Prefabricated concrete Information Delivery Manual

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30/10/2018	G. Zlabinger	1.1	Added BVBS to list of established interfaces, minor revisions
10/02/2020	K. Linhard	1.2	Restructuring of the Exchange Requirements

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Introduction & Scope

From the point of view of the precast industry, therefore, an open, future-proof, effective and cross-industry solution makes sense, involving ERP, CAD, MES manufacturers and plant manufacturers as well as the built-in component manufacturers.

The project is aimed at creating an internationally standardized interface maintained by the industry, based on existing interfaces already established in the prefabrication process, as AIA, Unitechnik version 1.0 to 6.1, UXML, PXML and BVBS. As prefabricated products are getting more complicated, demand for a more capable model exchange interface is on the rise.

The project is supported by the buildingSMART International community and the project group consists of members representing the industry, namely (in alphabetical order):

- AEC3 Deutschland GmbH
- bwb Beteiligungsgesellschaft mbH & Co. KG
- IABI.eV Institute for Applied Building Informatics
- IDAT GmbH
- Precast Software Engineering GmbH
- Progress Software Development GmbH
- RIB SAA Software Engineering GmbH
- Trimble Germany GmbH
- Unitechnik Systems GmbH

Motivation

At the beginning of the project there was a feasibility study and extensive research which format would be suitable for a new industry standard. It was concluded that IFC4 is the right format with the following arguments as a result of the feasibility study:

- Precast industry calls for a professional BIM integration for all systems involved in the Precast process
- Current interfaces limited in their possibilities.
  - e.g. no 3D-model description, no unique Id´s for objects, etc.
- The possibility of segmentation in IFC 4.0 makes it possible to map also precast elements
- Suitable entities in IFC 4.0 definition
- Very good documentation tools available
- Wide support through standardized viewer
- Very good support through Building Smart in national and international distribution
- Strong project group with market leaders in CAD, MES and ERP systems

Goals

- Creation of a universal basis for process optimization and information distribution in the precast area
- To bring the BIM idea more into the precast area
- CAD and PPS-Systems should be more closely linked to production
- Exchange over the international standard IFC, the precast industry is raising a higher, more professional level in the data exchange model
- Clear traceability over the building model and the building cycle
- Use IFC added value compared to existing interfaces
- BIM Collab format could be also used in the future to enable bidirectional communication among BIM Precast-Systems
- Small project core group, which enables an agile development of the new standard
- Low project management costs
  - No additional project manager / assistant

- Chairmanship changes among the project participants and includes the management of protocols and hosting of the workshops
- Professional advice and support in IFC by AEC3 and IABI

Document Overview

## Processes and tasks in automatic precast fabrication

A complex process including various sub-processes. It follows the AEC design and construction process relatively closely but adds some distinct and essential specifics that allow a high level of automation. The data exchanges, therefore, need to be strictly defined as human intervention is to be kept out of the exchanges.

The workflow of precast fabrication has been divided into the following three phases (see Process map) in which the processes take place:

- Project Description
  Definition of the building project including scope (product types), naming, location and handling of the architectural model.
- Construction & Design
  Includes construction of the precast panels as well as planning of the mounting and delivery process.
- Production
  Automated production of the previously constructed precast parts.

The responsible actors include:

