ATC-81

Development Of IFCs
For Structural Concrete

STRATEGIC PLAN

INITIAL RELEASE
Version 1.0
October 22, 2010

MADE POSSIBLE BY THE GENEROUS SUPPORT OF:

Charles Pankow
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in conjunction with

The ACI Foundation
and its Strategic Development Council

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DEVELOPMENT OF IFCs FOR STRUCTURAL CONCRETE STRATEGIC PLAN

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PREPARED FOR THE ACI FOUNDATION'S
STRATEGIC DEVELOPMENT COUNCIL BY

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PREFACE

The ACI Foundation is a subsidiary of the American Concrete Institute (ACI). It receives, administers and expends funds for educational, research and scientific purposes. The Strategic Development Council (SDC), a council of the ACI Foundation, serves to bring together the concrete industry, government and academia to focus on collaborative problem-solving in technology development. ATC-81 is one of the many ways that the SDC manifests its mission, bringing together these groups to improve the ability of software users across all professions and disciplines to effectively use Building Information Management (BIM) software tools to represent structural concrete construction.

In 2009, the ACI Foundation proposed to develop this Strategic Plan for the development of Industry Foundation Classes (IFCs) for cast-in-place (CIP), structural concrete components. The Foundation identified inconsistencies in the treatment of structural concrete components in BIM software. Because BIM software is on its way to broad adoption as the standard of care in the design and building industries, it is imperative that the concrete industry ensure that it is an effective tool for concrete design and construction. The task set forth was to specify the areas in greatest need of advancement, and to present strategies for such advancement.

Many specialized software platforms are needed to complete a project, and currently a great deal of time and money is spent duplicating design and documentation work that instead could be transferred automatically between professionals, once the software platforms can be made to effectively communicate. Many methods exist to transfer data between platforms, with varying levels of success, but IFCs have risen to become the most widely accepted method for communicating between software platforms. IFCs are neutral, non-proprietary exchange files, holding all types of building information data in a standardized format that software developers can treat uniformly. The development of better IFC representation of various aspects of structural concrete construction is the key to improving the way that professionals in the concrete construction field work with BIM technology.

The IFC protocol is extremely versatile and expandable; however, consistency in application is paramount. Consensus of users is required so that software developers can program their tools to properly interpret data from a wide variety of applications. The ACI Foundation and those who champion the goals and strategies this project recommends will bring together practitioners to determine standards of practice (such as naming conventions, measurement conventions, and the like). Dissemination of these standards will allow software providers to bridge the frustrating gaps that hinder the communication between software platforms, which would eventually allow users to hand off data seamlessly, without the costly efforts of re-working or tedious piece-by-piece examination and verification.

Because of the possibility of profound impact on the way practitioners work and use technology, the Charles Pankow Foundation emerged as a sponsor of this project. The Charles Pankow Foundation was established to provide the public with buildings of improved quality, efficiency and value by advancing innovation in building design and construction. It funds research, development and dissemination of new products and solutions that help the U.S. building construction industry be more efficient and more

cost competitive. Similarly, the Ready Mixed Concrete (RMC) Research and Education Foundation found a resonance with their mission and co-funded the project with the Charles Pankow Foundation. The RMC Research and Education Foundation focuses on the advancement of technology, safety and training in the concrete industry.

The Applied Technology Council (ATC) is uniquely suited to facilitate this project, following its mission of developing and promoting state-of-the-art, user-friendly engineering resources and applications. Members of the Project Advisory Panel come from backgrounds as diverse as government agencies, universities, industry publishing houses and private firms. The Project Management Committee includes engineers, architects, construction managers and software developers. Many of these participants are working together on a similar ATC project (ATC-75) and have established an efficient and robust method for moving from concept to implementation.

INTRODUCTION

Currently, those who work in the design and construction field and deal with reinforced concrete designs encounter some degree of difficulty using BIM tools for this complex construction type. A great deal of work has been done advancing BIM in many areas of the building industry, structural steel construction being one example. At this juncture the concrete industry can make significant steps forward in their impact on BIM software, building on the work of other industry areas, including the progress made internationally across many types of construction.

