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Finnish Transport Agency
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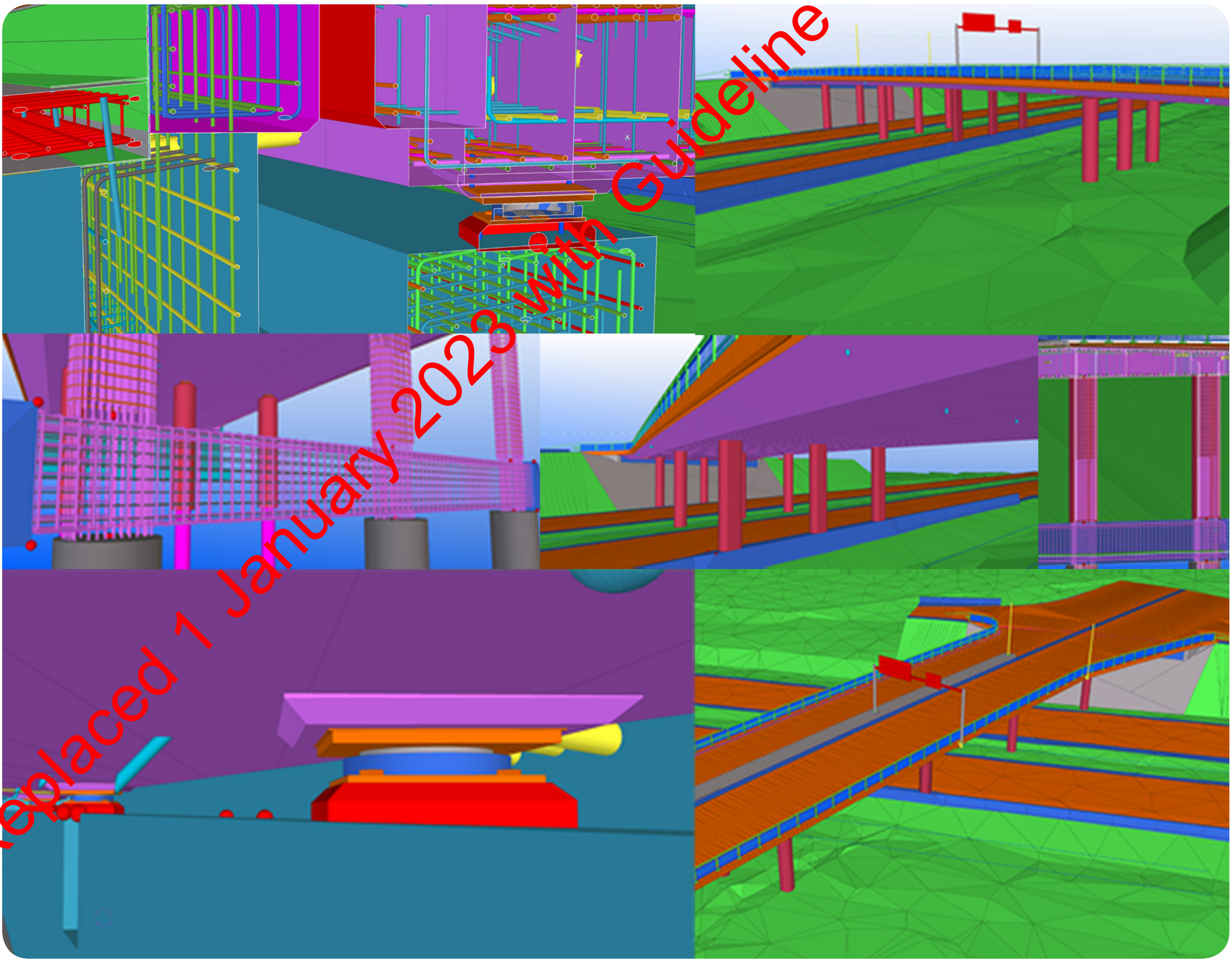
GUIDELINES OF THE
FINNISH TRANSPORT AGENCY

BIM Guidelines for Bridges



BIM Guidelines for Bridges

Guidelines of the Finnish Transport Agency 6eng/2014

Finnish Transport Agency

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GUIDELINE

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Engineering Structures

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Guideline: BIM Guidelines for Bridges
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BIM Guideline for Bridges

This BIM Guideline for Bridges is the English translation of the Finnish Transport Agency's Guideline "Siltojen tietomallintamisohje, Liikenneviraston ohjeita 6/2014". The official version of the Guideline is the Finnish version. Due to the stage of international development in building information modelling of infra structures and bridges, the use of English terms is not yet standardized and may vary in different countries, which have to be taken into account when reading this publication. In the event of any conflict between the Finnish version and the English translation, the Finnish version shall prevail.

The BIM Guideline for Bridges contains instructions on uniform procedures for the BIM-based design, implementation and maintenance of bridges. Common methodologies promote the adoption of new technology and enable the BIM adoption process to be implemented in collaboration between the designers, contractors and authorities.

This Guideline is intended to be used in Finland for all contract types. The Guideline covers the design phases and specifies the content of their modelling. The Guideline shall be applied to the modelling of all engineering structures. The Guideline also includes form templates designed to facilitate the creation of modelling requirements and any contract-specific agreements associated with an order. The forms (in Finnish) will be published on the Finnish Transport Agency website.

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Foreword

As the design, implementation and maintenance of bridges and other engineering structures become BIM-based, detailed specifications are needed for BIM-based operations. This Guideline helps the commissioner to verify the content of the ordered BIM. The Guideline serves to align the internal development of the Finnish Transport Agency, and also sets requirements for software companies and application developers.

The updates to this Guideline are based on the 'Guidelines for Bridge BIMs' developed by the 5D-SILTA2 consortium project. During the update, the structure of this Guideline was upgraded to a requirement level, where separate chapters issue more detailed specifications and instructions for application. In addition to many extra details, a new topic introduced in the Guideline is the creation of BIM-based source data, the fundamental idea of BIM communications and BIM-based functionality in the maintenance of engineering structures.

The update of the BIM Guideline took place in workshops with participants from several different organisations dealing with bridges. The repair section was written by Markus Siidorow of Siltanylund Oy. The sections concerning the specification of the maintenance model and the upcoming engineering structure register were written by Sakari Lehtinen of Datacubist Oy. Other parts of the Guideline were written by Heikki Myllymäki. In addition, the workgroup consisted of Timo Tirkkonen from the Finnish Transport Agency's Engineering Structures Group and Rauno Heikkilä from University of Oulu.

Lappeenranta, February 2014

Finnish Transport Agency
Infrastructure and Environment
Engineering Structures

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Concepts and definitions

This chapter defines the terminology used in bridge modelling.

Good modelling practices
The guidelines contain references to good modelling practices. Good modelling practice means that a model has been created logically and strictly according to the requirements, and it is associated with a BIM report that complements and explains the model. In addition, good modelling practices requires that the designer has performed quality assurance on the model, including (but not limited to) visual inspection, collision examination and an inspection report. A model created according to good modelling practice is easy to use for the desired purposes.

IFC Format
(Industry Foundation Classes) An international, continuously updated object-oriented data exchange standard ISO 16739 for construction business. The standard is developed by the BuildingSmart Alliance.

Immaterial object
Immaterial objects. Used for modelling e.g. the dimension data of a bridge.

InfraModel (IM)
An open LandXML-based data definition for the exchange of model-based infrastructure data.

Manufacturing model
A separately created model for the production of steel structures in manufacturing workshops. Does not replace the modelling of steel structures to their final format in the bridge product model (also see Implementation model).

LandXML
A commonly used XML-based specification used in earthworks for infrastructure and land survey data (also see InfraModel (IM)).

Initial information model
The current state model combined with other initial data required in basic design. The most important initial data is the design-phase material that serves as an input for basic design.

Soil model
A digital soil (subsurface) model. Contains the approximate (interpreted) interfaces of soil strata, and e.g. data on material properties and water content.

Terrain model
Digital model of the surface terrain Metaphorically speaking, the visible surface of the terrain.

Native format
BIM saved in the file format of the software used in the creation of the model.

Zero weight
Material specification for immaterial objects.

Current state model
The current conditions at the bridge site: the terrain, structures, geotechnical conditions and any objects in the vicinity of the bridge site that affect the design (buildings, protected sites, etc.). Does not contain designed material. The current state model becomes increasingly detailed as information accumulates. The detailed model is transferred as-is to the next design phase.

Traditional design
The guidelines contain references to traditional design. Herein, traditional design means a design process based on 2D documents.

Collaboration model of a bridge
Contains the initial information model, the bridge product model and associated technology areas, and the earthworks that belong to the bridge (for example ramps and slopes). Figuratively a "piece" of the road infrastructure model. This is the most significant model as regards the entire bridge site.

Infrastructure model of the bridge site
See 'combination model of a bridge'.

Initial design data
Created as the initial data for the bridge to be designed (cf. bridge site documents). Includes the initial information model of the bridge site. This data is generated by designers belonging to various technology areas.

BIM
A general term for digital data-containing models used in construction.

BIM material
Includes the BIM and associated materials, such as the BIM report.

BIM report, model specification
A BIM report is a text file attached to the BIM. The BIM report describes the completeness of the model version and its numbering and labelling scheme. The BIM report can contain a separate section for the initial information model. Alternatively, a separate BIM report shall be created for the initial information model.

As-built model
The as-built model is created during construction and handed over to the commissioner. Describes the actual implemented structure.

Implementation model
A model that guides the manufacture of structural components and construction work at the worksite; i.e. this model guides implementation and is refined from the bridge product model. The model typically contains various preliminary elevations and provisions for deformations, such as construction-time structures such as scaffolding and moulds. An implementation model can also mean a machinery control model for work machines refined from the product model, or a local measurement model created for measurement purposes.

Product model (Bridge product model)
A digital design of a bridge, produced by a designer. Contains and describes the product, i.e. the detailed structural geometry, structures and materials in the completed final configuration and conditions (temperature +10 °C). The product model does not contain preliminary elevations or provisions for deformations. The content and required precision of the product model are specified in these Guidelines by design phase.

Reference material
Plans and reports associated with initial design data. For example design criteria.

Virtual model
A model refined from the combination model; a photorealistic representation of the bridge site. The site is illustrated by e.g. adding plants, materials, lighting, traffic, different times of day and seasons. The virtual model may use non-designed and irrelevant data to illustrate the object.

Traffic artery model
Road surface model (in this Guideline, the term refers to the surface model of roads connecting to the bridge site). Triangulated at 5-metre intervals in straight sections, and 1-metre intervals in section where the geometry changes. The formats used in the basic design systems are 3D-dwg and IFC.

Combination model
A model-based description of the infrastructure. As its name implies, a combination model combines the various technology area models into a comprehensive whole that describes the entity to be constructed. Used in particular for fitting together designs of different technology areas. See also 'Combination model of a bridge'.

Maintenance model
A model that can be used in bridge maintenance and service processes. Added into the engineering structure register.

1 Introduction

1.1 Using the Guideline

The purpose of this Guideline is to define the content, structure and data presentation of bridge BIMs used in the projects of the Finnish Transport Agency. The Guideline lays down the rules for BIM-based design, which enables equality between operators in model-based projects.

The Guideline can be applied in all contract forms and design phases. A more detailed description of the phased of basic design can be found in the documents *Siltojen suunnitelmat TIEL 2172067-2000**) (in Finnish) and *Silta-alan konsultoinnin tehtävät RIL 214-2002* (in Finnish). The Guidelines apply to bridges, but can also be applied to the modelling of other engineering structures, such as embankment and pile slabs, support walls, noise barrier walls, tunnels, piers, culverts and maritime navigation aids.

*) The publication shall be updated to meet the needs of information modelling.

The instructions and requirements in this BIM Guideline are written using regular indentations in paragraphs. There are also separate passages that provide advice for applying the Guideline and serve as technical guides. The advice is written in italics and has an extra indentation.

> *This is an example of advice. The purpose of these pieces of advice is to help the users to apply this Guideline.*

1.2 BIM modelling in infrastructure construction

BIM modelling has become an increasingly common method for presenting the initial information of an infrastructure project, while also commonly used in the design and implementation of the project. A future goal is to use modelling also for maintenance purposes. In the future, uniform collaboration models for infrastructure will be created in the planning and design phases of projects. It is desired to include bridges and other engineering structures as part of the whole in order to ensure e.g. uniformity of design between technology areas. BIM modelling enhances productivity and quality.

Groundwork for the adoption of BIM has been laid in several research and development projects and programmes, especially in the Infra TM project coordinated by the Building Information Group. Research to promote the adoption of BIM is carried out in the InfraFINBIM work package that belongs to the PRE research programme of RYM Oy. The purpose is that, as of 2014, major infrastructure owners only purchase BIM-based services. In order to achieve this, the work package has developed the Inframodel 3 (IM3) data exchange format.

Furthermore, the Infra FINBIM work package creates and pilots modelling requirements and instructions, expands the infrastructure nomenclature to support BIM modelling and develops procurement procedures. Finnish expertise is also used in the standardisation of BIM-based data exchange. Section *6. Rakennustekniset rakennusosat* (Structural components requiring construction engineering) of the InfraBIM is based on this Guideline.

1.3 BIMs in the construction of new bridges and repairs of bridges

The use of BIMs in the design of engineering structures has attracted considerable interest in the last few years. The design of bridges is gradually moving to model-based design. The term BIM (Building Information Model) commonly occurs in discussions about information models. BIM generally means an information model that, in an ideal situation, stores the data of a building and its construction process in digital format throughout its lifecycle. In reality, BlM-based design is carried out at several different levels, with the purpose of achieving a whole that serves the processes as well as possible in each project. In BIM projects, data is exchanged between parties based on the model.

BIM-based basic design and lifecycle management has been developed in co-operation with different parties. The use of BIMs and their possibilities for basic design has been investigated in e.g. Älykäs Silta, 5DSilta, 5DSilta2 and 5DSilta3 development projects.

The purpose of modelling in basic design is to use 3D data so as to ensure that the design contains as few errors as possible, information is collected into a single location and exchanged with other parties, which in turn improves the financial performance and quality of the construction process.

1.4 Creation of a bridge BIM

1.4.1 Design and implementation phase

The BIM means a model-based collection of plans for a bridge. A BIM consists of an initial information model and one or more product models (3D models) where structural-component-specific information has been added. These two are assembled into a combination model that helps to create a model for the bridge site. Depending on the project, the combination model of a bridge can also be produced as the infrastructure model of an entire project. The BIM should always be accompanied by a BIM report. The bridge BIM can also be enhanced by other reports as necessary.

The information model is used to generate printouts (drawings) and other reports/lists for a given task and phase.