- Project Manager – Responsible for all tasks related to the building project
- Precast planner – Engineer experienced in planning of precast parts
- Mounting planner – Schedules mounting teams for on-site construction
- Delivery planner – Schedules deliveries for on-site construction
- Production planner – Manages daily production schedule & capacity planning
- Production manager – Oversees the production process
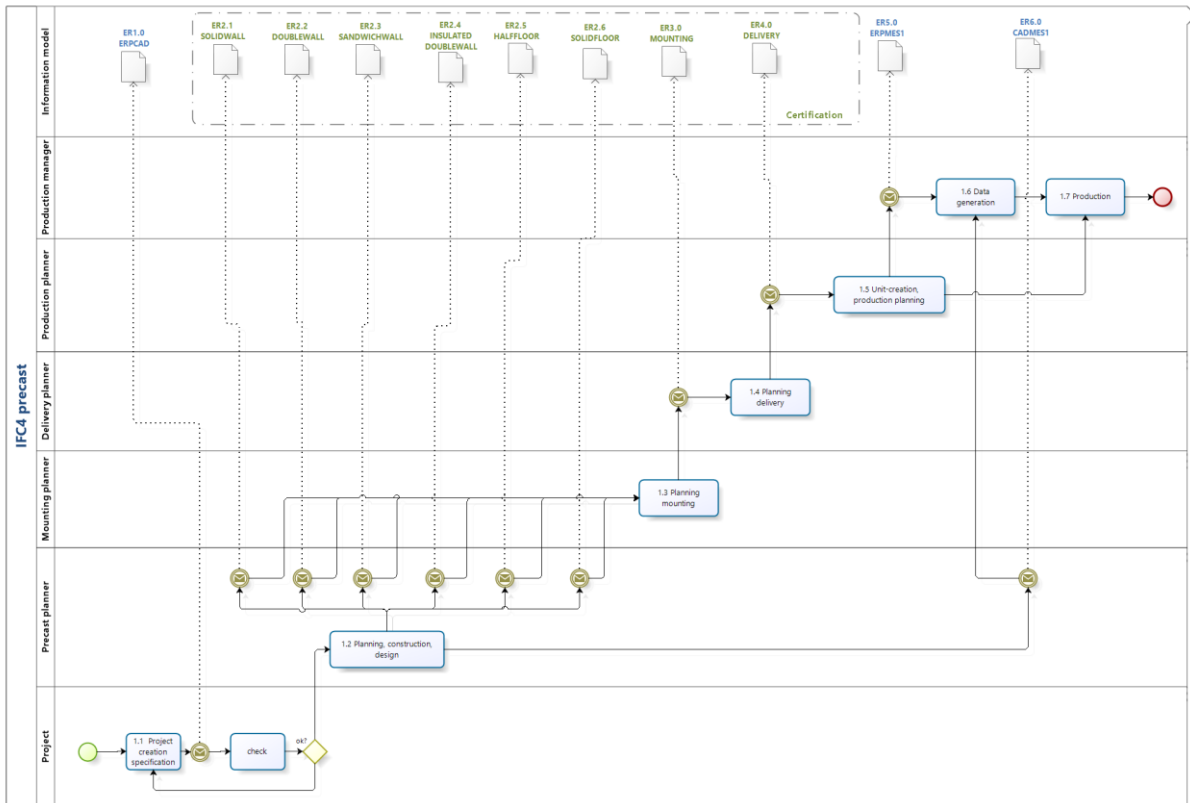
Figure 1: Process map

Exchange requirements

Every process in the main phases and performed by the actors also features a data exchange with a dedicated model that essentially gets enriched with information in every step i.e. information should not get lost. Following, are the descriptions of processes and the corresponding exchange models.

ER1.0 / ERPCAD1

Basic building project information such as project name & address are exchanged between the project manager and the precast planner. The project manager will make sure that all required information & documents such as architectural plans are available to the precast planner. Usually the project is initially created in an ERP or sales system and then transferred to the Precast CAD-system.

ER2 / CADERP1

After the precast planner has finished detailing the precast model (detailed design of individual precast parts) all information regarding quantity, type and schedule for the mounting of the parts on-site will be handed over to a mounting planner. The mounting planner will use this information to schedule the construction on-site together with the construction management. Planning of the mounting process can be assisted by an ERP system but is basically a resource or project planning task.

ER2.1 SOLIDWALL (solid wall)

The solid wall is a reinforced concrete wall element fully prefabricated in the precast plant. It is manufactured in a single production cycle and contains one or more layers of reinforcement as required. A filling with in-situ concrete on the construction site is not necessary.

SOLIDWALL
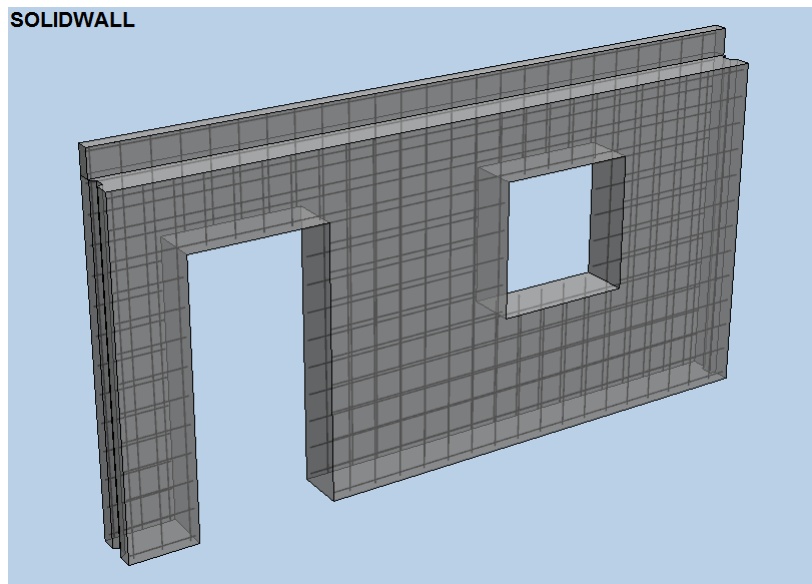
ER2.2 DOUBLEWALL (double wall)