ATC-81 is an effort to develop workable initiatives to increase the ease and efficiency of using BIM for structural concrete design and construction through enhanced interoperability or the ability to readily and reliably exchange data between disparate software programs. The Charles Pankow Foundation and the Ready Mixed Concrete Research and Education Foundation have joined forces to fund this important work through the American Concrete Institute's ACI Foundation and its SDC. The work of the project was divided into three tasks:

TASKS

▶ *Task 1 - Strategic Planning Research*

The Strategic Planning Research was carried out in the spring of 2010, building on the information gathered by the SDC in their 2009 survey of members' attitudes toward and usage of BIM software and methodology and the 2007 Domain Survey compiled by the Reinforced Concrete BIM Consortium in conjunction with Tekla. The 2010 work consisted of a series of practitioner group interviews in which the interviewer sought to gather participants' perspectives on and experience with BIM software. A diverse group of professionals participated, representing the engineering, construction, fabricating, detailing, software and academic arenas.

▶ *Task 2 - Strategic Planning Session*

The Strategic Planning Session was held in May 2010 in conjunction with SDC Session #27. See the Strategic Planning Session Report for details on the proceedings.

▶ *Task 3 - Strategic Plan Report*

The Strategic Plan Report is meant to capture the state of the industry and provide recommendations for initiatives that will bring meaningful and wide-ranging improvement to practitioners' use of BIM software for reinforced concrete design, construction and facilities management.

The Strategic Plan is the culmination of efforts by participants in the ATC-81 project to identify and prioritize initiatives and determine the best candidates for carrying out the work suggested. It is the intent of this document to challenge the concrete industry and the profession to develop the means to leverage BIM technology through the use of IFCs[1] to gain interoperability in the exchange of parametric modeling data. This document will be a living document, open to the addition of new initiatives, and embodying the completed and continuing work on these and possibly future initiatives set out after its first release.

1 Industry Foundation Class(es) (IFC) define the virtual representations of objects used in BIM models to establish their attributes, their relationships and inheritances.

OVERVIEW

This strategic plan was developed to guide the cast-in-place concrete industry on the priorities for development of BIM interoperability as a means to carry the industry forward with technology that will increase quality, productivity and reduce the cost of construction. The plan presents a development guide to illustrate to the industry the basic steps to develop and prepare a National BIM exchange standard, a set of industry exchange goals and strategies accompanied by a timeline and relative cost index for development of these exchange goals. In other words, this plan lays out for the industry what needs to be done, how to approach it and when it needs to be completed in order to foster CIP concrete BIM interoperability.