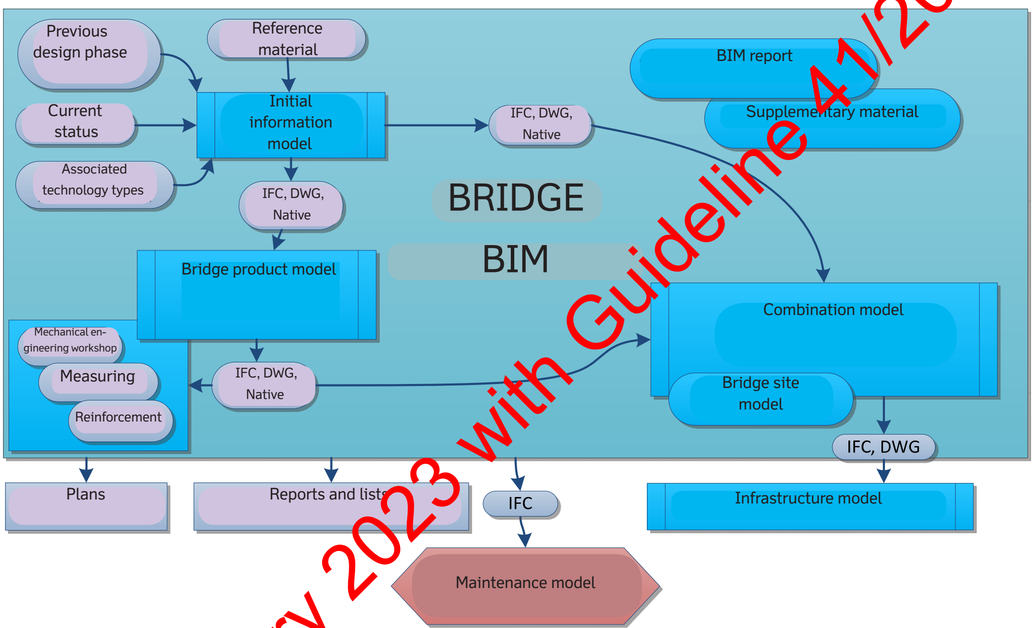

Diagram 1. Creation of a bridge BIM and formats used in data exchange

1.4.2 Maintenance phase

When transferring over to the maintenance phase, a maintenance phase model is created based on the models for engineering design and implementation. The maintenance model is created as specified in Chapter 6 of this Guideline. The maintenance model is attached with a BIM report.

2 Procuring BIM-based design

Bridges in the Finnish Transport Agency's projects shall be modelled as specified in this Guideline. The BIM-based design should proceed at the same speed as the design process.

The utilisation of BIMs in the Finnish Transport Agency's projects adheres to the following principle: **Notwithstanding the KSE 1995 terms and conditions, Section 6.2, the commissioner shall have the right to use all open format (IFC and LandXML/Inframodel) information model materials supplied during the provision of this service for their own purposes without the need for approval from the consultant; this includes the modification and further development of the aforementioned materials either on their own initiative or with help from a third party, and the use of this modified format for their own purposes. In addition to material provided in open format, the consultant shall, upon the commissioner's request, deliver the entire materials in native format without extra costs for use by the commissioner and other parties involved with the further implementation of the project.**

In procurement formats where the commission includes both design and implementation, the aforementioned principles shall be followed. Chapter 9 contains more instructions about the handover of a BIM.

Conceptually, it is often thought that information modelling is separate "add-on" or an independent function in projects. This leads to a partly skewed procedure where the commission is conventional but supplemented by an information model.

2.1 Determining the scope of modelling

When specifying tasks, the commissioner shall ensure that the BIM model requirements are unambiguous. In the tendering phase, ambiguities lead to inconsistent assumptions on the amount of work. The basic requirements for the BIM contents are specified in Appendix 2 of this Guideline. Appendix 2 corresponds to the requirements of Section 6. *Rakennustekniset rakennusosat* (Structural components requiring construction engineering) of the InfraBIM guidelines Appendix 3 of these Guidelines contains further specifications for the project-specific BIM requirements.

In the task definitions, modelling can be limited to apply e.g. only new bridges within a project. BIM-based implementation might increase project-specific contracting, in which case there might be a need to agree upon e.g. the precision of modelling between the commissioner and the supplier's experts.

The need for project-specific agreements depends on the difficulty of the project and the experience of the contracting parties. It is generally sufficient that the party starting the project reviews the BIM requirements in the procurement documents together with an expert.

2.2 Requirements for an operator

Before starting planning, an operator shall deliver the commissioner a report on the future content if the BIM, using the table in Appendix 3.

The operator shall provide the commissioner and other parties involved with the implementation of the target of the BIM material that was created following these Guidelines. The operator is obligated to submit the BIM or part of this created during the design of the target to the parties involved with the implementation as required, both in IFC and native format. The operator has the right to charge the direct costs incurred by the submission of the BIM.

If an operator sees that they cannot meet the BIM requirements, for example due to a technical obstacle, they must agree upon it separately with the commissioner's expert. It is prohibited to omit the modelling of a required part due to an obstacle without permission from the commissioner's expert. Matters related to the schedule are not considered technical obstacles.

> *Targets that are difficult to model might be encountered when modelling unusual structures without previous experience on such modelling.*

3 Information modelling in the creation of initial bridge data

The initial design data of basic design are specified in more detail in the publication Instructions for initial data on engineering structures *(Taitorakenteiden suunnittelun lähtötieto-ohje)*. This chapter contains instructions on defining the initial information model and technical instructions for creating model-based initial data.

In model-based design of a bridge, the initial information model of a bridge can be divided into three different entities: Design-phase data received from the designers of other technology areas, current state model and the data of the previous design phase. Every subsection forms a separate entity. Together, these entities can be used to create a uniform initial information model for basic design.

The scope and precision of the initial information model varies by design phase. The key thing is to provide to the basic designer the most critical information that affects the choices made in the design phase.

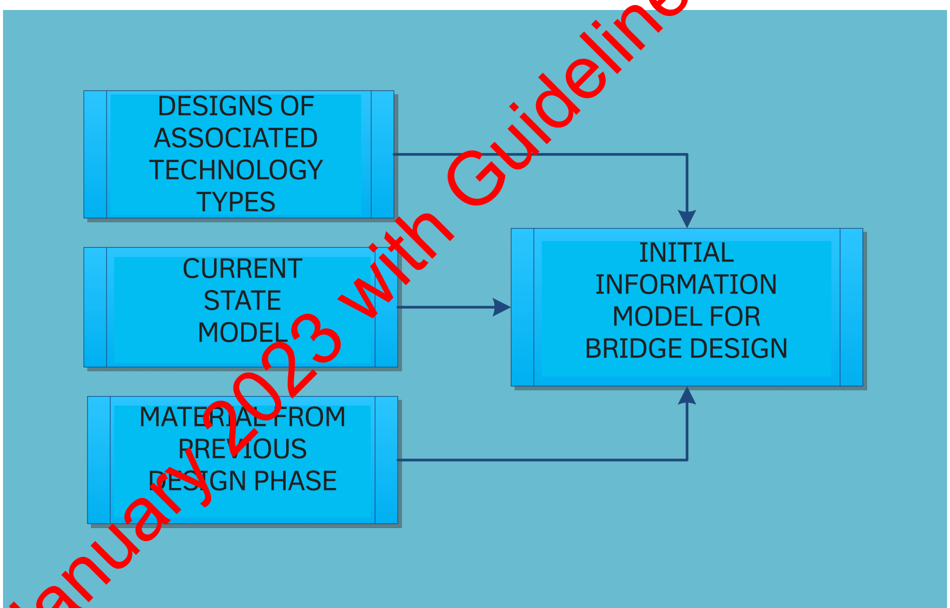

Diagram 2. Defining the initial information model in BIM-based design

During a BIM-based basic design, the initial design data and its precision accumulate as the design progresses from preliminary design to engineering design. For example, during the preliminary design and general design phase, the ground survey data can be point data, and are not interpreted as soil type boundary surfaces, but merely as point data.

Formats suitable for submitting the initial design data are 3D-DWG and IFC. A rule of thumb for obtaining the initial design data for a BIM-based bridge is that they should correspond to the creation of traditional bridge site documents: the information in the documents is created in a 3D format or format that supports BIM-based design.

> *The initial data of the design phase should be kept separate and as separate models so as to make it easy for the designer to distinguish between existing, planned and referential data.*

3.1 Material of associated technology areas

The initial data required for a BIM-based basic design consist of designed material from the design phase of roads and associated technology areas. The designer of each technology area is responsible for submitting their own materials to the basic designer. Likewise, the basic designer is obliged to submit their own material to the designers of associated technology areas.

The material consists of the following:

- Traffic pathways connecting to the bridge
  - Road
  - Railway
  - Waterway
- Other structures associated with the bridge
  - Abutments
  - Embankment slabs
  - Buildings and constructs
- Lighting and electrification
- Telematics
- Provisions (penetrations)
- Drainage systems
- Water management systems
- Energy transmission systems
- Environmental plan of the bridge
- Any other material

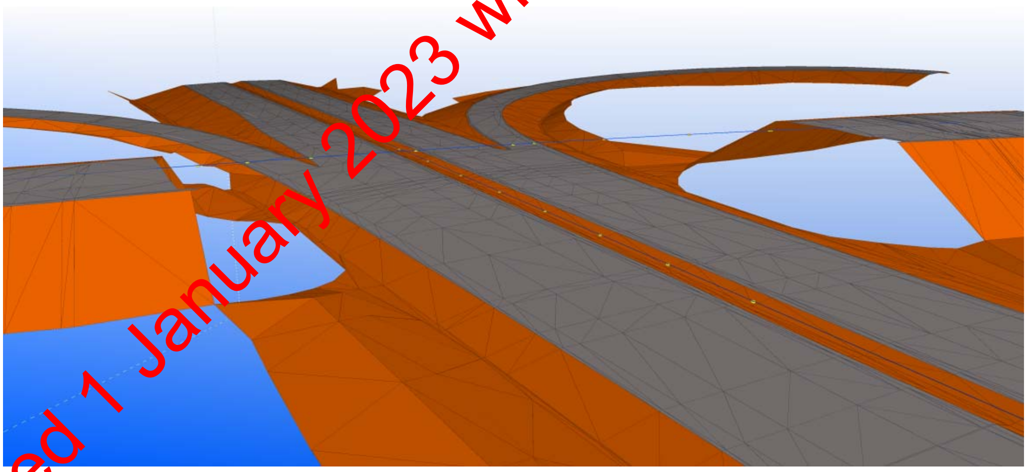

Image 2. Initial material for planning an overpass. (Repokallio overpass, Siltanylund)

The traffic pathway data is delivered as surface models, 3D-wireframes and tabulated numeric data. The designs for drainage, water management and energy transfer systems are submitted as volume provision objects in actual coordinates. Sufficient initial data for electrification, lighting, and other such point-like objects at the bridge site is the location in actual coordinates and the type of the designed device. The level of detail in the design material corresponds to the level of detail in the planning phase.

The data on measurement lines, the grade line and break line is submitted as 3D lines. A method that supports basic design software is to submit sequential coordinate data of the levelling course, guardrail lines and significant break lines. For example, a text file of the levelling course XYZ coordinates by level pile.

The designs of associated technology areas are not created by modelling; the material should be delivered in an electronic format in order for the designer to use the 2D material as a reference in the model.

3.2 Current state model

A current state model of the bridge site is created before the actual design starts. The current state model can be created as a separate task or as part of the design phase commission. The current state model is updated as the design proceeds and the initial data becomes more detailed and voluminous.

The material consists of the following:

- Terrain model
- Soil model
- Traffic pathways and their structures
- Municipal engineering
- Zoning data
- Environmental data
- Constructs and buildings
- Any other material

The soil data is modelled as surfaces. The existing structures are modelled as volume objects or volume provision objects. The structures to be modelled should, with sufficient precision, conform to their characteristic geometry so that the volume provision of the structures can be taken into account. For example, the drainage pipes must be modelled using their actual cross section; a wireframe model is not allowed. For bridges that cross waterways, the water heights are modelled as surfaces in the initial information model. The water surfaces to model are normal water level NW, medium-height water level MW and highest water level HW.

The scope of the current state model of a bridge site is specified in the document Instructions for initial data on engineering structures *(Taitorakenteiden suunnittelun lähtötieto-ohje*). The current state is surveyed sufficiently widely so that it includes all the factors that affect the design.

The current state model is complemented with a BIM report that specifies the most important data relating to the use, format and building of the model. The current state model is created as specified in InfraBIM information model requirements and instructions *(InfraBIM tietomallivaatimukset- ja ohjeet), Part 2,* Requirements for initial data *(Lähtötietojen vaatimukset*).

The designed material is not included in the current state model. The current state model only contains existing structures, terrain, etc.

In larger projects, the current state model can be a "piece" of the current state model of the traffic artery. In larger bridges and projects that con-

tain the design of one bridge, a current state model shall be created of the bridge site.

The current state models of the bridge site terrain and soil data are created in the InfraModel format. However, no engineering structure design software supports the import of InfraModel data. Suitable formats are 3D-DWG and IFC.

3.3 Material from the preceding design phase

The basic designs of the preceding design phase and the associated traffic arteries and technology areas are collected into a single model and submitted to the designer.

The model of the previous design phases can be used as a reference for the design, but it is delivered as part of the initial information model.

4 Information modelling during the various phases of basic design

This chapter contains instructions for the tasks in various design phases in BIM-based design. The design phase requirements shall be applied to the modelling of other engineering structures.

4.1 Preliminary design

Modelling in the preliminary design phase is carried out in bridge site classes I–II. In the preliminary design phase, combination models created from the terrain model, traffic artery model and bridge options, facilitate the efficient comparison of solution alternatives. In the preliminary design phase, the modelling precision is at draft level. Of immaterial data, the modelling shall cover the support lines, useful width and any opening requirements.

The preliminary design phase produces a combined model of the bridge site. A sufficient accuracy level for a bridge product model is the presentation of visible surfaces. The objects are not required to have volume or material properties.

> *The preliminary design phase is associated with the land use and needs assessment of a traffic artery. This phase investigates the construction of bridges belonging to different solution approaches and traffic artery alternatives and their impact on the environment. The quality of the material produced in the preliminary design phase can vary according to the needs of the specific case.*
>
> *Modelling in the preliminary design phase is carried out in so-called 'bridge first' projects (bridge site classes I-II). If a bridge is a part of a longer traffic artery, it is not sensible to create models of typical bridges in the preliminary design phase.*

4.2 General design

In the general design phase, the modelling covers the visible structures and equipment of a bridge and the associated earth structures, such as end ramps and slopes. A sufficient accuracy level for a bridge product model is the presentation of visible surfaces. Reinforcements and hidden structural components, such as crossbars are not modelled.

The significant immaterial data of a bridge are modelled in the general planning phase These include traffic engineering dimensions, opening requirements, traffic artery survey lines, support lines and principal points.

The general design phase includes a model-based investigation on the existing structures in the constructed area.

The numbering and labelling must conform to the requirements in section 4.8.3 . All targets belonging to a single project are collected into a single document in the BIM report. The general design phase produces a combined model of the bridge site.

> *The general design phase uses data from preliminary design or initial basic design as input to investigate bridge site options and create alternative drafts for a presentation. The objective is to create alternative designs for significant bridges and determine the environmental impact of the bridge construction.*
>
> *The combination of a traffic artery model and a bridge model, and the resulting visualisation makes it easier to compare the different alternatives and to make decisions. The bridge model can be turned into e.g. a virtual model, perspective printouts and illustrations on how the bridge fits the environment.*

4.3 Technical instructions for the preliminary and general design phases.

This section describes the structure and content of the bridge product model in the preliminary and general design phase.

4.3.1 Structural components and their precision

Modelling of structural components and the modelling precision
The modelling shall utilise appropriate software-specific objects so that the meaning of all modelled structural components and systems can be identified. Underground structures below the substructure are not modelled. Objects are not required to have volume properties, a surface model is enough.

Information on materials
The model must contain information on the materials of the main structural components (concrete, steel, wood).

Reinforcement
Not modelled. (Can be entered as attribute data of the structural components)

Prestressed tendons
Not modelled.

Cables
Modelled to show the number and location of the ropes in the model.

Attachment parts
Not modelled.

Insulations and surface structures
The topmost surface of surface structures is modelled.

Painting and shielding
Not modelled.

Appurtenances
Only guardrails are modelled.

Geotechnical structures
Not modelled.

4.4 Basic Design

In the basic design phase, all bridges of a project are modelled in compliance with the requirements.

