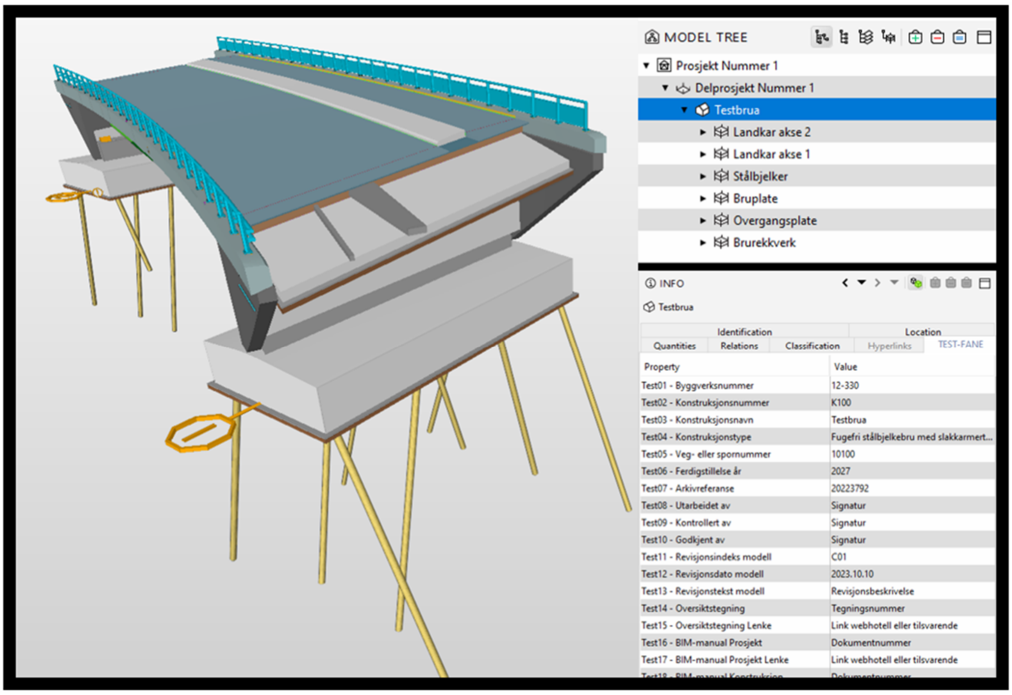

Figure 4.30 - Model and data structure with a custom-made property set at IfcFacility level called "TEST-FANE" shown in Solibri.

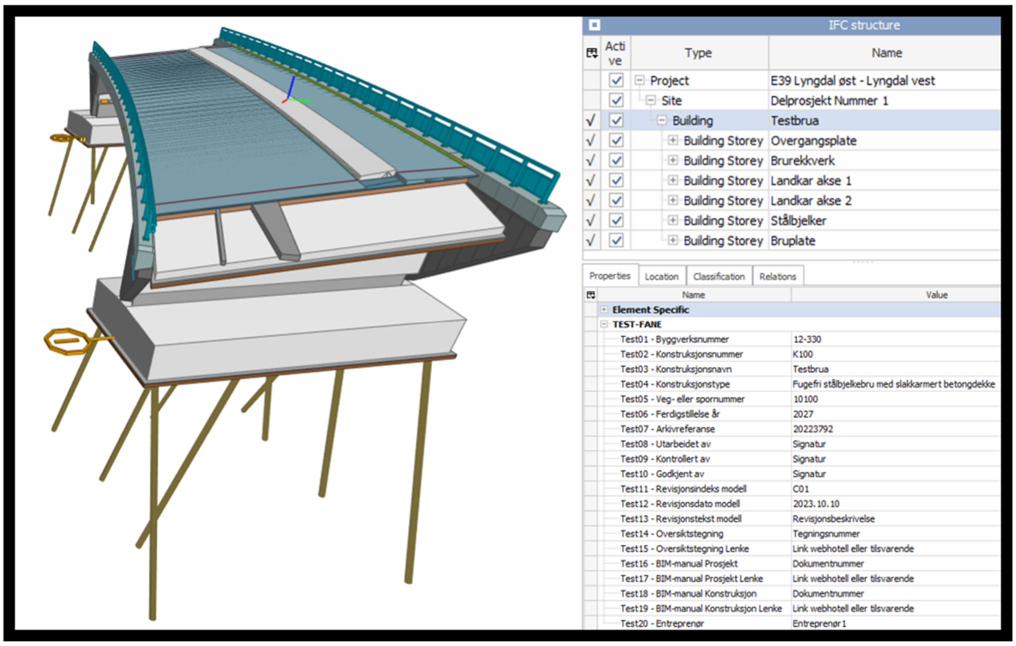

Figure 4.31 - Model and data structure with a custom-made property set at IfcFacility level called "TEST-FANE" shown in BIMvision.