The double wall is a semi-finished reinforced concrete wall system, with longitudinal and transverse reinforcement in both layers and connection by lattice girders. After installation, the double wall is poured with in-situ concrete on the construction site.
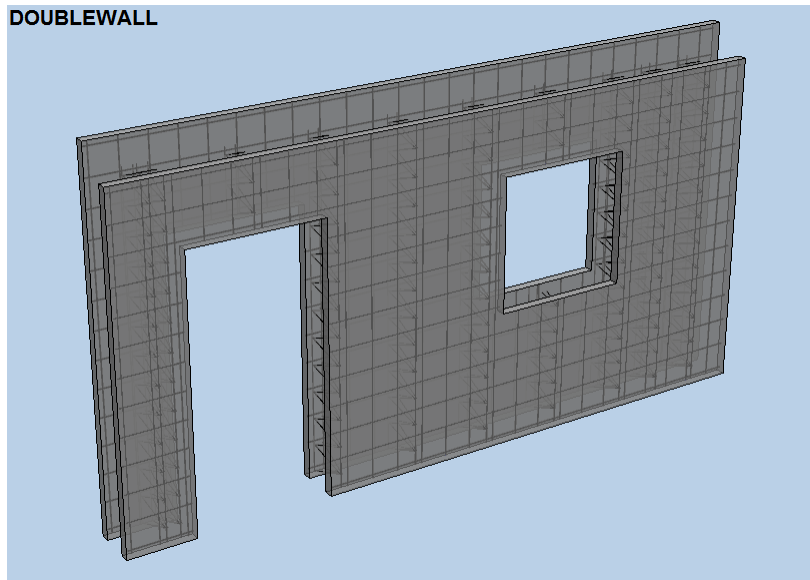
ER2.3 SANDWICHWALL (sandwich wall)

The sandwich wall is an insulated solid wall construction consisting of two reinforced concrete layers with intermediate insulation. The two layers are connected by fastener e.g. thermal anchors.
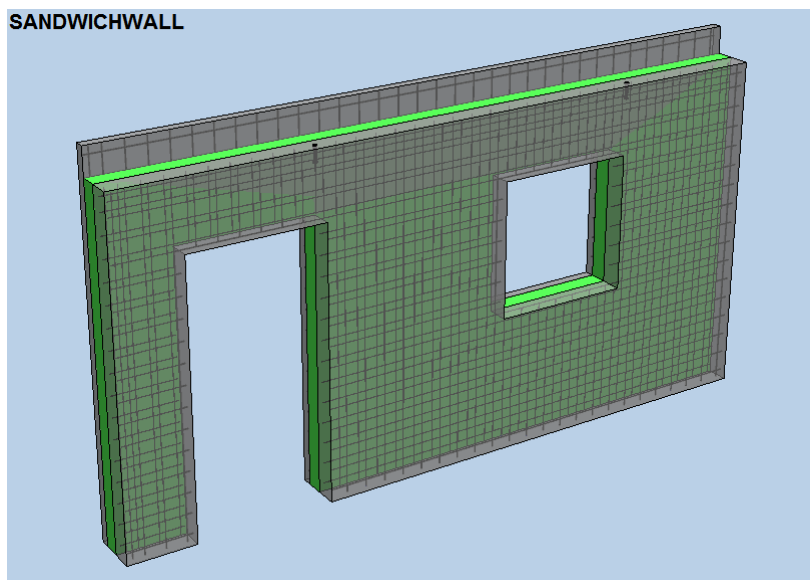
ER2.4 INSULATED_DOUBLEWALL (insulated double wall)