In the basic design phase, the modelling covers the visible structures, all substructures and associated earth structures, such as end ramps and slopes. Appurtenances are modelled as far as necessary. Reinforcement is not modelled. Small details, such as crossbeam joints, do not need to be modelled. The properties of the objects in the bridge product model are determined as specified in section 4.5 .

The initial information model becomes increasingly detailed, as data on the soil, traffic artery surface and its structural layers, and excavation boundaries is obtained during the design phase and added to the model.

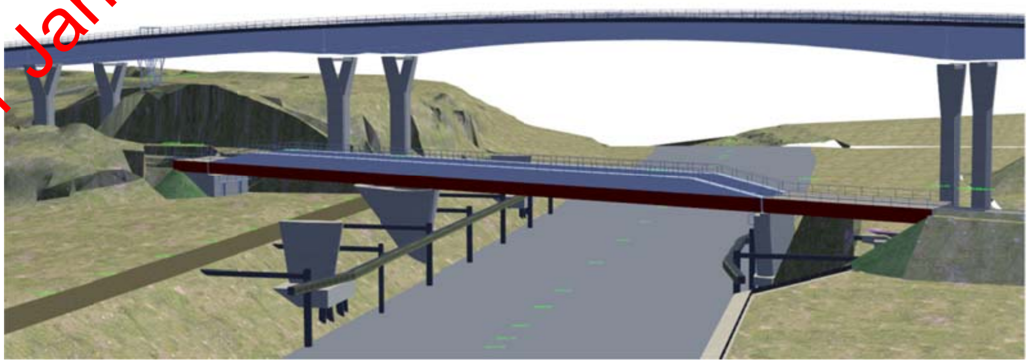

Image 3. Combination model of the road design phase. (Laitaatsalmi, Ramboll)

During the basic planning phase, a separate BIM report is created for each bridge site, as specified in Appendix 1. The numbering and labelling scheme must be uniform within a project and conform to the requirements laid out in section 4.8.3 .

A combination model of the bridge site is created for the commissioner. The combination model includes the product model of the bridge, the initial information model (current state model, design-phase material on the traffic artery and other models of associated technology areas). The combination models of individual bridge sites can be replaced with a single combination model of the traffic artery project that contains the bridge product models and associated technology areas.

The creation of a basic design is a design phase associated with the creation of road, track and street plans during a traffic artery project. In the case of waterway bridges, the phase is also required by the Water Act. The permits required for bridge construction are applied at this phase. Traditionally, this is the phase where the master drawing is created, presenting the appearance, structures and main dimensions of the bridge, as well as its fit to the environment and the road, street or track plan. In this phase, the requirements for the contents of a bridge BIM are equivalent to the requirements of a traditional master drawing.

Traditionally, basic design plans have been used as the basis for tenders for comprehensive contracts. In these cases, the creation of structural plans has been a part of the contract. This is possible also in modelling-based design.

4.5 Technical instructions for the basic design phase

This chapter describes the structure and content of the bridge product model to be generated in the basic design phase. Appendices 2 and 3 contain tables on the modelling requirements of engineering structures in each design phase, and of matters to be agreed upon on a project-specific basis.

A bridge BIM covers a single bridge site unless otherwise agreed.

4.5.1 Structural components and their precision

Modelling of structural components and the modelling precision
The modelling shall utilise appropriate software-specific objects so that the meaning of all modelled structural components and systems can be identified. The modelling method of structural components shall ensure that the location, name, type and geometry of the structural component are transferred along with the part itself during data exchange. The structural components shall be modelled as volume objects so that the quantities can be read directly from the model.

Information on materials
The structural components in the model must contain information about the materials of the structural components of the bridge. (Concrete, Steel, Wood)

Reinforcement
The reinforcement is entered as quantity information for the structural components. (reinforcement: kg/ concrete: m^3)

Prestressed tendons
The quantity of tensioned reinforcement is entered as quantity information for the structural components. (reinforcement: kg/ concrete: m^3)

Cables
Modelled to show the number and location of the ropes in the model.

Attachment parts
Not modelled.

Insulations and surface structures
The topmost surface of surface structures is modelled.

Painting and shielding
Not modelled.

Appurtenances
The most significant equipment is modelled. (Guardrails, Bearings)

Geotechnical structures
The most significant structures are modelled. (Mass exchange and subgrade filling of foundations)

4.6 Engineering Design

The engineering design phase is the phase where a complete product model of a bridge is created. The bridge is modelled in its entirety, including its equipment, devices, reinforcements, soil data and immaterial data. The dimensions and measurements of the model must be precise in the engineering design phase. Deliverables of this phase are a product model of the bridge and any separate models that complement the engineering design (manufacturing, etc.). Other deliverables are a BIM report and any other documents that complement the model. Numbering and labelling is carried out as specified in section 4.8.4 .

A combination model of the bridge site is created for the commissioner during the engineering design phase. The combination model includes the product model of the bridge, the initial information model (current state model, design-phase material on the traffic artery and other models of associated technology areas). The initial information model is made more specific until it meets the precision requirements of the planning phase. The combination models of individual bridge sites can be replaced with a single combination model of the traffic artery project that contains the imported bridge product models and associated technology areas.

> *The basic design approved during the engineering design process is used as the basis for creating an engineering desing for the construction of the bridge. The engineering design shall take into account the solutions shown in the bridge plan, the approved traffic engineering dimensions and any other changes. The final engineering desing shows the structures as they will be built.*

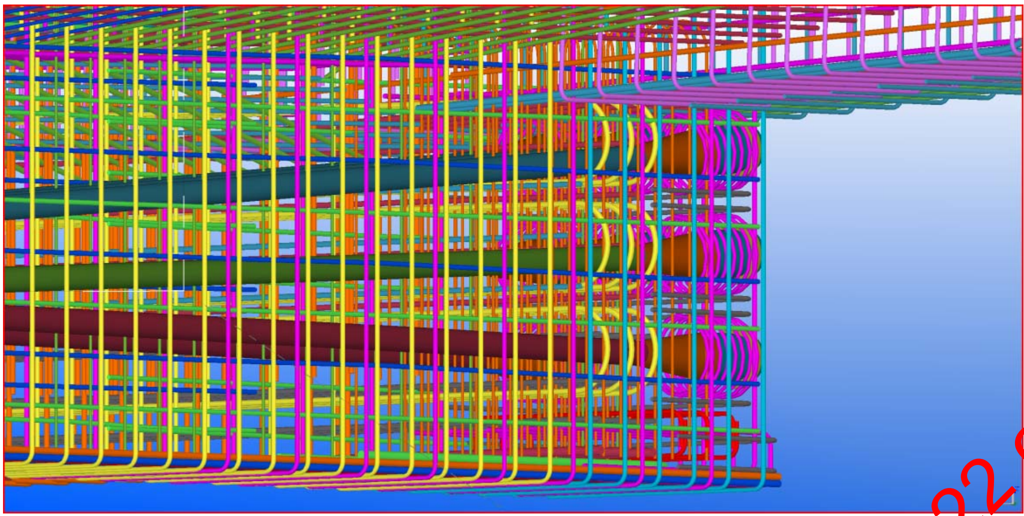

Image 4. Bridge end view from a model in the engineering design phase. (Vantaanjoki bridge, Destia/ Siltanylund)

4.7 Technical instructions for the engineering design phase

This chapter defines the structure and content of the bridge product model to be generated in the engineering design phase. Appendices 2 and 3 contain tables on the modelling requirements of engineering structures and a form template for matters to be agreed upon on a project-specific basis.

The status of the BIM at the moment of handover is described in the BIM report, as in the example in Appendix 1. A bridge BIM covers a single bridge site, unless otherwise agreed.

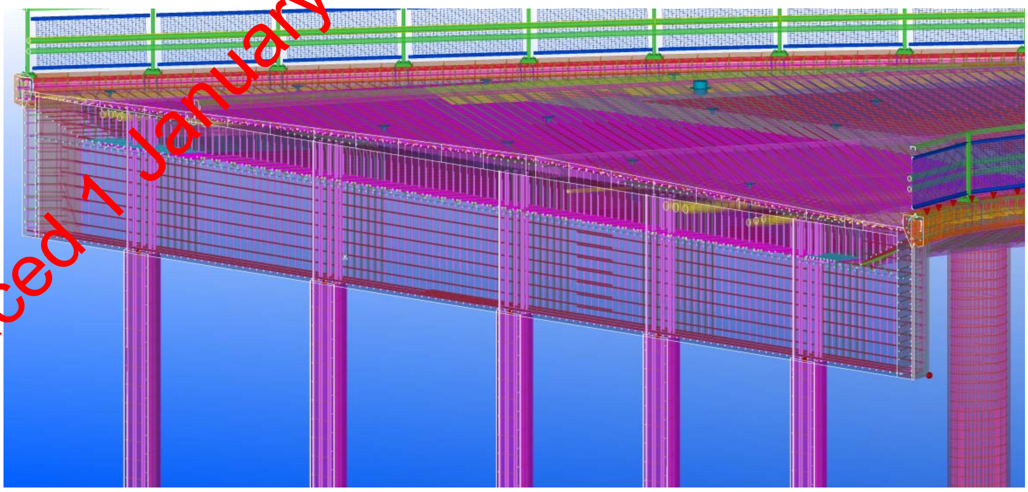

Image 5. Reinforcements of the end and deck. (Uittoväylä overpass, Kotka, Siltanylund)

4.7.1 Structural components and their precision

Modelling of structural components and the modelling precision
The modelling shall utilise appropriate software-specific objects so that the meaning and type of all modelled structural components and systems can be identified.

The basic structural components shall be modelled in a way that enables the transfer of their location, name, type and geometry along with the part itself during data exchange. The structural components shall be modelled as volume objects, so that the quantities can be read directly from the model. The structural components shall be modelled in a way that enables all actual components of the structural components to be distinguished.

Structural components based on standard-project drawings shall be modelled with appropriate precision. Example: the following items are modelled of a steel railing based on standard-project drawings: guide posts, poles, transfer structures, expansion joints, accessories (snow ploughing net, dense guardrail) and the attachment to the edge beam (bolt groups). It is not necessary to model the attachment components for a guardrail.

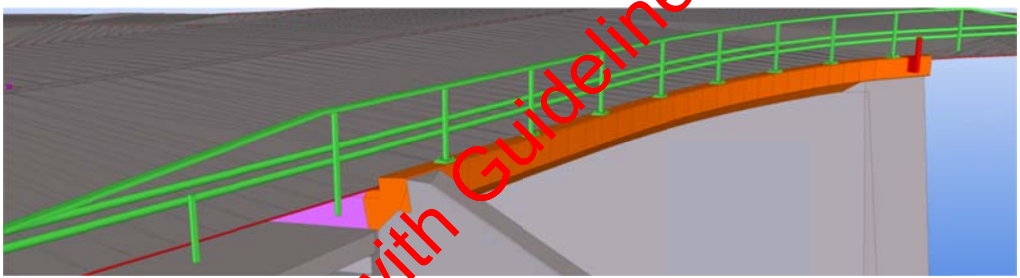

Image 6. Tieh H2 standard rail in a model (Uittoväylä overpass II, Kotka, Destia)

In order for the data to be exchanged appropriately between formats (native→IFC), the structural components shall be created with a tool intended for their design (for example, a foundation shall be created using a foundation tool). If the functions of these tools are not sufficient to model the structures, the structural components shall be modelled using suitable tools.

Information on materials
The structural components and attachment hardware in a bridge BIM shall contain the necessary information about materials. For concrete, these are strength, frost resistance and design class. For steel and wood parts, these are grade and surface treatment.

Reinforcement
The following features of reinforcement must be modelled: diameter, pitch, quality, bending type, anchoring and length of extensions. The modelling must take into account the space required by protective distances and auxiliary reinforcements, and the mutual reconciliation of the reinforcements.

Prestressed tendons
The following items are modelled for tendons: protective sheaths, reinforcement according to the tensioning method and anchor pieces. The model shall indicate the tensioning system, type, number of strands and the quality of injected mortar.

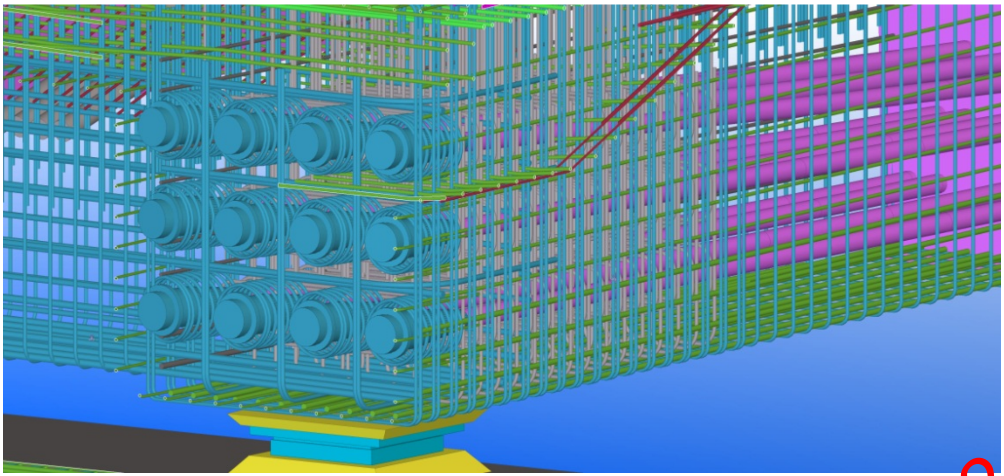

Image 7. Interlacing tendons with reinforcement (Kaukonen Bridge, Kittilä, WSPGroup)

Cables
Modelled with details.

Attachment parts
The attachment parts to model are bolts, welds and nailings. If a separate implementation model (manufacturing model) is create, attachment parts do not have to be modelled in the bridge product model.

Insulations and surface structures
The surface structures and insulation layers shall be modelled according to their characteristic thickness.

Painting and shielding
Covering with a characteristic thickness of less than 1 mm can be entered as object attribute data or modelled according to their characteristic thickness.

Appurtenances
The appurtenances of a bridge, such as manholes, bearings, the machinery of a moveable bridge and guardrail structures etc. shall be modelled in a way that indicates their location, geometry and type in the model.

Geotechnical structures
Frost insulation, excavations, fillings, transition slabs with expanded clay aggregate, transition wedges and other geotechnical structures joining the bridge and foundation reinforcement methods shall be modelled according to their characteristic size and location.

4.8 Other details

The instructions in this chapter should be observed in all design phases of model-based design.

4.8.1 The geometric shape in the bridge product model

The product model shall be modelled into a "final state" geometry, where all dimensional data and e.g. bearing advances are based on a temperature of +10C. This way the dimensions of completed structures can be verified against the production model. The preliminary camber and other anticipatory measures required in the manufacture of various structural components and management of bridge construction works are implementation methods that deviate from the product model, and these methods cannot replace any parts in the product model. For concrete bridges, the preliminary elevations can also be shown in the documentation that complements the plan. Moveable bridges are shown in the open and closed positions.

4.8.2 Modelling immaterial data

The immaterial data related to a basic design shall be modelled as follows: If the software used does not support the modelling of immaterial data, immaterial data is modelled as 'zero weight' objects. The shape, dimensions, numbering and labelling of each object used shall be reported in the BIM report.

Cast units and construction joints
Concrete casts shall be divided into actual cast units and construction joints shall be modelled.

Blocks and installation assemblies
Steel and wooden structures shall be divided into manufacturing and installation assemblies.

Useful width, span
The useful width and span lengths of a bridge shall be modelled as a chain line with an attached measurement that conforms to the requirements. The data can also be modelled as an object between the guardrails/support line, in which case the absolute value of the object length is the required useful width.