4.7.3. Symbols

Many current models make use of symbols (also called information symbols) as carriers of information (see Figure 4.32). These symbols often point to specific areas to inform users about important information. Symbols might for example point to small objects like leveling bolts that otherwise may be difficult to notice.

Other common uses of symbols include an indication on areas where earthworks are required as earthwork is not included as objects in some models. Instead, the symbol contains a reference to relevant earthwork drawings.

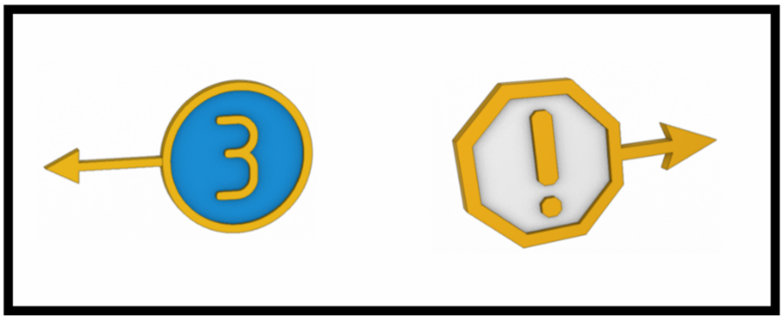

Figure 4.32 – Example of alternative symbol designs.

Many stakeholders wish to eliminate the use of information symbols in models. One reason is that by using symbols, information is no longer directly associated with the object to which it pertains. Keeping symbol information up to date has also proven challenging. Additionally, symbols take a lot of space and tend to clog up the model.

Annotations have been suggested as an alternative to symbols (see Figure 4.33). An annotation can convey much of the same information as a symbol, the advantage being that it is a digital text string and not an object. Additionally, annotations can be customized to only display relevant information, and the user avoids distracting symbols and irrelevant data.

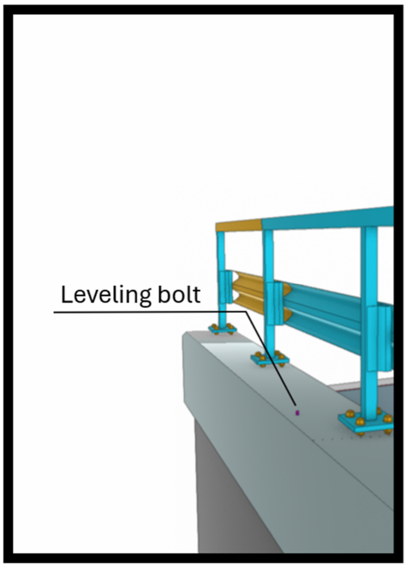

Figure 4.33 – Example of metadata displayed as an annotation.

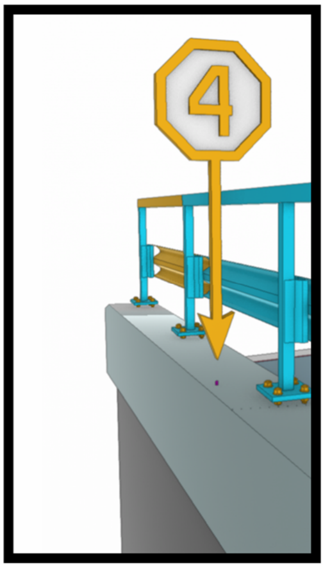

Figure 4.34 – Example of a symbol.

4.7.4. Division of Sub-Models

NPRA standard N400 Bridge Design (2023-01-01) recommends dividing model deliverables into the fewest possible sub-models when submitting for review and approval. Several stakeholders have expressed a desire for this to remain a recommendation rather than a requirement, as needs vary from project to project.

NPRA standard N400 Bridge Design (2023-01-01) further recommends that as-built model deliverables for operators be delivered as one single IFC file per construction. Some operators do however prefer to receive models of form and reinforcement separately, as this ensures that file sizes remain small enough for software to function effectively.