The insulated double wall is a hybrid wall construction consisting of two reinforced concrete layers which are connected by lattice girders or thermal anchors. Between the two layers an insulating layer is installed. At the construction site, the area between the layers is poured with in-situ concrete.
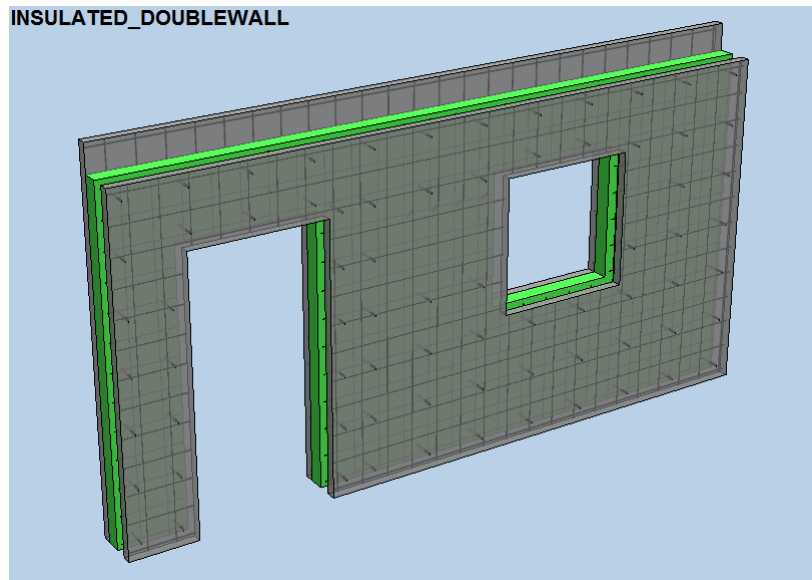
ER2.5 HALFFLOOR (half floor)

The half floor is a semi-finished slab system with lattice girders, longitudinal and transverse reinforcement. It consists of prefabricated large sized reinforced concrete slabs and is filled with in-situ concrete on the construction site.
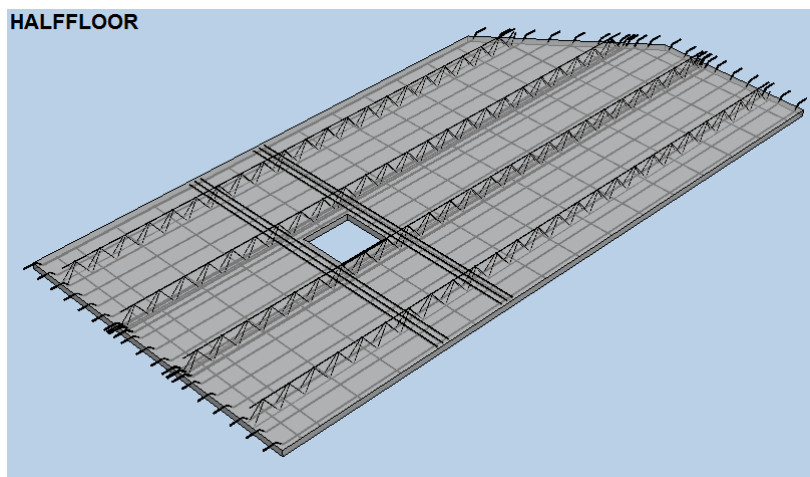
ER2.6 SOLIDFLOOR (solid floor)

The solid floor is a fully prefabricated reinforced concrete slab system with longitudinal and transverse reinforcement. A filling with in-situ concrete on the construction site is not necessary.

SOLIDFLOOR
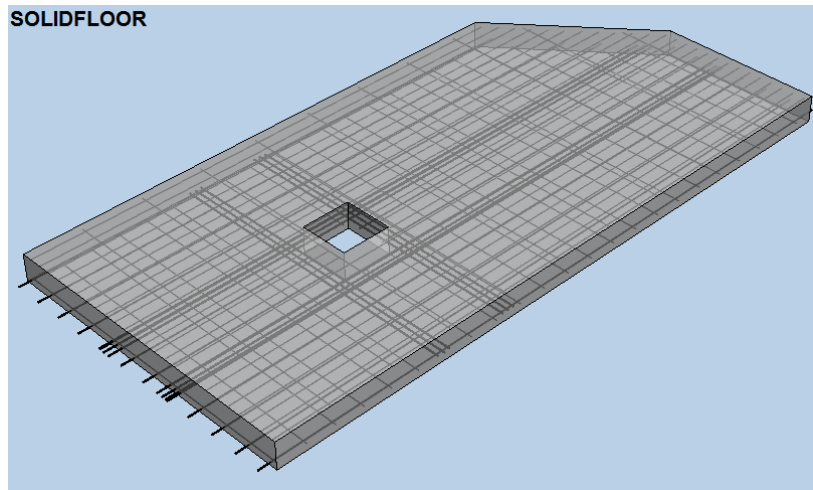
ER3.0 / ERPERP1 Mounting??

As soon as the required delivery dates for certain parts are set, the schedule will be passed on to the delivery planner. The delivery planner can then plan the delivery of products & material to the construction site based on the schedule and requirements of the mounting teams. This task is usually assisted by an ERP and / or logistic software.