Opening requirements (structure gauge)
The opening requirements and structure gauge of a bridge shall be modelled as objects that outline the space required in the most critical part.

Bridge geometry lines, traffic artery grade lines
The geometry lines and traffic artery grade lines that define a bridge are modelled as line-like objects by level pile. Moreover, piles at even tens and twenties are modelled with a separate object whose attributes specify the location of the point on the traffic artery (pile number, kilometre number).

Support lines
Support lines are modelled using an object intended for the purpose, or an equivalent object. Modelling height below the substructure, all support lines are modelled at the same height.

Structure jacking points
The jacking points are modelled as volume provision objects.

4.8.3 Location of the bridge in the coordinate system

The model of the bridge site shall be located in the official coordinate and elevation system of the project. The units of measurement shall be metres. A local coordinate system can be specified for the bridge site model, if required by the modelling technique. However, the local coordinate system shall lie entirely within the positive quarter of the coordinate system. Turning the coordinate system is not allowed.

The location of the bridge is modelled by using the principal points. The principal points are modelled at the actual intersection of each support line and the inside of an edge beam, at the height of the top edge of the edge beam. Principal points are also modelled at the outer corners of wing walls.

Usually, the easiest way to specify a point is to model a so-called measurement point, for example a cone whose tip indicates the desired point in the model.

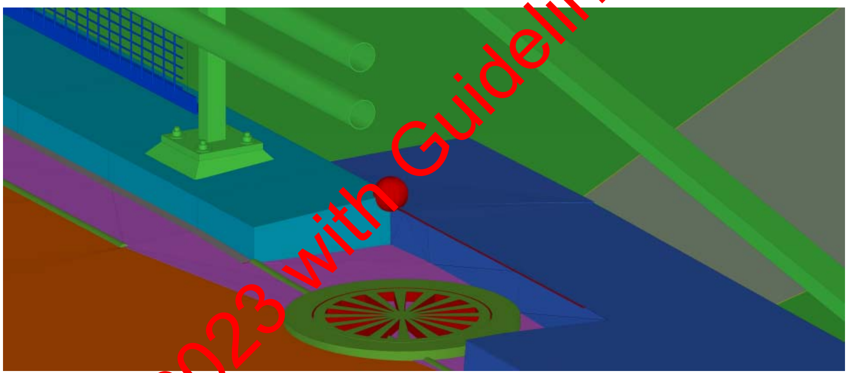

Image 8. The location of the outer corner of the wing wall modelled using a measurement point.

If the software does not support modelling in the actual coordinate system, the required transformation information for coordinates and units of measurement shall be stated in the BIM report. In such a case, the coordinate system to use and any required coordinate transformations shall be reported in the BIM report.

4.8.4 Component numbering and labelling

Irrespective of the software, the top level of the part numbering scheme shall be a location code pursuant to the guideline *Sillan määrälaskenta TIEH 2100052-v-07* (Quantity calculations for a bridge, TIEH 2100052-v-07):

000	Entire bridge
100	Abutment 1
200	Abutment 2
110/210	Foundation slabs of the culvert
310-390	Intermediate supports
400	Superstructure

500	arc component
600	Accessories
900	Other structural components of the bridge site

The following location code shall be used for immaterial data and reference models that do not match the location codes of the quantity calculation guideline:

1000	Other data related to modelling technique

The engineering structures in a project are labelled and numbered uniformly, adhering to the top levels shown above. The labelling and numbering scheme shall be submitted to the other parties in the BIM report of the model. The level of detail in the numbering and naming scheme shall conform to the example in Appendix 1.

It is recommended that the numbering of structural components follow the requirements in chapter 6 , because this ensures that the components are directly labelled as required by the maintenance model. The BIM report shall describe the labelling and numbering scheme so precisely that the users of the model can use the description directly to retrieve data from the model.

4.8.5 Units of measurement

A common practice is that the units of measurement in traffic artery models are expressed in metres, whereas bridge models use millimetres. When creating a combination model, the unit of measurement must be agreed upon taking into account the different scales in different software and file exchange properties. The combination model shall indicate precisely which components belong to which technology area.

The measurement and location data generated from the product model shall be delivered in the coordinate system, using metres as the unit of measurement. The engineering drawings of steel components shall be delivered using millimetres as the unit of measurement.

4.9 Design quality assurance

The purpose of quality assurance is to improve the quality of the designs and exchange of information between the parties. This in turn improves the efficiency of the design, planning , construction and maintenance processes throughout the lifespan of the bridge. Herein, quality assurance means the verification of the correctness of the model contents, and any data exchange files generated from it.

The design documents generated from the model shall be verified following the designer's own quality assurance process. The designer shall verify in different phases of the project that the content of the model is as agreed, and that any data exchange files generated from it are correct. Any deviations shall be reported in the BIM report form delivered with the model.

The designer shall prove that the model has undergone internal quality assurance by creating a quality assurance document that shall be attached to the material submitted to the authorities for approval.

The inspection methods of the model can be visual inspection and any collision detection features in the software used. Overlapping structures are often easy to detect by a careful visual inspection of the model. The various reports created from the model can also be used to check e.g. the quantity, properties, numbering and labelling of the components.

The designer can use the software's own tools for quality assurance. Any corrections shall be made to the original model. When reviewing the model, particular attention must be paid to collision inspection of reinforcements in locations where the correct placing of reinforcements is important. Examples of such locations are places where the supports and pillars join the deck.

4.10 Collaboration model of a bridge

4.10.1 The role of the combination model as a design entity

The combination model is the most significant model concerning the entire bridge site. By combining the models of the different technology areas at agreed intervals, any conflicts in the designs can be detected as early as possible. A combination model is a major improvement over traditional design, where conflicting designs are difficult to detect before the implementation. The role of the combination model is even more important in areas with densely constructed infrastructure.

The combination model engages the designers of different technology areas to co-operate more closely. Depending on the nature of the project, a suitable time interval for assembling a combination model is about 2–4 weeks.

4.10.2 Creating a combination model

In a combination model, the product model of a bridge is combined with the initial information model and the models of other technology areas. The operators shall provide the commissioner with an opportunity to review the combination model of a project at agreed intervals. Unless otherwise agreed, an operator shall submit the combination model to the commissioner for review together with the approval of designs and plans.

The scope of the combination model shall be specified by the commission and by design phase. The primary models used in the combination are the bridge product model and the initial information model.

A combination model is created either by transferring the bridge model into the combination model of the entire project or by importing into the bridge site model the other technology area models that join the bridge site. The BIM report shall describe the creation method of the combination model.

Image 9. A bridge product model combined with the initial information model and other technology area models. (Laitaatsalmi Road Plan, Ramboll)

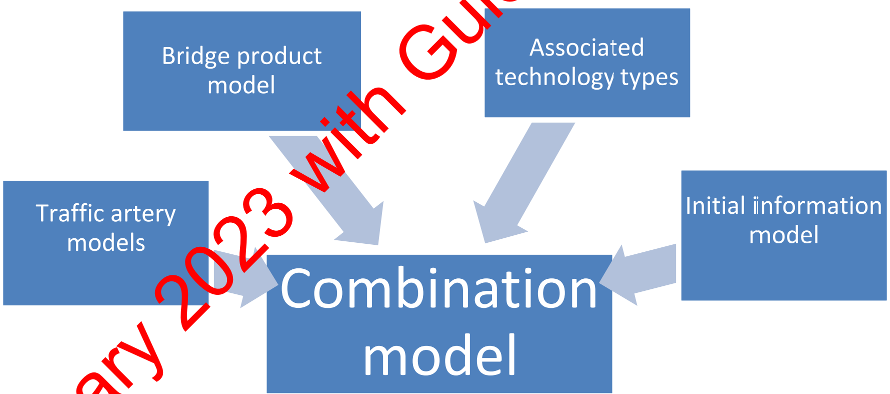

Image 10. The principle of creating a combination model of a bridge site.

5 Information modelling in construction management and contract reception

In the execution phase, the bridge product model can be utilised in many different ways. The visual nature of the information model makes it easy for the parties to familiarise themselves with the entity already at an early stage. When planning for the works, the bridge components can be associated with scheduling information. This information can then be used for visualising the construction and work planning by using the quantity management and scheduling properties associated with the model objects in the design software. The components of the product model contain a great deal of different information that can be used in many ways during the implementation phase.

During the on-site measurement, the geometry data of the model can be transferred directly into the measurement devices. It is possible to complement the designer's model by modelling the scaffolding structures or by adding them as reference files. It is also possible to complement components by adding other data needed during construction. The model enables the rapid generation of bills of quantities for e.g. requests for contracts. The model also speeds up the process of seeking authoritative approval for changes.

A separate as-built model can be used for monitoring the actuals and creating quality reports of the bridge. The contractor is responsible for creating the as-built model, and it is submitted to the commissioner among the quality documents. The as-built model can draw together the actual materials by structural components (material certificates as well as inspection and condition reports) and quality assurance measurement results (measurement reports).

Free viewer applications are available for viewing IFC files. Due to the shortcomings of the IFC data exchange, efficient utilisation often requires the use of the native format of the design software, and a version of the software intended for contractors.

The as-built model can be compared to the designed product model in order to gain an understanding of deviations, their magnitude and any breaches of tolerance limits. The as-built model can be measured by a 3D laser scan of the bridge and the geometry of the bridge site using sufficient raster density and measurement accuracy.

Tachymetry can be used as the measurement technique for the as-built model. Other measurement techniques that add precision and data to the as-built model can also be used if desired, including photography, GPR (Ground Penetrating Radar) and infrared scanning. The as-built model can be used as one of the initial data for the maintenance and future repairs of the bridge.

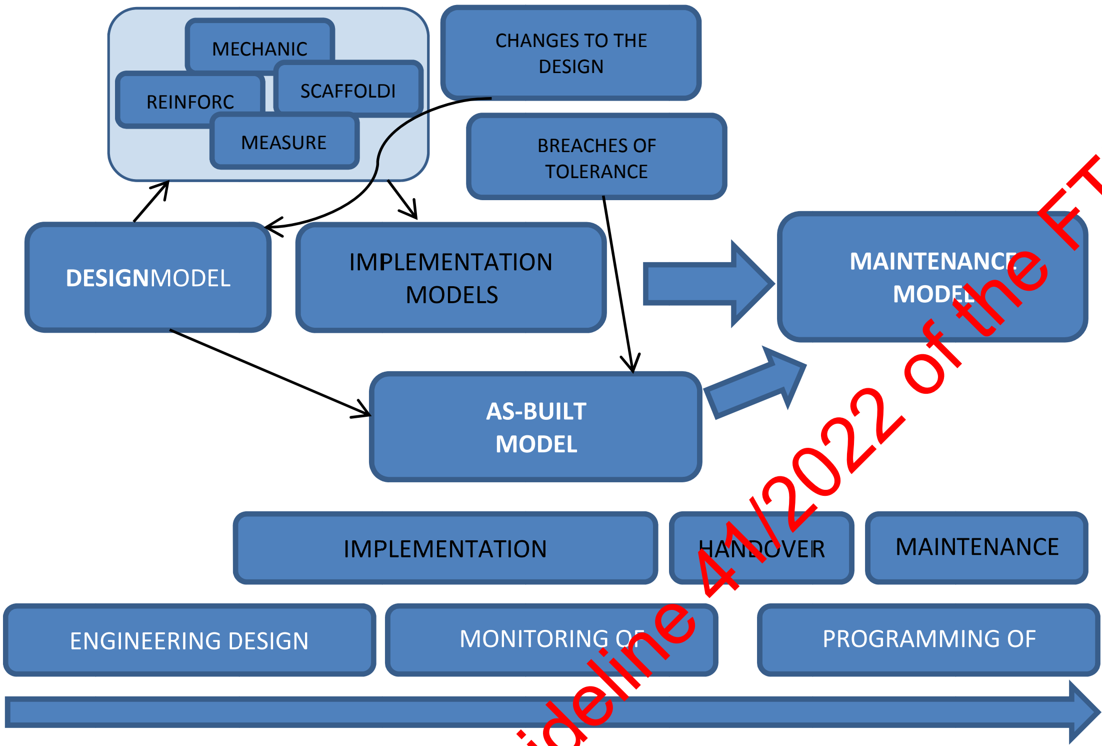

Image 11. The creation of models from engineering design to maintenance.

5.1 Utilising the implementation models

During the implementation phase, separate implementation models can be created for the following areas. The creation of separate enterprise resourcing and planning models during the implementation phase shall be agreed upon on a project-by-project basis.

5.1.1 Manufacturing model

The manufacturing model for steel structures shall be created during the engineering design of the steel structure. This model shall include all details required for manufacturing the structure. The manufacturing model takes into account the preliminary camber of the structure, so the model cannot be used as is in the bridge product model. The manufacturing model can be used to replace the modelling of attachment parts in the product model, in which case the manufacturing model shall be attached as part of the bridge BIM. The manufacturing model may not be visible in the combination model. The shape of the manufacturing model shall conform to a manufacturing temperature of +20C°.

When creating a manufacturing model, careful attention must be paid to preliminary elevations. For example, vertical stiffening plates shall be modelled in a way that makes them vertical in the final form of the bridge.

5.1.2 Reinforcement model

The reinforcement model shall be created during engineering design. The reinforcement model enables the ordering of the reinforcement from a reinforcement company without the need of a separate reinforcement list. However, this requires a project-specific agreement between operators. During the contracting phase, a reinforcement model can be further refined by complementing it with reinforcements required for supporting the existing reinforcement.

> *Applications exist to visualise the reinforcement and help in the installation work. The model can be used for searching for reinforcements by position. The installation planning, based on colours is used in several projects.*

5.1.3 Measurement model

The measurement model is a model created by the contractor from the design model. A measurement model is created by transferring the structural geometry from the design model into a format that can be read by a measurement device. Any required adjustments are added into the measurement model. The measurement model enables the transfer of geometry directly from the design systems into the measurement systems without the need for separate tables. This greatly reduces the potential for human error. There is no need to create geometry tables for the commissioner.

5.1.4 Scaffolding model

The construction-time scaffolding plan can be created by modelling. A model can be used for seeking an approval from the Finnish Transport Agency for the open spaces required by traffic safety. There is no need to produce separate drawings in addition to the model.

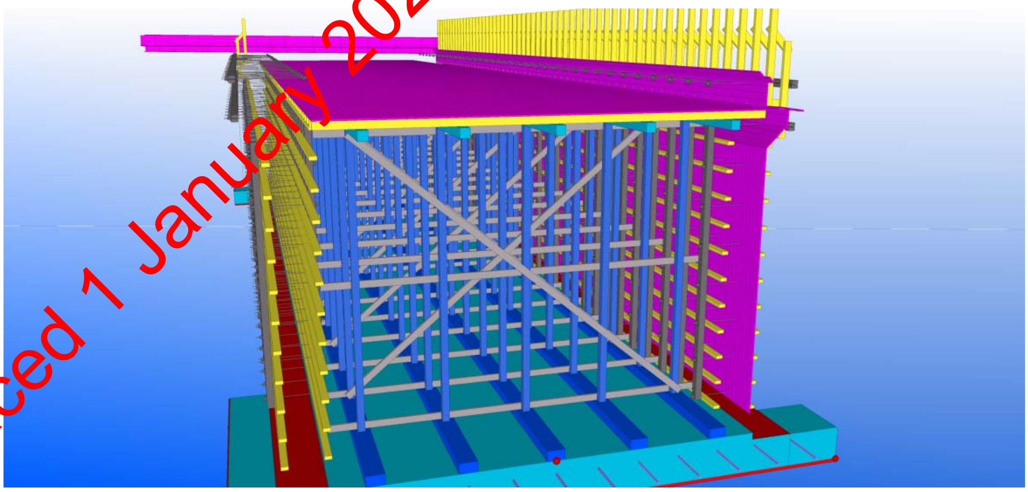

Image 12. Modelling scaffolding and a mould. (Tikkurila underpass, Destia)

5.1.5 Worksite area plan

Superimposing an area plan on a bridge site combination model is a highly visual method for creating a safety plan for the area A 3D model makes it easy to identify the space requirements during the construction phase.