4.7.5. Revision Management

Revision management is currently handled in various ways across projects. Some projects specify revision numbers for both the model and each object, while others specify revisions for objects only. Whether an additional property for describing the revision is used or not, also varies. Additionally, some projects combine information on revision with the revision date, (for example «B_20230522»). Many stakeholders would like to see revision management standardized.

4.7.6. Links to External Documents

In model-based projects, there is often a need to make references from models to various documents and drawings. Examples are BIM manuals and layout drawings. Effective methods for linking documents and drawings to models is crucial for making information easily accessible in a construction phase. Additionally, the methodology also needs to work efficiently when archiving models for use by operators.

NPRA standard N400 Bridge Design (2023-01-01) requires that linked documentation be placed in folders that have relative paths to the model. The necessary documents should be placed in a standardized folder structure. This requirement is not met in all projects, as contractors using models at site have found it challenging to implement. Many stakeholders have for this reason requested a more detailed guide on how to manage links in models to external documents. One proposed solution is that references be made to document numbers and drawing numbers only, without using interactive links. This will eliminate the need for relative paths.

4.7.7. Information on Earthworks

Currently information on earthwork is shown in numerous ways across projects. Some models do not contain objects representing earthworks and instead reference earthworks drawings. Other models have earthworks shown as objects with metadata.

Feedback indicates that most designers prefer to convey information on earthworks through drawings. Contractors are divided on whether they prefer to information on earthworks on drawings or as objects in the model.

A disadvantage of showing earthworks as objects in the model is that objects representing earthworks fill up significant space and decrease model overview. Additionally, the shape of earthworks at site change frequently, making it hard to keep model objects representing earthworks up to date. In addition, information on earthworks interface disciplines such as construction, geotechnics, landscape architecture, and road design. It can therefore be challenging to determine which discipline the earthworks model should belong to, resulting in information being overlooked or forgotten.

The benefit of representing earthwork as objects within the model is that it consolidates as much information as possible directly in the model, minimizing the reliance on external documents. Model objects representing earthworks can also be used for surveying and machine control data and provides a relatively accurate representation of quantities. This can also clarify the division of responsibilities between resources handling construction and those responsible for earthworks.

4.7.8. Standardization of BIM Manual

NPRA standard N400 Bridge Design (2023-01-01) requires models in model-based projects to be accompanied by a BIM manual. The manual should provide information on model data structure and where and how relevant metadata can be found. Some stakeholders want the BIM manual's format to be standardized, making it easier and faster to find relevant information in the manual. The need for a standardized BIM manual will however be reduced if all models are standardized with the same data structure.

4.7.9. Predefined Sections in the Model

One advantage of a model over a drawing is that it centralizes a wealth of information in a single location. With the current available software, many people do however find layout drawings a faster way of getting an overview of important aspects of a construction. A layout drawing quickly offers an overview of key dimensions and relevant details, sparing the user from manually extracting measurements from a model.

To improve model usability for these kinds of user cases, several stakeholders have requested ways of creating predefined sections with predefined dimensions and annotations in the models. This will save time and reducing uncertainty for the model user. This will also greatly improve model usability for operators, where employees often need to obtain an overall understanding of several constructions per day. Additionally, it will make quality control of dimensions and metadata easier. Predefines views will also be beneficial at site, where manually acquired measurements in handheld devices can be challenging. It might however prove laborious to produce the predefined sections with predefined dimensions and annotations.

5. DISCUSSION AND FUTURE WORK

5.1. Summary

The feedback received clearly indicates that there is significant interest in the industry for developing common guidelines for the use of models in the planning, design, execution, and operation of infrastructure structures. Although different stakeholders emphasize different aspects, there is a widespread support for standardization as it undoubtedly will benefit the industry as a whole. However, clients, consultants, contractors, and operators face varying needs and challenges, as highlighted below.

5.2. Clients' view

The key feedback from clients is summarized as follows:

- A standardized data structure in the model will enable better analysis and data extraction. It is therefore suggested to standardize properties and property sets.
- Predefined dimensions in the model will simplify quality control. Acquiring measurements in the model can be challenging and time-consuming with current software.
- Object colours should be used to reflect reality as much as possible.
- Relevant properties should be coordinated across disciplines. Properties related to the process codes (referring to R762) should be prioritized.
- A standardized method for including cost information in the model will make budgeting and cost monitoring more accurate and efficient.