ER4.0 / ERPERP2 Delivery??

All information regarding the grouping and delivery of products will be passed on to the production planner. The production planner will choose a production date and production facility based on delivery date and available storage capacity. The production planning takes place in a specialized precast PPS software (often a module integrated into an ERP system).

ER5.0 / ERPMES1

Before production takes place, all information has to be passed to the MES system supervising the production. The production planner will transfer all data including information about the project, order, customer, delivery & production schedule as well as a detailed geometric description of each precast product from the PPS system to one or more MES systems. The MES systems will then take care of transferring the required information to each worker / machine involved in the production process.

ER6.0 / CADMES1

When precast product data needs to be checked for producibility by the precast planner, he will send previews of the precast product data to the MES system for review. This exchange can also be used in cases when no PPS system is available or involved in the process. Information about the production schedule has to be passed to the production manager by other means.

Functional parts

Functional parts are the definitions of elements that will be exchanged and correspond in IFC4precast to the Exchange Requirements ER 2.1 - 2.19.

IFC4precast - main structure

The right diagram shows entities and relations between the objects from precast user's point of view. The left UML-diagram shows the main structure of the object model on which IFC4precast is based.
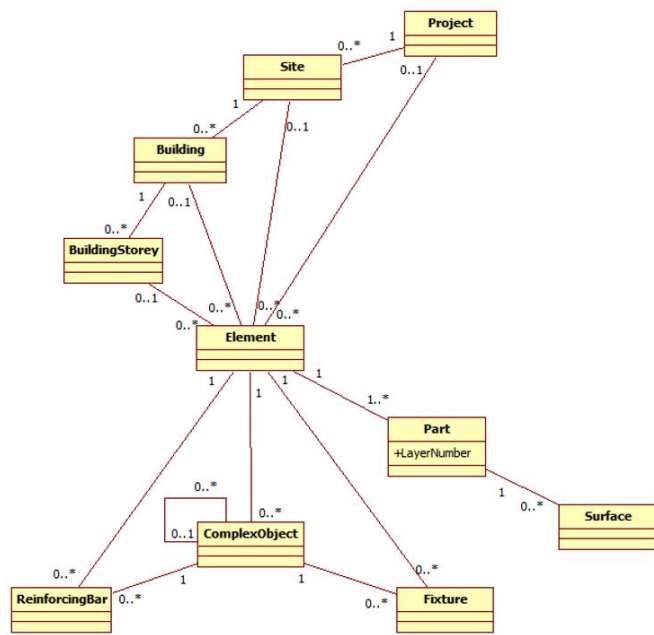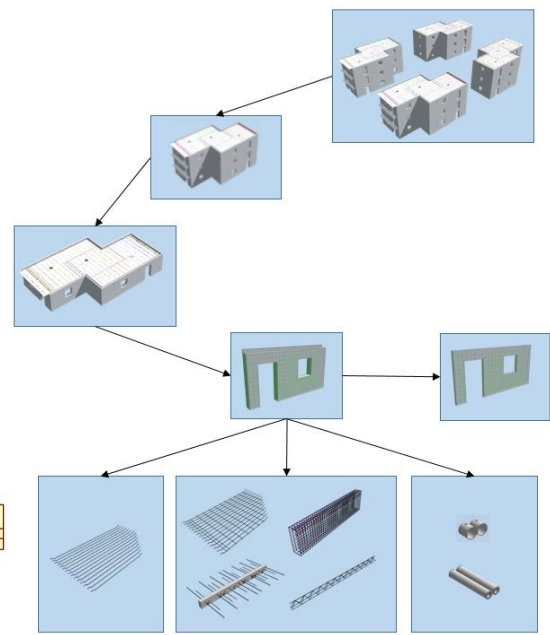
Figure 2: main structure

Precast element types

- SOLIDWALL (solid wall)
- DOUBLEWALL (double wall)
- SANDWICHWALL (sandwich wall)
- INSULATED_DOUBLEWALL (insulated double wall)
- HALFFLOOR (half floor)
- SOLIDFLOOR (solid floor)

IFC4precast – reinforcement

To describe all types of reinforcement needed in precast fabrication only two concepts are sufficient. First, we use the predefined IfcReinforcingBar to fully describe one single reinforcing bar. On the other hand, we have assemblies of single bars – represented by the IfcElementAssembly – to describe more complex, composite reinforcement objects, e.g. a mesh, a cage or a lattice girder. The geometry of such complex objects is given implicitly through the geometry and the placement of the single bars.