5.2 Using the as-built model in quality assurance

The quality of the as-built bridge can be monitored using the model in the following areas.

5.2.1 Reporting of measurements using the as-built model

The as-built measurements can be combined with the bridge product model to create a monitoring model for the bridge that is actually built. The monitoring model enables the detection of deviations from the plans. The measurements shall be carried out as specified in the guideline *Sillan laaturaportointi* (Bridge Quality Reporting).

5.2.2 Material certificates, inspection and condition reports.

The material certificates can be added into the as-built model by structural component.

6 Information modelling in the maintenance of bridges

The maintenance of bridges could in the future benefit greatly from model-based procedures.

6.1 Creating a maintenance model

When moving over from the production phase to the bridge maintenance phase, a maintenance model shall be created and saved into the engineering structure register in the IFC format*). The maintenance model is created on the basis of the design and as-built models. It is recommended that the maintenance model be created by the creator of the bridge engineering design. The maintenance model should conform to the actual circumstances at the bridge site as accurately as possible. The creation of a maintenance model is a part of the commission for design and execution.
*) The register will be modified to enable this function.

> *In practice, the structures within the implementation tolerances can be transferred directly from the bridge product model to the maintenance model. Of the various technology area models, all elements significant to maintenance should be included in the maintenance model. In general, the maintenance model can be thought to result when the models of the bridge site are combined into a single maintenance-phase IFC file.*

6.2 The functionality of the maintenance model in the engineering structure register

6.2.1 Storing maintenance models in the engineering structure register

In the future, the content of the engineering structure register shall be expanded to cover bridge BIMs. The models enable new practices and improve the old practices of using and complementing the data in the register during bridge maintenance.

These possibilities can be actualised only when software packages can import reliable data and models from the register that fulfil the requirements of the software. This requires that the data in the models stored in the engineering structure register is uniform, up to date and correct both in its content and structure, i.e. normalised.

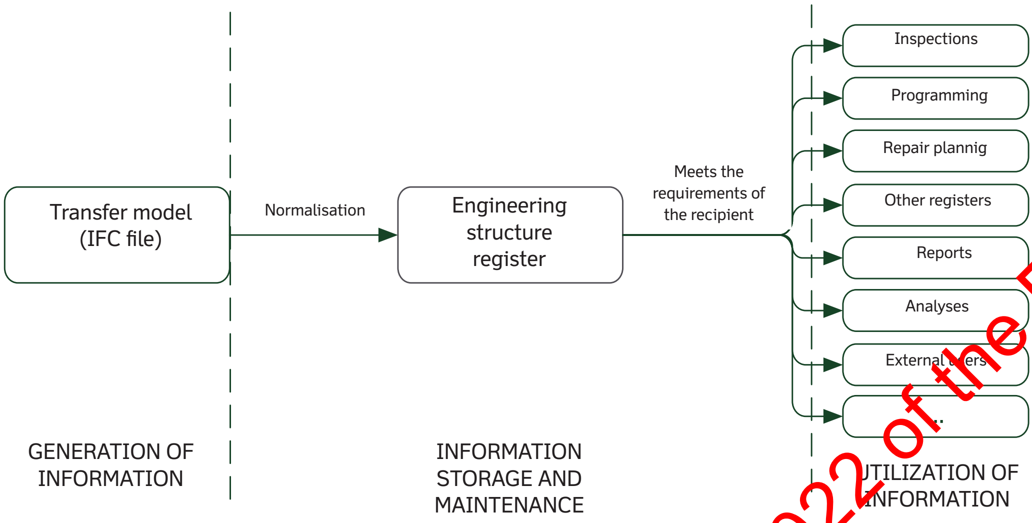

Image 13. Data processing diagram.

The data in the bridge BIMs and IFC transfer files does not automatically fulfil the requirements of the engineering structure register. This is caused by the fact that several factors affect the data content and structure of the bridge models: each engineering bureau has its own tools; there are several versions of the modelling software; the design offices have developed their own components, macros and standardised modelling practices to improve their operations. Even the modeller's personal preferences affect the storage and location of data in the ICF. As a result, the Finnish Transport Agency has defined a standard operating procedure (SOP) so as to ensure that the BIM data stored in the engineering structure register is uniform and reliable.

6.2.2 BIM communications

The transfer or maintenance models to the engineering structure register shall take advantage of BIM communications. To succeed in BIM communications, the operators must understand the SOP, know their role therein and commit to this role. The SOP and requirements specification are presented below to enable the designer to determine

- Whether they are capable of creating the required information models
- How much resources are needed to create the required information models

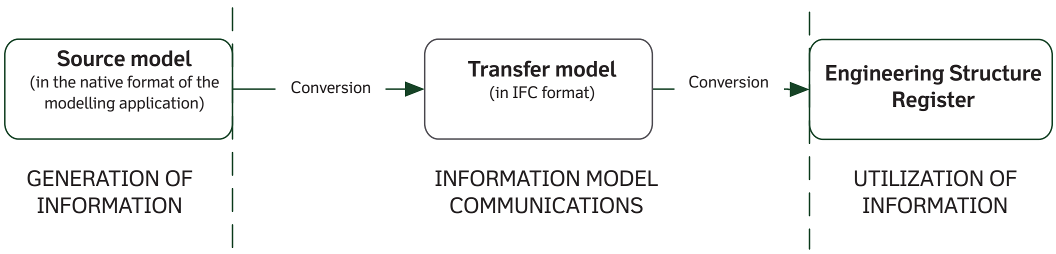

Image 14. Model processing diagram.

In BIM communications, data is exchanged as a BIM from one party to another, in this case from the designer to the Finnish Transport Agency's engineering structure register. It is critical to understand that BIM communications is only related to the exchange of data between parties.

> *BIM communications is not associated with the creation of BIMs or their use in-house, such as when the operator creates drawings from their own models. In BIM communications, the creator of the data does not send their native BIM (source model) to the recipient. Instead, they send a transfer model derived from the native BIM. The source model could be e.g. a Tekla model and the transfer model an IFC model created from the Tekla model.*

6.2.3 Tasks of the BIM communications

The BIM communications is associated with the following tasks: requirement specification, validation of the conformity of the models, editing the transfer model and delivering the transfer model. The following is a brief outline of each task and associated responsibilities in connection with the engineering structure register.

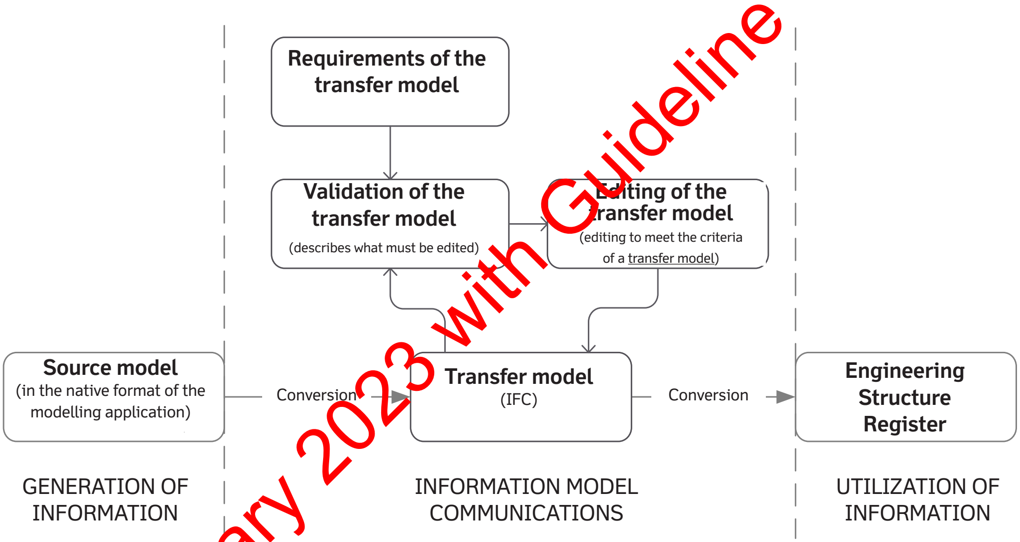

Image 15. Diagram of the tasks of BIM communications.

6.3 Requirements for the maintenance model

The transfer model arriving into maintenance is subjected to requirements to ensure that it is suitable for use in an engineering structure register. The requirements for a transfer model are defined by the Finnish Transport Agency. The designer shall commit to delivering compliant transfer models and shall plan and resource their own operations accordingly.

> *It is important to understand that these requirements apply to the transfer model, not to the source model. A precondition for meeting the requirements of the transfer model are good modelling practice and consistency of the source model, but they do not automatically guarantee that the transfer model meets the requirements. Since the requirements apply to the transfer model, the designer can freely use their own modelling application and modelling policies; and only the transfer model must comply with the requirements.*

The requirements of the transfer model only apply to the data content and structure, not to the design solution. The transfer model shall be in the required format, the required data in the transfer model shall be in the required location, and the value sets shall conform to the defined permissible values lists.

An efficient and reliable use of the engineering structure register requires that data stored and maintained in it be normalised. In the requirements for the transfer file, this manifests itself as various sets of permissible values. Most of these permissible values are copied directly from the parameter tables of the Bridge Register. The sets of permissible values can be found in tabular appendices to the requirements. The use of permissible values can be made easier by using them in e.g. various modelling or editing pull-down menus in modelling software or IFC transfer file editors.

6.3.1 Data exchange format of the transfer model

Requirement number	1.1
Required data content	---
Required data structure	The transfer model shall be delivered as an IFC2x3 file (P21 file format)
GUIDELINE	

6.3.2 General requirements

Requirement number	2.1
Required data content	The transfer model must contain information stating that it is only intended for use in the engineering structure register.

Requirement number	2.2
Required data content	The transfer model must truthfully describe the as-built structure of the bridge. The transfer model shall contain all structural components required to describe the design, as specified in Section 4.7 of the Finnish Transport Agency's BIM Guideline for Bridges. Geotechnical structures are not required.
GUIDELINE	Depending on the software and IFC settings, hidden objects can be omitted from the transfer model.

Requirement number	2.3
Required data content	The transfer model shall only contain structural components that describe the design
GUIDELINE	Separate as-built models notwithstanding, any structural components modelled or copied, for example, next to the model for various reasons are not a part of the design. (cf. manufacturing model)

Requirement number	2.4
Required data content	The transfer model file shall be named as specified by the Finnish Transport Agency.
GUIDELINE	The transfer model file shall be named according to the bridge number and name. For example, O-31 Kenraalin silta Bridge shall be named as: O31_kenraalinsilta.ifc

Requirement number	2.5
Required data content	The transfer model shall be located in the official coordinate and height system of the project as specified in section 4.8.3 .
GUIDELINE	

6.3.3 Project information

Requirement number	3.1
Required data content	The transfer model must contain the bridge number.
Required data structure	PsetSingle : IfcBuilding --> ePset_Liikennevirasto --> Bridge number (IfcIdentifier)

Requirement number	3.2
Required data content	The transfer model must contain the bridge name.
Required data structure	PsetSingle : IfcBuilding --> ePset_Liikennevirasto --> Bridge name (IfcIdentifier)

6.3.4 Data structure of the transfer model

Requirement number	4.1
Required data content	All structural components of the transfer model must be defined a location as stated in the quantity calculation guidelines. The location shall be defined as described in Section 4.8.4 .
Required data structure	PsetSingle : IfcProduct --> ePset_Liikennevirasto --> Location (IfcIdentifier)

Requirement number	4.2
Required data content	All structural components of the transfer model that consist of several geometrical objects shall be modelled as assemblies. Such assemblies are: • Appurtenances; for example all components of guardrail shall belong to the same assembly • The reinforcements of concrete components shall belong to the same assembly as their parent object. • If the bridge deck is modelled using several segments, all segments shall belong to the same assembly The assemblies shall be created at the structural component level: An abutment is not an assembly, but the individual structural components joining it (wing wall, transition slab, front wall, etc.) and their reinforcements are separate assemblies. In intermediate supports, the shoe and pillar are separate assemblies, including the reinforcements. The deck is a separate assembly including reinforcements, and the wearing surfaces are separate assemblies as well.
Required data structure	Assembly: IfcElementAssembly --> IfcRelAggregates --> IfcProduct
GUIDELINE	For example: In Tekla Structures software, this means the definition of assemblies and cast units. Moreover, the user must ensure that assembly writing is enabled in the IFC export setting.

6.3.5 Data content of the structural components of the transfer model

Requirement number	5.1
Required data content	The structural components of the transfer model must bear the name of the structural component. The only permissible names for the structural components are those specified by the Finnish Transport Agency. Synonyms are prohibited, and so are abbreviated names.
Required data structure	PsetSingle : IfcProduct --> ePset_Liikennevirasto --> Name of structural component (IfcIdentifier)
GUIDELINE	The permissible values are listed in *Table 1*. The values conform to the Structural Component parameter table if the Bridge Register. Names have been added to reinforcements and immaterial data objects. The list contains permissible values for appurtenances; the values come from the following parameter tables of the Bridge Register: Guardrail, Luminaire, Bearing, Expansion joint device, Touch protection, Fixed inspection devices The appurtenances have been given a prefix describing the type. This makes it easier to use the value set.

Requirement number	5.2
Required data content	The structural components of the transfer model must contain information about their material. The only permissible names for materials are those specified by the Finnish Transport Agency. The name of concrete, steel, wood and reinforcements must describe their quality.
Required data structure	PsetSingle : IfcProduct --> ePset_Liikennevirasto --> Material (IfcIdentifier)
GUIDELINE	The permissible values are listed in *Table 2*. The values conform to the Material of Structural Component parameter table the Bridge Register. A further quality specification has been added in the table for concrete, steel, wood and reinforcements.

Requirement number	5.3
Required data content	The frost resistance of the concrete structural components in the transfer model must be specified. The permissible values for frost resistance are those defined Finnish Transport Agency.
Required data structure	PsetSingle : IfcProduct --> ePset_Liikennevirasto --> Frost resistance (IfcIdentifier)
GUIDELINE	The permissible values are listed in *Table 3*.

Requirement number	**5.4**
Required data content	The structural components of the transfer model must contain the bridge part ID. The only permissible names for the IDs are those specified by the Finnish Transport Agency.
Required data structure	PsetSingle : IfcProduct --> ePset_Liikennevirasto --> Bridge Component ID (IfcIdentifier)
GUIDELINE	The definition of an ID is associated with the definition of load-bearing class. It is defined together with the load bearing class group (see 5.5). The IDs are specified in the Finnish Transport Agency's Guideline for Applying the Eurocode, Design of Concrete Structures - NCCI 2.