5.3. Consultants' Views

The key feedback from consultants is summarized as follows:

- A standardized data structure in the model will enable better analysis and data extraction. It is therefore suggested to standardize properties and property sets. Some of these property sets should be positioned higher in the IFC hierarchy (see figure 4.28).
- Clearer and more detailed requirements and recommendations for model design should be established. The resources required for model production and progress uncertainty are currently unnecessarily high due to the lack of a clear regulatory framework.
- The use of symbols should be discontinued and replaced by object metadata and/or the use of annotations.
- Predefined dimensions in the model will simplify quality control. Acquiring measurements in the model can be challenging and time-consuming with current software.
- In some cases, drawings convey information more effectively than models.
- It is important that standardization is done in a way that facilitate innovation rather than limiting it.
  Standardization should ensure that models contain essential and accurate information. Excessive detail and surplus data can cause critical elements to be overlooked.

5.4. Contractors' Views

The key feedback from contractors is summarized as follows:

- A standardized data structure in the model will enable better analysis and data extraction. It is therefore suggested to standardize properties and property sets.
- Handheld devices such as tablets and mobile phones used at construction sites have limited functionality. Therefore, only information relevant during construction should be available in the model at this phase. Additionally, predefined sections with predefined dimensions and annotations will make the use of models at site significantly easier.
- Models with substantial amounts of data can create stability issues in handheld devices used at site.
- Conscious use of object colours will improve model quality for use at construction sites.
- It is important to consider cost versus benefit when deciding on a level of detail for a model. A highly detailed object will not always add value to the model in a production phase.
- In some cases, drawings convey information more effectively than models.

5.5. Operators' Views

The key feedback from operators is summarized as follows:

- A standardized data structure in the model will enable better analysis and data extraction. It is therefore suggested to standardize properties and property sets.
- A standardized use of IFC entities will improve data extraction capabilities.
- There is a need for standardizing the way models and the accompanying documents are stored and archived.
- Predefined model sections that include dimensions and MOM (Management, Operation and Maintenance) documentation will simplify the documentation process and improve model useability for operators.
- Standardization should be attempted across disciplines such as bridges, tunnels, and roads.
- Properties and metadata should be aligned with the MDL (Master Document List). MDL is still under development.

5.6. Challenges and Obstacles to Standardization

The project group has identified the following challenges and obstacles to standardization:

- It should be considered whether implementing standardization could negatively impact ongoing projects and the current way of working and also whether it will limit future innovation.
- Limitations in software can be a barrier to standardization. Tekla and Revit's limited ability to export files in IFC4.3 format is an example.
- It is important to consider how new requirements and recommendations will affect the skills needed for designing and utilizing models. As an example, creating predefined views with predefined dimensions and annotations currently requires skills in programming and parametric design.
- It is important to consider which regulations should encompass the updated requirements and recommendations. These may need to be grouped and integrated into different regulations. For instance, model requirements for the construction phase might fit into

different regulations than those for the operation phase. Additionally, the time needed to revise regulations can pose a challenge.

- The way models are produced supports a one-way flow of information from designers to contractors to operators. This makes it challenging to optimize models in regard to operators' needs.
- Methodology for enriching models with metadata after the models have been handed over by designers is currently deficient. This makes it challenging for operators to keep models updated with relevant metadata.
- Recommendations intended to be temporary can quickly become an unofficial industry standard. These unofficial industry standards might later be hard to get rid of.

5.7. Recommendations for Further Work

The project groups' conclusion is listed below:

- A standardized data structure with defined properties and property sets is crucial for further standardization efforts. This should be prioritized in future standardization work. Properties related to project information and general construction information should be placed at a higher level in the IFC hierarchy.
- Close contact with software vendors is important to highlight industry challenges and needs. This will also help to expedite improvements. Current challenges with exporting IFC4.3 files from Tekla and Revit are important examples and the need for improvements should be addressed. Referring to regulatory requirements when communicating with software vendors is likely to significantly expedite this process.
- To promote standardization, initial requirements and recommendations should be limited and easy to implement. It is also important to weigh benefits against costs and ensure that requirements and recommendations do not hinder further innovation.
- It should be determined which regulations the requirements and recommendations should be included in. Model requirements for the construction phase might for example belong in different regulations than model requirements for an operation phase.
- How models and object metadata can be updated during an operational phase needs to be considered.
- Validation of IFC files using IDS (Information Delivery Specification) could significantly increase model quality.
- It is highly recommended that NPRA continue the standardization project. Continuity is particularly important as there still is a significant need for further work, testing and follow-up.
- The use of symbols should be discontinued and replaced by object information and/or annotations. It is however important that the industry develops efficient methods for producing dimensions and annotations in open BIM formats before this transmission is done.
- Models should contain predefined dimensions in areas where acquiring measurements manually are challenging. It is however important that the industry develops efficient methods for producing predefined dimensions in open BIM formats before this transmission is done.
- Requirements from NPRA standard N400 Bridge Design (2023-01-01) stating that project deliverables should either be model-based or drawing-based should be reconsidered. Some designs and details are challenging to present in a clear and unambiguous manner in model-based deliveries.