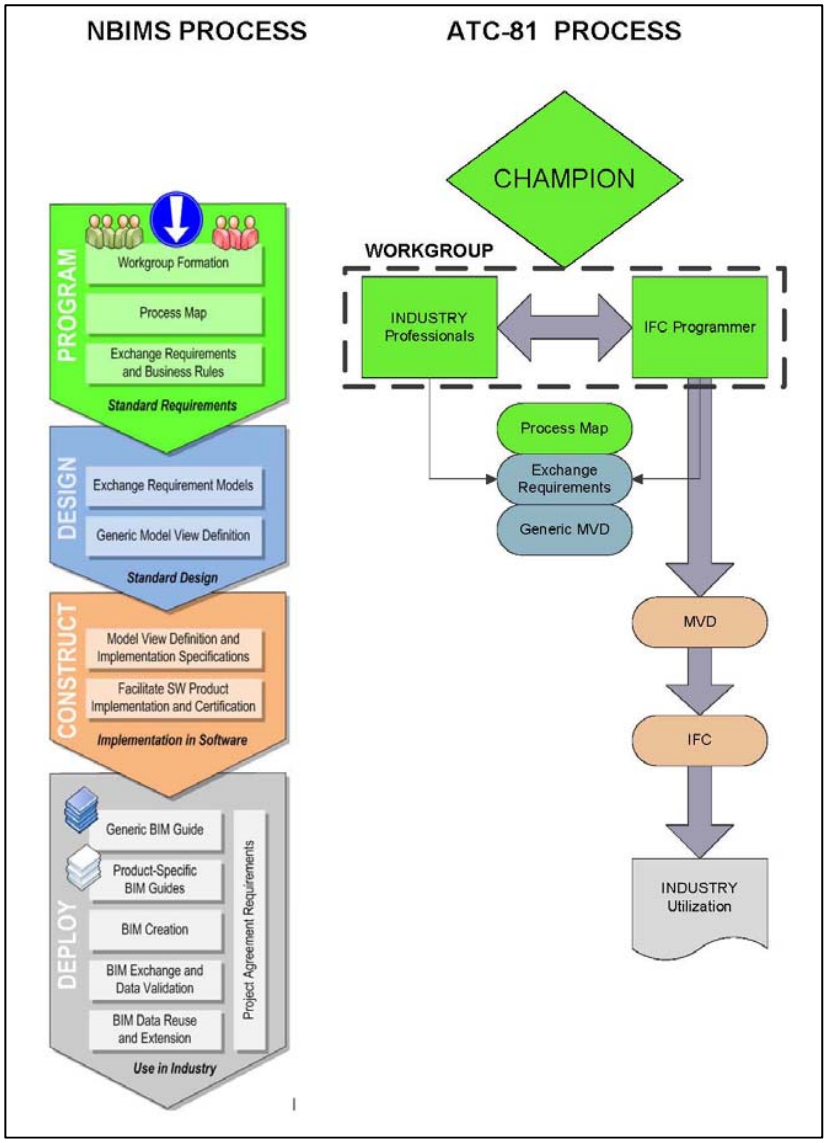
The goals in this release were developed by a consensus of industry leaders during the ATC-81 Strategic Planning Session in May, 2010. Professionals from the Project Management Committee, the Project Advisory Panel and session participants were gathered to discuss the research to date and their ideas of the most productive and universally relevant steps in the endeavor to fully embrace BIM and Virtual Design & Construction. The participants divided into focus groups centered around the themes of design/detailing, detailing/manufacturing/fabrication and construction. These groups discussed what data they work with internally, and what information they "pull" from others and "push" to others. The group as a whole determined that the information that is exchanged between stakeholders should be the primary focus, so the "push" and "pull" data became the first tier of priorities. The focus groups developed lists of goals for improving the data exchanges discussed and identified the proper parties to pursue each goal. The section of this document discussing the goals and strategies is meant to be a guideline. Each goal is listed with a title, an identified champion, a guideline definition or scope, and estimates of the time and cost investment involved. The planning group has suggested the goal, but the champion was selected as the expert agency judged to be the best group to carry the initiative forward and should be free to evolve the goal as appropriate.

The goals are achieved through development of an exchange standard. The development of an exchange standard is a process defined in the National BIM Standard™ (NBIMS). The plan provides an overview of the NBIMS process. The working groups that will be preparing the exchange standard would work within the criteria of the latest NBIMS processes to develop the exchange standard.

The NBIMS process defines the means by which the goals laid out for achieving a critical level of BIM interoperability can be achieved. This plan represents an ongoing process that industry needs to embrace and continue to carry forward. Through its successful implementation a greater and growing level of interoperability will be achieved, resulting in increased efficiency, quality and sustainability across all participants in the concrete construction industry.

DEVELOPMENT GUIDE

The National BIM Standard™[2] is published by the Building Smart Alliance (bSa) a council of the National Institute of Building Standards (NIBS). As the title indicates, NBIMS establishes the standard definitions for BIM exchanges. The detailed requirements for the exchanges are contained in NBIMS; this discussion on the development guide is not intended to replicate the level of detail in the NBIMS, but to highlight the basic requirements to give those using this strategic plan a general understand of what's involved in developing an exchange standard. An additional valuable resource is the *"BIM Project Execution Planning Guide,"* Version 2.0, released July 2010[3]. The Guide was authored by a team of individuals within the Computer Integrated Construction (CIC) Research Program at Penn State as a product of the BIM Project Execution Planning buildingSMART™ alliance (bSa) Project.