Requirement number	5.5
Required data content	The structural components of the transfer model must contain a specified material load-bearing class. The only permissible names for the group are those specified by the Finnish Transport Agency.
Required data structure	PsetSingle : IfcProduct --> ePset_Liikennevirasto --> Load bearing class group (IfcIdentifier)
GUIDELINE	The definition of a load-bearing class group is associated with the definition of load-bearing class. It is defined together with the bridge component ID (see 5.4). The load-bearing class groups are specified in the Finnish Transport Agency's Guideline for Applying the Eurocode: Design of Concrete Structures - NCCI 2

Requirement number	5.6
Required data content	Surface treatment must be specified for the steel and wooden parts of the transfer model. The only permissible values for the surface treatment are those specified by the Finnish Transport Agency. The guardrails, luminaires and bearings in the transfer model shall contain a defined method of protection. The only permissible names for the surface treatment and method of protection are those specified by the Finnish Transport Agency.
Required data structure	PsetSingle : IfcProduct --> ePset_Liikennevirasto --> Surface treatment (IfcIdentifier)
GUIDELINE	

Requirement number	5.7
Required data content	The reinforcements of the transfer model must have thickness specified.
Required data structure	PsetSingle : IfcProduct --> ePset_Liikennevirasto --> Thickness (IfcIdentifier)
GUIDELINE	

Requirement number	5.8
Required data content	The structural components of the transfer model must have 3D geometry conforming to the precision specified in Section 4.7.1 .
Required data structure	
GUIDELINE	

6.3.6 Immaterial data

Requirement number	**6.1**
Required data content	The transfer model must contain the following objects describing immaterial data: Endpoints, useful width, requirements for openings, bridge geometry lines, traffic artery grade lines and support lines. The objects shall be modelled as specified in Section 4.8.2 .
Required data structure	
GUIDELINE	

Requirement number	**6.2**
Required data content	The immaterial objects of the transfer model must have a specified name. The only permissible names for the objects are those specified by the Finnish Transport Agency. Synonyms are prohibited, and so are abbreviated names.
Required data structure	PsetSingle : IfcProduct --> ePset_Liikennevirasto --> Name of structural component (IfcIdentifier)
GUIDELINE	The permissible values are listed in *Table 1*. Please note that the list of values contains the permissible names for structural components.

Table 1. Structural components

NOT KNOWN	PLATFORM OUTSIDE THE LIGHTHOUSE	TOUCH GUARD, VERTICAL WALL	LEADING BEACONS
FOUNDATION SLAB	PLATFORM INSIDE THE LIGHTHOUSE	TOUCH GUARD, SLANTED WALL	HELICOPTER PLATFORM
CHEST	WEARING SURFACE	TOUCH GUARD, BRIDGE, ENCLOSED	LIGHT BOX
SHOE	WEARING SURFACE SEAMING	TOUCH GUARD, SHORT PEAK + NET	SAFETY RAIL
FOUNDATION WALL	RAILWAY TRACK RAILS WITH ATTACHMENTS	EDGE ON THE BRIDGE	WINDOW
SIDE WALL	SLEEPERS	LUMINAIRE, OTHER	LIFTING BAR
FRONT WALL	PROTECTIVE RAILS WITH ATTACHMENTS	LUMINAIRE, STEEL POLE	ATTACHMENT PLATFORM FOR LUMINAIRES
SUPPORT WALL	BORDER BETWEEN THE BRIDGE AND EMBANKMENT	LAMP POST, ALUMINIUM POLE	RADAR REFLECTOR
WING WALL	HOOK BOLT	LUMINAIRE, WOODEN POLE	REFLECTOR FOIL
BACKWALL	SUPPORT LAYER	LUMINAIRE, FLUSH MOUNTING	GUARDRAIL OF MARITIME NAVIGATION AID
BEARING PLATFORM	RAIL EXPANSION DEVICE	LUMINAIRE, SURFACE MOUNTING	MARITIME NAVIGATION AID MAINTENANCE PLATFORM
BEARING BEAM	WOODEN BALKS	LUMINAIRE, LANDSCAPE LUMINAIRE	BEARING ELEVATION
NECK	PROTECTIVE LAYER	LUMINAIRE, INSIDE LUMINAIRE FOR BRIDGE	PRESSURE EQUALISING PIPE
SUBSTRUCTURE EDGE BEAM	WATERPROOFING	LUMINAIRE, TUNNEL LUMINAIRE WITH COMMON SUPPORTS	ANTI-CLIMB DEVICE
OLD MAN BAR	TOP SURFACE OF DECK SLAB	LUMINAIRE, SEPARATELY SUPPORTED TUNNEL LUMINAIRE	FRONT RAMP
PILLAR SUPPORT	SEAMING OF SURFACE STRUCTURE	LUMINAIRE, A TUNNEL LUMINAIRE ATTACHED DIRECTLY ONTO THE WALL OR CEILING	SLOPE
PILE SUPPORT	GUARDRAIL POLE	CABLE RACK	ROAD TO THE BRIDGE SITE
WALL-LIKE SUPPORT	BRIDGE GUARDRAIL GUIDE BAR AND SLATS	PROTECTIVE TUBE	ROAD OR TRACK SLOPE
DIAGONAL SUPPORT	ROAD GUARDRAIL GUIDE BAR	TRAFFIC SIGN	EDGE ON THE ROAD
ANCHORING	PROTECTIVE NET OR PLATE	FIXED INSPECTION DEVICE, MAINTENANCE BRIDGE	SURFACE WATER MANHOLE

SUBSTRUCTURE EDGE LANE	FILTER RAILING	FIXED INSPECTION DEVICE, MAINTENANCE BRIDGELET	SURFACE WATER PIPE
SUBSTRUCTURE SEAMING	NOISE BARRIER GUARDRAIL	FIXED INSPECTION DEVICE, LADDER	SURFACE WATER GUTTER
TIMBER GRATING	EXPANSION EXTENSION OF THE TOP GUIDE BAR	FIXED INSPECTION DEVICE, INSPECTION HATCH	DITCH
THRESHOLD BAR	LOW BRIDGE GUARDRAIL	FIXED INSPECTION DEVICE, MAINTENANCE PIER	EMBANKMENT GUARDRAIL
WALL OF TUNNEL OPENING STRUCTURE	COLLISION PROTECTION STRUCTURE	FIXED INSPECTION DEVICE, SEPARATE STEP LEVEL	STAIRS
ROOF OF TUNNEL OPENING STRUCTURE	CONCRETE GUARDRAIL	ACCESS HOLE DOOR	SEAMING
CAISSON	RAILING, LOW	SPACE FOR EXPLOSIVE CHARGE	EROSION PROTECTION FOR INTERMEDIATE SUPPORT
CORNER ABUTMENT	GUARDRAIL, HIGH, NOT DENSE	HOOK FOR EXPLOSIVE CHARGE	ROCK EYE
SHEET PILING WALL	GUARDRAIL, HIGH, DENSE	WATER DRAINAGE PIPE	PORTAL
PONTOON	GUARDRAIL, HIGH SLAT GUARDRAIL	OBSERVATION POINT	HEIGHT LIMITER
SET BAR	GUARDRAIL, HIGH SLAT GUARDRAIL/PEDESTRIAN WALKWAY OR CYCLE PATH	CONTACT PIN	GLARE SHIELD
ANCHORING CHAIN	GUARDRAIL, HIGH WOODEN GUARDRAIL	DRIP SKIRTING	TRAFFIC LIGHT
ANCHORING RUBBER CABLE	GUARDRAIL, STONE GUARDRAIL	SHIP GUIDE BAR	LANE GUIDANCE
ANCHOR WEIGHT	GUARDRAIL, METAL GUARDRAIL	LOG DRIVING GUIDE BAR	INFORMATION DISPLAY
ANCHORING SHAFT	GUARDRAIL, WOODEN GUARDRAIL	FASTENER	TECHNICAL BUILDING
ABUTMENT	GUARDRAIL, CONCRETE GUARDRAIL	CONNECTION TUNNEL FOR VEHICLES	ROCK CUT
REVETMENT WALL	GUARDRAIL, SPECIAL GUARDRAIL	CONNECTION TUNNEL FOR PERSONNEL	CHEST TENDER POST
CHANNEL BOTTOM SLAB	GUARDRAIL, HIGH PROTECTIVE NET	WORK OR MAINTENANCE TUNNEL	CAISSON TENDER POST
CHANNEL THRESHOLD	GUARDRAIL, LOW PROTECTIVE NET	OTHER TUNNEL, SHAFT OR TECHNICAL SPACE	PILLAR/PILE TENDER POST
CHANNEL FLOW BEAM	GUARDRAIL, FILTER RAILING	EMERGENCY EXIT	BOAT RAMP
BEARING SUPPORT	GUARDRAIL, EMBANKMENT GUARDRAIL	EMERGENCY EXIT LIGHT	ROPE WINCH
SET WALL GROOVE	GUARDRAIL, RAILWAY BRIDGE GUARDRAIL	EMERGENCY LIGHTING	EMBANKMENT LEVEE
CHANNEL ROCK WALL	GUARDRAIL, GLASS NOISE BARRIER GUARDRAIL	FIRST-AID FIRE EXTINGUISHER	LEVEE PONTOON

BOTTOM PART OF TRUNK PIPE	GUARDRAIL, ANIMAL FENCE	EMERGENCY TELEPHONE	RUBBISH BIN
SOLDERING OF THE FOUNDATION HOLE	GUARDRAIL, STEEL NOISE BARRIER GUARDRAIL	SURVEILLANCE CAMERA	EROSION PROTECTION FOR ABUTMENT
EROSION PROTECTION FOR MARITIME NAVIGATIONAL AID	GUARDRAIL POLE ATTACHMENT PLATE	VENTILATION OR SMOKE EXTRACTION FAN	EROSION PROTECTION FOR BACKGROUND AREA
ICEBREAKING CONE	BOLT ATTACHMENT OF GUARDRAIL POLE	VENTILATION SHAFT	EROSION PROTECTION IN FRONT OF THE PIER
BASIC PILLAR	GUARDRAIL FASTENER OR EXTENSION	GENERATOR	PIER SIGN
LIGHTHOUSE PIER PLATFORM	FOUNDATION CASTING FOR GUARDRAIL POLE	PUMPING STATION	WATER TRAFFIC SIGN
ABUTMENT EXTENSION	EXPANSION JOINT DEVICE, OTHER	WASH WATER COLLECTION BASIN	EXCAVATED ROCK COVERING FOR A CHANNEL RAMP
EDGE BEAM	EXPANSION JOINT DEVICE, SEAM ELEMENT	DOOR OR HATCH	STACKED ROCK COVERING FOR A CHANNEL RAMP
EDGE LANE	EXPANSION JOINT DEVICES, SEAM BAND	CLOSING BOOM BARRIER	TRACK TO THE BRIDGE SITE
EDGE BEAM EXPANSION JOINT	EXPANSION JOINT DEVICE, 1-ELEMENT	FIRE HYDRANT	PROTECTIVE FENCE
ROOT ELEVATION	EXPANSION JOINT DEVICE, MULTI-ELEMENT	RAINWATER MANHOLE, -SEWER IN TUNNEL	EMBANKMENT WALL
EDGE WALL (ALSO EDGE BEAM ELEVATION)	EXPANSION JOINT DEVICE, FIVE-BAR PATTERN	WASTEWATER MANHOLE, -SEWER IN TUNNEL	ELEMENT SEAM
DECK SLAB	EXPANSION JOINT DEVICE, MASS MOVEMENT SEAM	INSPECTION MANHOLE IN TUNNEL	GROUNDING
MAIN SUPPORTER, BEAM	EXPANSION JOINT DEVICE, PONTOON JOIN	PIER LOWER PLATFORM	EMBANKMENT GUARDRAIL POST
MAIN SUPPORTER, ARC	MASS MOVEMENT SEAM	PIER STAIRS	MAINTENANCE ACCESSWAY
MAIN SUPPORTER VAULT	SUPPORT LANE	RESCUE DEVICE KIT	TRACK CATENARY PYLON SUPPORT
MAIN SUPPORTER, BOX	PONTOON ATTACHMENT	BOLLARD	ACCESS RAMPS
MAIN SUPPORTER, GRID	PONTOON ATTACHMENT SHOE	FENDER	ELEVATOR, SUPPORT STRUCTURES
MAIN SUPPORTER, PIPE	PROTECTIVE PLATE FOR RAILWAY BRIDGE EXPANSION JOINT	EDGE REINFORCEMENT	STAIRWAY WALLS AND CANOPIES
SECONDARY LONGITUDINAL SUPPORTER	SEAM BETWEEN THE SUBSTRUCTURE AND SUPERSTRUCTURE	WOODEN PROTECTIVE DEVICE	EMBANKMENT GUARDRAIL ELEVATION PART
CROSSWISE SUPPORTER	BEARING, NO BEARING	CRANE	PROTECTIVE NET OF EMBANKMENT GUARDRAIL
TRANSVERSE TIE	BEARING, OTHER	LEVEL CHANGE DEVICE	HIGH EMBANKMENT GUARDRAIL

DIAGONAL TIE	BEARING, STEEL BEARING, ROLL	RING FENDER	EMBANKMENT GUARDRAIL FOUNDATION
PYLON	BEARING, OTHER STEEL BEARING	LIFE PRESERVER	REINFORCEMENT, MAIN BAR
SUSPENSION CABLE	BEARING, RUBBER SLAB BEARING	HEAVING LINE	REINFORCEMENT, DISTRIBUTION REINFORCEMENT
RETAINER ROPE	BEARING, RUBBER CASE BEARING	BOAT HOOK	REINFORCEMENT, STIRRUP
HANGING BAR	BEARING, RUBBER CUP BEARING	RESCUE LADDER	REINFORCEMENT, HELICAL STIRRUP
STAY CABLE	BEARING, SPHERICAL BEARING	PILE PROTECTIVE SHEATH	REINFORCEMENT, SPLITTING REINFORCEMENT
SUPERSTRUCTURE SEAMING	BEARING, SPECIAL BEARING	BUMP PROTECTION	REINFORCEMENT, ADDITIONAL REINFORCEMENT
SHOTCRETED, IN A ROCK WALL TUNNEL	BEARING, KREUZ-EDELSTAHL BEARING	CORNER ABUTMENT, ACCESSORY	IMMATERIAL OBJECT BRIDGE LOCATION
SHOTCRETED, ROCK CEILING IN TUNNEL	ARTICULATED JOINT	PROTECTIVE PLANKS	IMMATERIAL OBJECT, USEFUL WIDTH
SHOTCRETED, SEPARATE LINING STRUCTURE ON TUNNEL ROOF	DOWNSPOUT	MAINTENANCE ACCESSWAY (CONSOLE AND GRILLE)	IMMATERIAL OBJECT, REQUIREMENT FOR OPENING
SHOTCRETED, SEPARATE LINING STRUCTURE ON TUNNEL WALL	DRIP TUBE, DRIP HOLE	COATINGS (E.G. CERAMIC TILES)	IMMATERIAL OBJECT, SPAN
INSTALLED SEPARATE LINING STRUCTURE ON TUNNEL CEILING	DRAIN	MOBILE BOLLARD	IMMATERIAL OBJECT, SUPPORT LINE
INSTALLED SEPARATE LINING STRUCTURE ON TUNNEL WALL	TOUCH GUARD, NOISE BARRIER WALL	ATTACHMENT ROPE	IMMATERIAL OBJECT, STRUCTURE JACKING LOCATION
MAIN SUPPORTER, TROUGH-SECTION BEAM	TOUCH GUARD, NOT KNOWN	EMERGENCY EXIT STAIRS	
MAST	TOUCH GUARD, HORIZONTAL PEAK/CONCRETE	SHIP ATTACHMENT HOOK	
GUY WIRE	TOUCH GUARD, HORIZONTAL PEAK/METAL	IDENTIFICATION PART OF A MARITIME NAVIGATIONAL AID	