Single reinforcing bar types

The type of a single reinforcement bar can be one of the following:

GENERIC (generic)

A generic reinforcing bar which may be straight or bent. It can be a loose individual bar or it may be physically connected (welded) in a mesh or cage assembly.

TOPFLANGE (top flange)

The reinforcing bar in a lattice girder which is located at the top of the girder is called top flange, highlighted in figure GIRDER A).

BOTTOMFLANGE (bottom flange)

A reinforcing bar in a lattice girder which is located at the bottom of the girder is called bottom flange, highlighted in figure GIRDER B). Usually a girder has two reinforcing bars of this specific type.

DIAGONALBAR (diagonal bar)

A reinforcing bar in a lattice girder which connects bottom flange and top flange is called top flange, highlighted in figure GIRDER C).

HANDLINGAID (handling aid)

A reinforcing bar is called a handling aid when it is used to perform tasks like removing the precast element from the pallet or to transport it.
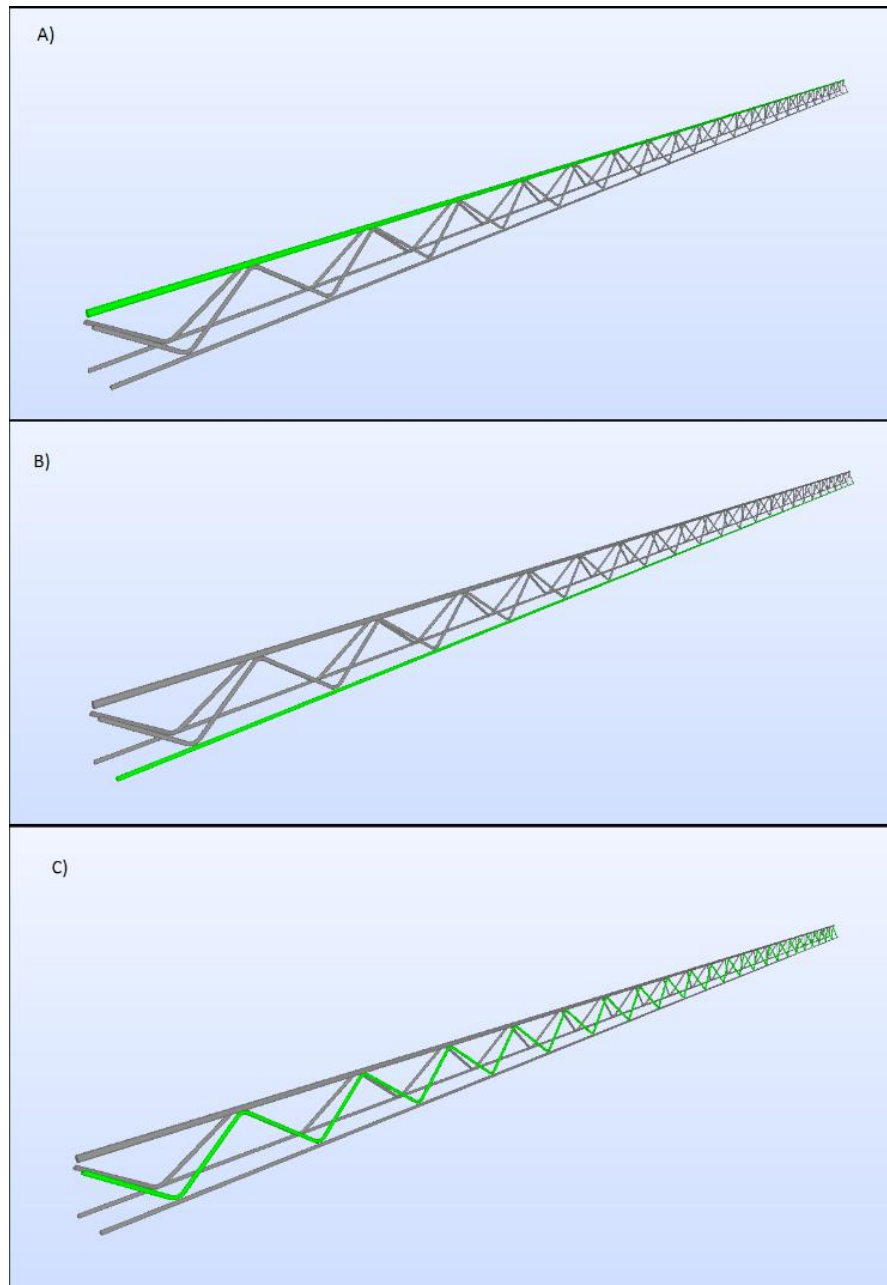

Figure GIRDER

Reinforcement unit types

For the reinforcement units currently only two types are defined.