6. OTHER RELEVANT INFORMATION RELATED TO STANDARDIZATION

This chapter provides a brief summary of handbooks, standardization initiatives, and conceptual definitions relevant to the information in this report.

BOLC (Bjørnafjorden Open Live Center)
BOLC was a pilot project where methods for real-time project management were developed. BOLC has served as a "proof of concept" for this type of working methodology and has laid the foundation for MOPS.

GIS (Geographic Information System)
Files that describe roads and terrain. GIS was previously delivered in SOSI format but is now delivered in GML format, which can also describe volumes.

Guideline R110 Model Basis (Retningslinje R110 Modellgrunnlag)
R110 describes how documentation should be ordered, produced, controlled, and delivered in NPRA road projects. R110 also describes the requirements for information content, accuracy, and precision in models, as well as how models should be used and exchanged between different project participants. R110 replaces V770 (2015) and R700 (2007).

IDS (Information Delivery Specification)
IDS is a standardized method for defining and structuring digital information in construction projects. IDS specifies what information should be delivered in various phases of a project and in which file format, so that information can be exchanged effectively between different disciplines and systems. IDS is developed by buildingSMART International.

ITS (Intelligent Transport System)
Intelligent Transport Systems (ITS) is a collective term for the use of new technology in the transport sector to make transport systems safer, more efficient, and more sustainable.

ISO 16739-1
ISO 16739-1 is an international standard that describes how the IFC format is intended to be used for data sharing within the building and property management industry.

ISO 55000 - Asset Management
ISO 55000 is an international standard for Asset Management. The standard provides guidelines for effectively planning, developing, operating, and maintaining assets in a cost-effective manner while ensuring quality and safety during the management period. The goal of the standard is to optimize the value of assets throughout their lifecycle and contribute to sustainable and efficient resource management.

KIM
The KIM project focuses on structuring and standardizing information deliveries in BaneNOR's (Norwegian Railway Infrastructure Management) development projects. The goal is to provide logical names for objects and properties in accordance with industry standards.

MOPS
MOPS is the NPRAs project management tool designed for the development phases of road projects and is used in projects where NPRA is the client. MOPS is a method for real-time project management using digital tools for monitoring and optimizing projects through a data model containing information about the project's structure, activities, resources, and schedule. MOPS defines requirements for project file formats and encourages the use of the BCF format for quality control routines.

NOSSB
NOSSB is an interdisciplinary collaboration among clients (including Statsbygg, Sykehusbygg, and BaneNOR) focusing on requirements for properties and property sets in IFC deliveries.

NS-EN ISO 19650
NS-EN ISO 19650 is an international standard for managing information in construction projects using BIM. The standard provides guidelines on how information should be organized, structured, and exchanged between the parties involved in the project.

NS 8360 BIM Objects for Buildings
NS 8360 is a series of standards for type coding and classification of objects and linking properties and values to the IFC model. NS 8360 is intended to support automatic recognition of object types and the information related to object types between different IFC-compatible programs and to contribute to increased efficiency and quality in the use of building information models.

NVDB (Nasjonal Vegdatabank)
NVDB is a national database of the Norwegian road network. The database contains information about the road network, including road standards, traffic data, geographic information, road markings, and road lighting. Road objects are located on the road network as either points or areas. These objects can include both physical objects like signs, culverts, or barriers, as well as events like landslides and accidents, and more abstract data such as speed limits and traffic volumes. NVDB is developed by NPRA and is a crucial resource for planning, development, and management of the Norwegian road network. Data from NVDB is also used by other public agencies, private companies, and research institutions.

R762
R762 provides uniform rules for the scope, material requirements, execution, tolerances, documentation, and quantity rules for the construction of bridges and quays. The process code is hierarchically structured according to the decimal system. Related work is grouped into ten groups called Main Processes. The main process for the construction of bridges and quays is given in Main Process 8.