Table 2. Quality of material

UNKNOWN	GLASS	S275JR	B500K
CONCRETE	C45/55	S275J0	B500S
STEEL	C50/60	S275J2G4	B600KX
WOOD	C40/50	S275J2G3	B700K

STONE	C35/45	S355JR	L40
ALUMINIUM	C30/37	S355J0	L30
BITUMEN	C25/30	S355J2G3	T40
BITUMEN RUBBER	C20/25	S355J2G4	T30
RUBBER	C16/20	S355K2G3	T24
PLASTIC (PVC,PE)	C12/15	S355K2G4	T18
POLYMER CEMENT CONCRETE	C32/40	S355J2H	C24
POLYMER COMPOSITE	K25-2	S320GD+Z	C30
OTHER POLYMER	K25-1	S280GD+Z	C35
ASPHALT CONCRETE	K40-2	S355K2	GL24c
CAST ASPHALT	K35-2	S355J2	GL28c
TARMAC	K35-1	S275J2	GL30c
PEAT	K30-2	S235J2	GL32c
GRASS	K30-1	S350GD+Z	GL24h
GRAVEL	K40-1	X70	GL28h
SOFT ASPHALT CONCRETE	K100-1	X60	GL30h
SURFACING OF GRAVEL ROAD	K80-1	S550J2H	GL32h
STAINLESS STEEL	K60-1	S440J2H	Kerto-T
CARBON FIBRE	K50-1	AISI316	Kerto-S
POLYMER MODIFIED	K70-1	AISI304	Kerto-Q
CEMENT MORTAR	K45-1	1470/1670	TREATED WOOD
COPPER	S235JR	1570/1770	BASIC GROUND
CRUSHED ROCK	S235JRG1	1630/1860	BEDROCK
MACADAM	S235JRG2	A500HW	GRAVEL
BRICK	S235J0	A700HW	IMMATERIAL OBJECT
CERAMIC TILE	S235J2G3	B500B	
GLASS FIBRE	S235J2G4	B500C1	

Table 3. Frost tolerance

P20
P30
P50
P70

Table 4. Surface treatments

UNCLASSIFIED	HOT DIP GALVANISED
PAINTING	SPRAY GALVANISING
ALKYD PAINT	ALUMINIUM COATINGS
TVL 2.1	SPECIAL COATINGS
TVL 2.2	WAX COATING
TIEL 3.1	GREASE COATING
CHLORINATED RUBBER PAINT	ANTICORROSION TAPE

TIEL 3.2	SHOTCRETING
TIEL 3.3	SHOTCRETING
POLYURETHANE PAINT	COATING
TIEL 3.4	IMPREGNATION
TVL 4.6	POLYMER-BASED
TIEL 4.8	COATING
TIEL 4.9	CEMENT-BASED
TIEL 4.12	COATING
EPOXY PAINT	CATHODIC PROTECTION
TIEL 4.1	CATHODIC PROTECTION
TIEL 4.2	LINING
TVL 4.3	STONE LINING
TVL 4.4	METAL LINING
TVL 4.5	TIMBER LINING
VINYL PAINT	IMPREGNATION
TVL 4.7	SALT IMPREGNATION
METALLIC COATINGS	CREOSOTE IMPREGNATION

Table 5. Tendon anchor type.

Active anchor
Passive anchor

6.3.7 Validation of the transfer model

The transfer model shall be validated before submitting it to the engineering structure register. This ensures that the transfer models fulfil the requirements of the engineering structure register. Please note that the validation applies only to the data content and data structure of the transfer model. not to the design solutions. The transfer model is examined to verify that the required object types and their attributes are present in the model and that the attribute value sets conform to the specifications.

The designer is responsible for ensuring that the data content of the transferred maintenance model (transfer model) conforms to the bridge site and meets the requirements of the engineering structure register. The Finnish Transport Agency is responsible for saving the data into the register as well as its further refinement and use.

The Finnish Transport Agency is entitled, but not obliged, to validate the transfer models. If the Finnish Transport Agency finds that the transfer model does not conform to specifications, the Finnish Transport Agency has the right to report the defects to the creator of the transfer model. The creator shall be obliged to amend the defects found.

6.3.8 Editing the transfer model

If the transfer model does not meet the requirements of the engineering structure register, the model must be edited to meet the requirements. The majority of edits are fairly simple actions, such as moving an item of data to the correct data field. Since the requirements do not apply to the design itself, the editing does not alter the design. If, for example, there is a typographical error in the bridge structure numbering or labelling, correcting this error does not change the design solution. The only thing that changes is the ease of availability of the data in the engineering structure register. The creator of the transfer model is responsible for editing the model.

6.3.9 Delivering the transfer model

The transfer models shall be delivered to the engineering structure register in IFC format. The update of the engineering structure register is still a work in progress. When the update is complete, the Finnish Traffic Agency will issue instructions on how to submit transfer models to the register.

A BIM report subject to Section 8.1 of the BIM Guideline for Bridges shall be delivered along the transfer model. Along with updates to the engineering structure registers, the BIM report might be integrated as part of the transfer model. In this case, the required information in the BIM report shall be entered directly as attribute data of the objects of the model. This makes it easier to find and utilize the data.

6.3.10 Coordination of BIM communications

The tasks of the BIM model expert appointed by the Finnish Transport Agency include the coordination of BIM communications in project: specification of project-specific information model requirements, delivering the requirements to the designers, scheduling and monitoring BIM communications, possible validation of transfer models and solving various problems and technical obstacles.

6.3.11 Quality of the transfer model

Quality is a concept that is difficult to define and often causes a lot of confusion in BIMs. However, the quality of transfer models is defined unambiguously: a transfer model is of high quality when it fulfils the detailed requirements that apply to it. Thus, the quality of a transfer model in the engineering structure register is defined by the Finnish Transport Agency's requirements for a transfer model.

7 Information modelling in the repair of bridges

7.1 Scope of modelling

7.1.1 Determining the scope of bridge modelling

Bridges are subjected to different levels of repairs. The scope of bridge repair and modelling is determined by the results of the extended general or special inspection of the target. The modelling of a repair project must be agreed upon a project-by-project basis, taking into account e.g. the repair type, available initial data and the benefits obtained from the model.

The scope of the repair project affects the choice of planning methodology. In small-scale bridge renovations, the modelling covers only the assemblies that will be renovated. Modelling yields its greatest benefits in large-scale repairs, such as targets that require widening of structures or renovation of the superstructure.

> *Repair projects are usually associated with a great deal of hidden information that is, nevertheless, critical for planning, such as underground structures and reinforcement. If the basic data is very incomplete, it might not be sensible to use modelling in the planning of the target.*

7.2 Initial information model for repair planning

Bridge repair projects usually consist of entities covering one or several bridges. A characteristic feature is that the sites are geographically separated and are thus separate targets. Therefore, an initial information model is usually needed separately for each bridge site.

> *If a repair target is associated with a larger project, such as the improvement of a traffic artery, the initial information model for the repair target can be taken from the traffic artery's initial information model and complemented with the special requirements of the repair site.*

The scope and form of the initial information model of the repair site should be considered on a project-by-project basis. In general, a sufficient scope for an initial information model for repair targets is the terrain model of the site and old drawings complemented with other available material, such as photographs, basic and inspection information and any information about pipes and cables. The initial information model of the repair site can also be a mere terrain model onto which the old structures of the bridge are mapped with e.g. laser scanning of sufficient precision.

The terrain and current traffic artery data are delivered as surface models. Data on any new traffic arteries shall be delivered as surface models and numeric data. The existing structures of the repair target shall be presented as agreed, either as a volume model, surface model, wireframe model or point cloud.

The repair targets in bridges are associated with many hidden structures, which is why the terrain model consists of data measured from the visible parts of the terrain and structures. This is why it is usually sensible that the creator of the repair plan creates volume objects of the old structures by using the old designs of the target.

Concerning underground structures, the shape and extent of damage can be determined by probing and inspections by divers.

When generating the initial information model, the surrounding terrain and the traffic artery leading to the bridge site are mapped in sufficient detail. Moreover, the model shall contain all appurtenances at the bridge site, such as poles, road area poles, boundary marks, guardrails and road markings. A sufficient number of auxiliary points for construction must be left at the bridge site during the measurements. The location of the auxiliary points shall be detailed in the initial information model. If foundation surveys are carried out in a repair project due to e.g. the changing loading of the structure, the soil data shall also be included in the model.

The road leading to the bridge site should be mapped for at least 100 m from both ends. If the repairs cause the grade or slope of the road to change at the bridge location, this distance should be increased. The surrounding terrain should be mapped for at least 5 metres outwards from the opposite side of a ditch.

7.3 Contents of a repair plan model

When using modelling for the planning of repairs, the models created are the bridge BIM and the BIM reports. The main features of a bridge are always modelled in their entirety, or at least the parts that are the target of repairs.

7.3.1 Requirements for the content of the repair plan model

The modelling shall follow the modelling requirements for structural components specified in Section 4.7.1 . The modelling contains the old and new structures, equipment, devices, new reinforcements installed in the structures, and the reinforcements in the old structures that will join the new structures.

For immaterial modelling, the requirements in section 4.8.2 shall be followed.

In repair targets, particular attention should be paid to the actual data on openings. For example, the actual underpass height shall be marked in the model.

Remaining existing structures

The existing structures that will not be removed shall be modelled with precision equal to the requirements that apply to the execution of the replaced/repaired part.

The holes for tie bars shall be modelled in the old structure as using actual size. Any new reinforcements of the old structure that remain functional in the new structure shall be modelled.

Structures to be demolished

The estimated demolishing limits shall be modelled, including:

- The planned concrete chipping borders
- Appurtenances to be demolished

The structures to be demolished shall be modelled at a dedicated "level", if the software allows it

Changes to the traffic artery geometry

If the traffic artery grade changes from the old one, and no traffic artery design is carried out at the target, the model shall show the fit of the new grade to the existing grade.

Appurtenances at the bridge site that are not a part of the bridge itself.

Guardrails and other structural components of the bridge site shall be modelled with sufficient precision that enables their location and type to be determined from the model.

Traffic arrangements during the works

The space requirements during the works shall be modelled, e.g. for driving lanes etc.

7.3.2 Special characteristics of the repair plan

The old structural components of repair targets are usually subjected to various minor repairs, such as mortar patches, surface treatment and injections into cracks. Presenting the aforementioned small repairs in the BIM is not necessary at this point, but they must be presented in the bridge repair drawing.

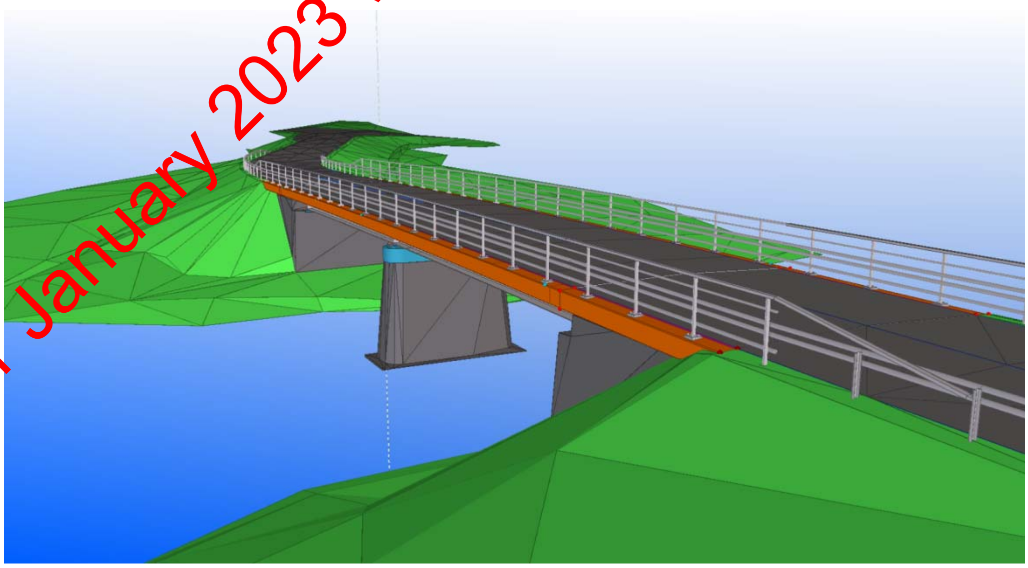

Image 16. An exemplary model created during superstructure renovation. (Madesalmi Bridge, Siltanylund)

8 Production of plan and inspectiondocuments

8.1 BIM report

The BIM report is the most important document to be attached to the model, and it shall always accompany the model when it is handed over. The BIM report describes the status of the BIM model at the time of handover. The BIM report must contain records of any deviations from the agreed model content in different phases of the project, as well as other problems in the model content and transfer files generated from this, such as limitations of software encountered during modelling. If the model is complemented in phases, the correctness of the BIM components, i.e. their status shall be described in the BIM report. The BIM report shall be stored along the BIM. This Guideline contains an appendix with a sample BIM report.

The BIM report must indicate the following:

- The target
- The content of the model
- Associated reference models / technology area models
- The software package used, its version and file format
- The coordinate system and height system
    - The location of any local coordinate system
- A description of the part naming and numbering scheme
- Any shortcomings and incompleteness in the model with regards to the requirements of the phase, i.e. the status of the components
- The precision of any traffic artery geometry and other associated structures in the BIM
- The status of the inspection of the model, such as the collision inspection of reinforcements
- Quality assurance of the product model
- Inspection and approval information of the model (In a Finnish Transport Agency project, an approval by the Finnish Transport Agency)
- Any other matters to be taken into account

8.2 Generation of design documents

The BIM is the primary and binding design document. Any imprecision or deviations on the model must be described in the BIM report.

Drawings shall be generated from the product model by applying the Finnish Transport Agency Guideline *Basic Designs [Siltojen suunnitelmat] TIEL 2172067-2000 *)*, and the content of the drawings shall meet the commissioner's requirements. Appendix 4 contains an example of design-phase documents that support modelling.

*) The publication shall be updated in 2014–2015 to meet the needs of information modelling.

> *The goal is to have bridge models and the information in these available to all parties of a project. A precise model reduces the requirements on the content of drawings. Drawings might still be needed in the future, but less than at present, and the content and division of the drawings will change. In model-based design, it is often easier to create several drawings of an aspect than showing everything in a single drawing.*

> *In the initial phase of modelling, software packages set limitations to the model contents and the presentation of drawings. The currently used methods of presentation are not possible or appropriate. The goal is to use the model produced as much as possible without unnecessary drawings.*

8.3 Content of material to be submitted for authoritative review and approval

The material to be submitted for authoritative review and approval shall be a combination model of the design target in native and IFC format, as well as drawings generated from the model. The approval of the plans shall be based on the model and drawings.

> *Separate software exists for the review of models and e.g. communication between the designer and reviewer. The reviewer of the design can enter comments directly into the model, the designer can reply to the comments and make the necessary corrections and complements. This kind of software enables linking to other materials from the model components, such as links to PDF files of calculations. This helps the users to access other critical data of the bridge in addition to the visual model.*

> *In the future, the review and approval of bridge plans can be carried out by using the model alone. As this becomes reality, the importance of the designer's own review and quality assurance shall become even more important.*

8.4 Fulfilling the design archiving requirements

Drawings for archiving shall be created as specified in the archive creation plan. The format of the drawings shall conform to the presentation methods of the sample drawings in Appendix 4 and the Guideline *Basic Designs [Siltojen suunnitelmat] TIEL 2172067-2000*.

> *The electronic archiving of BIM-based designs is proceeding. The format to be used for the archiving shall be determined later. The BIM Guideline will be updated as the project proceeds.*

9 Handover of a BIM model

9.1 Handover - copyright

Projects that contain bridges and other engineering structures can involve several parties already at the design phase. The effective use of a BIM throughout the project requires that the model be available for all parties.