LATTICEGIRDER (lattice girder)

The lattice girder is an assembly of physically connected reinforcing bars and can used to connect disjoint concrete parts in a precast concrete product. e.g. first and second part of a double wall. See figure GIRDER.

GENERIC (generic)

General reinforcements assemblies, like loose bars, meshes and cages.
It has deliberately been refrained from distinguishing between meshes, cages and loose bars. In fact, the distinction between these types is merely on production side and not a design requirement.

IFC4precast – mounting parts

Mounting parts can be of varying types and are either fully embedded or partly protruding from the precast element. In general, mounting parts do not serve a structural purpose. If they do, the structural properties are usually combined with additional features which regular concrete and reinforcement cannot provide (such as thermal insulation). The geometry of the mounting part largely depends on the type of mounting part.
Following is a list of different mounting part types handled by IFC4precast. The list is expected to extend as mounting parts for precast elements will continue to evolve.

ELECTRICALOUTLET

A hollow object, usually made out of plastic, which is embedded in the precast element and used for electrical installation. Usually placed at the surface so it can be accessed after casting. Must be kept free of concrete. Most of the time the shape is basically a cylinder, but rectangular or other irregular shapes also occur. Is often used in combination with other electrical installation parts such as conduits.

ELECTRICALCONDUIT

A hollow, tube-shaped object, usually made out of plastic, which is fully embedded in the precast element and used for electrical installation. May be bent (not always mounted in a straight line). Is often used in combination with other electrical installation parts such as distributors and outlets.

SANITARYINSTALLATION

A hollow, sturdy object, usually made out of plastic or metal, which is fully embedded in the precast element but may protrude out of the element at certain points. Used for sanitary installation. Comes in various shapes and sizes.

HVAC

Various objects for heating, ventilation and airconditioning purposes, usually made out of metal, which may or may not be embedded in the precast element but will lead to openings in the finished product. Usually not fully mounted during automatic production, but on site. The mounting part can have different shapes but will usually lead to a spherical or rectangular opening in the element.

INSULATION

Extra insulation added into or onto the precast element. May be mounted during production to embed the insulation within the core of the element or onto the finished element after casting and curing for outer insulation. Is usually made up of artificial

materials such as polystyrene foam. Raw material usually has a cuboid shape but can be cut into various polyhedron-like shapes during production.

PARTCONNECTOR

Special objects which are embedded into the element to serve as reinforcement and / or as wall connectors in case of doublewalls. Usually meant as replacement for or addition to common steel reinforcement. Often made up of insulating material as an improvement over regular steel reinforcement which may create a thermal bridge through insulating layers. Can also be used in cases where corrosion is a major issue. Come in various shapes and sizes and usually made from plastic, fibre-glass or high-grade steel. Different from regular steel reinforcement because usually not produced at the precast factory (external supplier), therefore weaker requirements on the exact geometry of the part.

STRUCTURALTHERMALBREAK

Special type of insulation with added reinforcement bars which are an integral part of the mounting part. Serves as reinforcement but also as insulation. Usually placed at the border of an element with reinforcing bars protruding out of the element (typically used for balconies). The insulating part usually has cuboid shape while the reinforcing bars have a cylindric shape and are usually not bent.
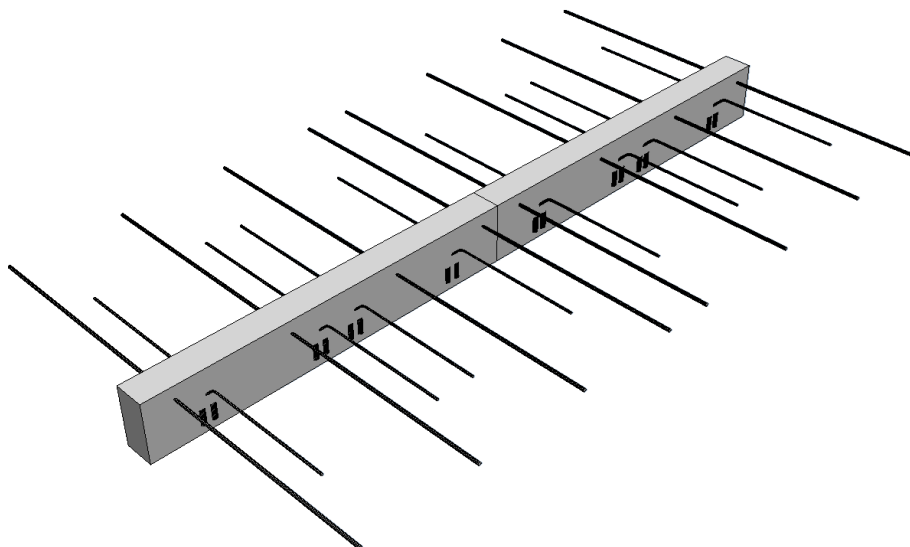
HANDLINGAID

Parts which are embedded into the precast concrete element to allow for easier handling and transport in the factory or on site. Usually mounted at the side or top of an element to allow for crane attachment. Can have various shapes and sizes (hooks, eyes, etc.). Sometimes also done by welding bent bars to the main reinforcement, therefore being part of the reinforcement and not a distinct mounting part. Can be made up of more parts some of which are added after casting and curing.

CONNECTOR

Parts which are embedded into the precast concrete element to connect the element to other precast elements or parts of the building. Similar to handling aids but used for connection rather than transport. Usually mounted near the surface of the

element. Can have various shapes and sizes. Depending on the usage, other parts of all kind may be welded or screwed onto the connecting parts on site.
Can be made up of more parts most of which are added after casting and curing or on site.

CLADDING

Various cladding or facade parts which are not strictly part of the structural precast concrete element and usually added on site after finishing structural works on the building. In some cases, these parts can already be added during production (floor or wall tiles for example).

DOOR

Doors or at least their frames may be added to the precast concrete element during production. Usually mounted manually with no strict requirements on detailed geometry.

WINDOW

Windows or at least their frames may be added to the precast concrete element during production. Usually mounted manually with no strict requirements on detailed geometry.

IFC4precast – PRADAP

The **P**recast **A**rticle **D**ata **A**ccess **P**rotocol (PRADAP) is a communication protocol for the exchange of mount part data in the precast industry. Such data is required in CAD-Systems, ERP-Systems as well as in the production and therefore there is the need of synchronized data. For a best possible, fully automatic precast production process, the synchronization of mount part articles is of great importance.

The main idea of the concept is that the article data is not in a single central database, but may be distributed over the systems involved in the precast production process. In fact, every single system is interested in different details of the article data, e.g. for the production the geometry of the article is of fundamental importance whereas the ERP-System is rather interested in its basic price. Due to a uniform reference-ID each component knows where to query the required detailed information. One main advantage is its flexibility; it can be decomposed by company internal components (ERP and MES) or even by external components (CAD-System or article supplier).

Exchange Models

As stated in the previous section, information exchanges in the precast fabrication process enrich information in every step. There are certain reviews taking place where information and the model get checked for compliancy, especially exchanging between Production planner and Production manager. This is the most complicated

exchange and has very strict requirements on geometry, project and element structure as well as semantic data.

Concepts

Along with model and exchange definitions, information has been grouped into specific concepts that allow a unit of information to be assigned to a functional part. The units of information that we can distinguish between are the following:

1. Identification
2. Geometry
3. Placement
4. Material
5. Type information
6. Decompositon (in case the object is complex)
7. General semantic information (Properties)

In the following paragraphs the concepts will be explained in detail.

Identification

The purpose of this definition is to provide the corresponding functional part with a human readable identification i.e. name and description of the particular object instance. This way, any object in a project can be distinguished from an object of the same type by manual inspection.

Geometry

Due to specific geometric information requirements for automatic fabrication of precast elements different types of elements have to be delivered with that in mind. For example, the bending machines for reinforcement bars require the geometry to be delivered as a series of linear segments and bending radii as well as a diameter of the bar. On the other hand, a part of a precast element is best described with a boundary representation which enables volume calculations and clash detection to be performed.

Placement

The main requirement for placing various elements in precast structures is that these are relative to their parent element. This means that an electric outlet placement is relative to the parent precast element part in which it is installed. Consequently, the outlet will move with its parent.

Material

The decomposition of precast elements requires a single material to be assigned to parts.

Type information

For the purpose of model queries as well as general organization of elements the types described in chapter Functional parts have to be reflected in an IFC4precast model file. Certain rules have to be followed, for instance a precast element is composed of parts, a part can have mounting parts etc. These rules are defined in the object definitions and shall be covered in the Type concept.

Decomposition

This concept is dependent on the Type information concept. In case the defined type of an object allows decomposition, the particular structure shall be defined here.

Properties

Any semantic information required and delivered by the precast domain shall be defined and organized in the form of properties grouped in property sets. Property sets can be assigned only to the corresponding types and cannot be used on other types of elements.