9.1.1 Transferring a model to the parties of a project

A data model shall be transferred to other parties a specified in Chapter 2 . If necessary, a separate transfer agreement shall be created among the operators. The agreements shall specify the file formats, intended purpose of the model, use rights and copyrights. A bridge BIM, including the BIM report, becomes available in the agreed format for other parties. A model that is delivered in the native format shall be accompanied with all the libraries used in this, so that all essential design information is preserved and transferred along with the model. Such information includes e.g. the material and profile libraries used in the model.

> *If the connection libraries are not handed over, it must be verified that any objects modelled with connections are transferred correctly, including their attributes. It is recommended that no components or libraries be used in the design that cannot be handed over in their original format along with the model. The format can be a native format or formats converted thereof, such as 3D-DWG, LandXML/IM and IFC.*

9.1.2 Preservation of copyright

The right to use and utilise the BIM at the target specified in the commission contract or BIM handover contract shall be transferred, but the copyright remains with the creator of the BIM. As regards type designs, the design contract shall contain provisions for wider use and utilisation rights. After the project ends, the models shall be handed over to the commissioner in the native (original) and IFC format for archiving.

Sample BIM report

BIM report

Project:	Tikkurilantie Road between Riipiläntie Road - Katriinantie Road, Vantaanjoki Bridge, Vantaa
Project number:	S39678 Tikkurilantien ST
Author:	Timo Nurmimäki /Siltanylund Oy
Software Version:	Tekla Structures 17.0.5
Format:	Tekla native
File name:	Vantaanjoki.db1
Date:	23/08/2012
Status:	Approved

Content of the model by structural component:

100 Abutment T1:
The geometry of the concrete parts/piles of the abutment has been modelled.
Reinforcement modelled
Equipment modelled
Status: *Approved*

200 Abutment T4:
The geometry of the concrete parts/piles of the abutment has been modelled.
Reinforcement modelled
Equipment modelled
Status: *Approved*

310 Intermediate support T2:
The geometries of the concrete components, piles and pillars of the intermediate support have been modelled.
Reinforcement modelled
Equipment modelled
Status: *Changed*

320 Intermediate support T3:
The geometries of the concrete components, piles and pillars of the intermediate support have been modelled.
Reinforcement modelled
Equipment modelled
Status: *Changed*

400 Superstructure:
The geometry of the concrete components of the superstructure has been modelled.
Reinforcement modelled
Equipment modelled
Status: *Approved*

600 Appurtenances

1000 Reference:
The grade line of Tikkurilantie Road is modelled by level piles (at one meter intervals) using profile D25. At pile interval 1240–1360, the level pile readings are modelled at 20-metre intervals. The value of the pile reading is in the Name field of the object. Principal points have been modelled.

The traffic artery designer’s terrains and ground structures belonging to the bridge are modelled as triangle meshes.

Coordinate system:
The origin of the local coordinate system of the BIM is located at X=89300.000 ;Y=48900.000 (VVJ) The unit of measurement in the modelling is millimetre. The model’s height system is N60. The positive direction of the Y axis of the local coordinate system in the BIM is north.

Documentation:
Documents associated with the designs are linked to the model by using the Tekla Comment Tool. Due to the shortcomings of the Comment Tool application, the user must re-link the files and documents to the documents in the folder.

Status:
The Status of structural components has been modelled. The Status can be found in the Representation settings of the software: ”FMC_Status”.

Status colours:

In design
In internal review
Internal review complete
Project review
Project approval
Review by the authorities
Change planning
Completed
Changed

Associated reference models:

Geopinta.dwg	= load-bearing moraine / rock
Taso.dwg	= 2D view of the bridge site NOTE: For reference only
Paalulaatat.ifc	= Embankment slab geometry model
Aluesuunnitelma.ifc	= 3D version of the area and safety plan
Ratasilta.ifc	= An indicative 3D model of the railway bridge

Numbering:
The list is made more complete as the modelling proceeds.

Phases used in the modelling.

Number:	Name:
100	Abutment T1
200	Abutment T4
310	Intermediate support T2
320	Intermediate support T3
400	Superstructure
600	Appurtenances
700	Associated structures
1000	Reference

Class:	Name:
99*	Terrain/Traffic artery surfaces
202*	Pile shoe
203*Pile	
204*	Concrete filling of pile
205*	Pillar
207*	Bearing beam
210*	Front wall
250*	Deck
251*	Edge beam
253*	Wing wall
254*	After-cast
255*	Surface structure
281*	Transition slab
282*	Pile toe
283*	Steel guardrail
284*	Bearing/provision
285*	Drainage equipment
286*	Appurtenances
287*	Appurtenances
288*	Appurtenances
390*	Tensioned reinforcement/protective sheath
391*	Tendon anchor

Reinforcement Class

Class:	Name:
500*	After-cast main bar
501*	After-cast stirrup
504*	Tie bar
511*	Wing wall vertical reinforcement
512*	Wing wall horizontal reinforcement
513*	Wing wall vertical reinforcement
514*	Wing wall horizontal reinforcement
515*	Wing wall stirrup
516*	Wing wall stirrup
521*	Beam side surface reinforcement
522*	Beam bottom surface reinforcement
523*	Beam top surface reinforcement
524*	Beam stirrup
525*	Beam additional reinforcement
530*	Beam vertical reinforcement
531*	Beam helical reinforcement
540*	End beam front side vertical reinforcement
541*	End beam front side horizontal reinforcement
542*	End rear front side vertical reinforcement
543*	End beam front side horizontal reinforcement
544*	End beam stirrup
545*	End beam additional reinforcement
570*	Substructures, vertical reinforcement
571*	Substructures, horizontal reinforcement
572*	Substructures, vertical reinforcement
573*	Substructures, horizontal reinforcement
574*	Substructures, stirrup
575*	Substructures, additional reinforcement
576*	Substructures, horizontal reinforcement
577*	Substructures, horizontal reinforcement
578*	Substructures, stirrup
581*	Longitudinal reinforcement of the deck top surface
582*	Crosswise reinforcement of the deck top surface
583*	Longitudinal reinforcement of the deck bottom surface
584*	Crosswise reinforcement of the deck bottom surface
590*	Edge beam horizontal reinforcement
591*	Edge beam, stirrup

Reference Class:

Class:	Name:
2	Measurement point
4	Grade line
5	Principal point
6	Pile reading

Other matters to be taken into account:

The bearings and expansion joint devices are modelled as volume provision objects. 22 August 2012 Changed the tie bar reinforcement if the pillars, added surface water tubes for support T1 and concrete gutters below.

Requirements for the modelling of engineering structures in the design phases

	NO requirements for modelling.
	The visible surfaces shall be modelled in significant targets. Create a surface model. (Cf. the precision of preliminary planning and general planning, bridge site class I and II)
	Model all visible components at all targets. Create a surface model.
	Model the components in their entirety in all targets. Create a volume model. (Cf. the precision of road and track planning)
	Model the components in their entirety in all targets. Complete description of the structure. (Cf. the precision of engineering design)

4100 UNSPECIFIED STRUCTURAL COMPONENTS REQUIRING CONSTRUCTION ENGINEERING

4110 Concrete structures

	Preliminary design	General design	Basic design	Engineering design
4110 Concrete structures				

4120 Steel structures

	Preliminary design	General design	Traffic artery design	Engineering design
4120 Steel structures				

4130 Wooden structures

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4130 Wooden structures				

The modelling requirements of an unspecified structural component that require construction engineering shall be agreed upon separately.

4200 BRIDGES

4210 Bridge support structures

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4211 End supports				
4212 Intermediate supports				
4213 Bridge support structure insulations				*
4214 Bridge support structure coverings				*
4219 Other bridge support structures				

* Modelled according to their characteristic thickness

4220 Bridge superstructures

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4221 Concrete structures in the superstructure				
4222 Concrete element structures in the super-structure				
4223 Steel structures in the superstructure				
4224 Wooden structures in the superstructure				
4225 Stone structures in the superstructure				
4226 Superstructure surface coverings				*
4229 Other bridge super-structures				

* Modelled according to their characteristic thickness

4230 Bridge deck surface structures

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4231 Insulation				*
4232 Protection of insulation				*
4233 Bridge pavement		**	**	*
4239 Other surface struc-tures of the bridge deck				*

* Modelled according to their characteristic thickness ** The top surface of the bridge pave-ment is modelled

4240 Bridge accessories

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4241 Expansion joints				
4242 Bearings and joints			*	
4243 Machineries and control rooms				
4244 Transition slabs				
4245 Safety devices	**	**	**	
4246 Bridge grounding				
4247 Support layer cut device				
4248 Drainage devices				

4249 Other appurtenances of the bridge				

*Only bearings are modelled
** Only guardrails are modelled.
During the engineering design phase, the model must indicate the location, geometry and type of all appurtenances.

4300 PIERS

4310 Pier support structures

	Preliminary design	General design	Traffic artery design	Construction planning
4310 Pier support structures				

4320 Pier superstructures and surface structures

	Preliminary design	General design	Traffic artery design	Construction planning
4320 Pier superstructures and surface structures			*	**

* Applies to pier superstructures
** The surface structures are modelled according to their characteristic thickness

4330 Pier appurtenances

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4331 Tender posts and piles				
4332 Crane tracks				
4333 Logistics systems				
4339 Other pier appurtenances				

During the engineering design phase, the model must indicate the location, geometry and type of all appurtenances.

4390 Other pier structures

	Preliminary design	General design	Traffic artery design	Engineering design
4390 Other pier structures				

4400 Foundation and support structures

4410 Foundations and transition slabs

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4411 Caisson foundations				
4412 Transition slabs				
4419 Other foundation structures				

4420 Abutments, support walls and stairs

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4421 Abutments (>700mm)				*
4422 Support walls				*
4423 Gabions				
4424 Stairs				
4429 Other support structures				

* The coverings shall be modelled according to their characteristic thickness.

4490 Other foundation and support structures

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4490 Other foundation and support structures				

4500 ENVIRONMENTAL STRUCTURES

4510 Protection and noise barrier structures

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4511 Noise barrier walls				*
4512 Noise barrier guardrails				*
4513 Vibration damping structures				**

4519 Other damping structures				**

* The coverings shall be modelled according to their characteristic thickness.
* During the engineering design phase, the model must indicate the location, geometry and type of all structures.

4520 Art structures in the surroundings

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4521 Environmental art		*	*	**

* Modelled as a volume provision
** Any foundations of environmental art that require on-site casting shall be modelled as a volume model; the part above ground can be modelled as a volume provision, surface model.

4600 CONSTRUCTS AND FITTINGS

4610 Shelters

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4611 Canopies		*	*	**
4612 Storage buildings		*	*	**
4613 Accessories of the shelters				**
4619 Other shelters			*	**

* Modelled as a volume provision
** Any foundations of shelters that require on-site casting shall be modelled as a volume model; the part above ground can be modelled as a volume provision, surface model, when the shelter is ordered as a prefabricated product. The model must indicate the location, geometry and type of the product.

4620 Appurtenances

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4621 Accessories of the playgrounds and leisure areas		*	*	**
4622 Accessories for exercise and recreational areas		*	*	**
4623 Accessories of traffic areas		*	*	**
4624 Works of art		*	*	**
4629 Accessories				**

* Modelled as a volume provision.
** Any foundations of appurtenances that require on-site casting shall be modelled as a volume model; the part above ground can be modelled as a volume provision, surface model, when the object is a prefabricated product or a work of art. The model must indicate the location, geometry and type of the product.

4700 Water traffic structures and dams

4710 Dams and dam structures

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4711 Adjustable dams				
4712 Flood pumping stations				
4719 Other dams and dam structures				

4720 Sluice structures

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4721 Flood gates				
4722 Sluice chambers				
4729 Other sluice structures				

4800 Concrete structures of underground spaces

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4800 Concrete structures of underground spaces				

The modelling requirements for concrete structures of underground spaces shall be agreed upon separately

4900 other structural components

	Preliminary design	General design	Traffic artery design	Construct-ion planning
4900 Other structural components				

The modelling requirements shall be agreed upon separately.

Matters to agree upon on a project-by-project basis

1. GENERAL INFORMATION ABOUT THE PROJECT

Project:	
Design phase:	
Bridge / bridge sites:	
Design action:	

Author		**Date and time**	

Parties to the project	Task	The software to be used

2. INITIAL INFORMATION ON THE PROJECT / ASSEMBLING AN INITIAL INFORMATION MODEL

Available initial information *This section presents the initial data needed and used in modelling*	Supplier	Format	Note
Initial information / Initial information model			
Current state model			
terrain model			
soil model			
structures and systems			
map and geographical information			
design information			
traffic artery model			
drainage			
foundation structures			
Preceding design phase			
models of the preceding design phase			
Reference material			

3. COORDINATE SYSTEM AND LABELLING

Component numbering and labelling *Description of the numbering and labelling system used. The requirements in section 4.8.4 shall be followed.*

Coordinate system:		
Height system:		
A separate local coordinate system:	**Yes / No**	
Description of the deviation		

4. CONTENT OF THE BIM

Content of the bridge BIM *Structural components are added into the table if necessary*		
Structural component	**Content of the design phase**	**NB!**
Superstructures		
surface structures		
insulation		
superstructure, concrete / steel / wooden structures		
joints of steel / wooden structures		
concrete elements		
linings		
Foundations and substructures		
piles		
frost insulations		
foundation slabs		
support structures, intermediate supports and abutments (end supports)		
moisture insulations		
linings		
Associated structures (embankments, traffic arteries)		
ramps, slopes and their linings		
embankment slabs		
abutments		
drainage		

Appurtenances		
Expansion joint devices		
bearings		
transition slabs		
contact pins		
tubes for explosive charges		
grounding		
lighting		
cable / pipe racks		
Tie bars (anchors etc.)		
Guardrails, guide bars and touch protection walls		
bridge guardrail		
transition guardrail		
road fence		
touch protection structures		
bump protection and collision protection structures		
Drainage devices		
drip tubes		
pressure equalising pipes		
surface water pipes and drains		
downspouts		
Reinforcements *This section specifies the modelling precision of the reinforcement needed in the design phase*		
- as quantity information for structural components		
- modelled in detail		
Tendon strands, tendon tubes and equipment *This section specifies the modelling precision of the reinforcement needed in the design phase*		
- as quantity information for structural components		
- modelled in detail		
Other project-specific details *This section can be used for specifying orders for less commonly used equipment, etc. (Lifting/turning bridges, appurtenances for cable-stayed/suspension bridges)*		

5. CREATING A COMBINATION MODEL

Combination model
A combination model shall be created as specified in Section 4.10 .

Author	**Format**

6. MATERIAL TO BE GENERATED FROM THE MODEL

Material to be generated from the model and any special tasks
This section is intended for describing any special design requirements associated with reporting, investment/quantity calculations, timesheet reports, official/user/worksite meetings and other such meetings where the commissioner must be present. *For example: moulds and scaffolding, phases of construction/implementation, etc.*

Task	**Author**

7. HANDOVER OF THE MODEL

Handover of the model
Matters presented here: intended purpose of the model, software version and formats, quality assurance / inspection

Purpose	**Task**	**Format**

8. CONTENT OF THE AS-BUILT MODEL

As-Built materials
This section presents the content and author of the data to be imported into the as-built model *Any data that is critical for quality assurance must be imported into the model*

Table of Contents	**Author**

9. MAINTENANCE MODEL

Maintenance model to be stored in the engineering structure register *The author is presented here* *The maintenance model shall be created as specified in Chapter 6*

Author	

Finnish Transport Agency

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