2 United States, National Building Information Modeling Standard, Version 1 (12/2007). Version 2 is scheduled to be released in July 2011.
3 www.enger,psu.edu/bim

The implementation of the strategic goals is accomplished through the concerted effort of the leadership of the champion agency, the support of industry professionals and the technical support of a consultant experienced in the IFC process. These individuals form what it called the "workgroup". The workgroup is comprised of a small group of individuals (5 to 15), including the IFC consultant, who are responsible for establishing the scope and context of the exchange standard as defined in the Information Delivery Manual[3] (IDM). The IDM is used to define the goal and the specific attributes involved in the data exchange to enable interoperability through IFCs. The development of IFCs is defined by the process outlined in Section 5 the NBIM Standard phases of development and implementation. This section of the NBIMS lays out the requirements for implementing any BIM exchange standard. The basic processes are (see illustration in Figure 1):

- Programming
- Design
- Construction
- Deployment

Programming Phase

The first step is the programming phase. In this phase the Champion will need to organize the workgroup that will be working to fulfill the exchange goal. Programming will initiate with a review of the goal and the suggested attributes associated with the goal and the development of the business processes involved. The spreadsheet discussed in the following section and provided in the Appendices lists suggested attributes, and it is expected that the group performing the work will edit and expand as necessary. Once the attributes to be developed are agreed upon, the workgroup would move to the spreadsheets to develop and capture the attribute data in the Design Phase.

It should be emphasized that the programming phase is critical to developing a successful exchange standard. It is at this phase that the scope of the exchange attributes is defined, such as:

- What kind of geometry will be exchanged
- What kinds of ancillary features will be addressed
- Defining the level of specificity for reinforcing
- What level of embeds are required
- What level of concrete finishes need be defined

This list only highlights a few of the attributes that need be considered. These attributes need to be mapped to the different exchanges, so it is known "what" and "when" are they exchanged.

[3] Information Delivery Manual is the exchange definition written in non-technical prose for use by end-users. Describes the business process, stakeholders, exchange points, information requirements and business rules.

▶ Design Phase

"Design" refers to organizing the exchange information in a format that takes into account the existing concepts as well as those new to a particular exchange requirement. The format is presented in a manner that allows it to bridge the exchange dialogue between the language of the industry members of the working group and that of the software programmers. The developed exchange requirements are then utilized in the development of the products of the Construction Phase. The resources developed in this phase should be coordinated with and delivered to the IFC Solutions Factory permitting a broad international coordination and dissemination with other interested parties.

▶ Construction Phase

The "Construction" phase is a reference to constructing or linking the generic information exchange requirements of the design phase, with the specific elements that exist or need to be developed in the standard IFC schema or the specific programming language structure. The 'constructed' schema is formatted into Model View Definitions (MVDs)[4] that permit the object data exchanges to occur through IFC files. The construction phase will also address help with test models for implementation: both drawing models to implement, then export, and P-21 or XML files to import.

▶ Deployment Phase

Deployment begins once the technical work of generating the MVDs and binding them to the IFCs is completed. They are then are ready to be implemented into a variety of software applications to support the interchange of BIM object data. The overarching goal of interoperability is finally achieved through implementation and validation of the exchange protocols. Deployment will also need to consider the technical validation and testing of the functioning IFC exchanges to ascertain that they are working as the program users intended.

DETAILED DEVELOPMENT CONSIDERATIONS

The overarching purpose of these efforts is to develop software-friendly data structures, which will allow BIM software programmers and BIM users (practitioners) to better accommodate reinforced concrete construction data and practices. The ATC-75 project developed IFCs for the structural domain using the NBIMS exchange protocols and can serve as a ready reference to how this process can apply here to the CIP concrete effort. The ATC-75 project was a broad effort to begin to shape data exchanges for the collective assets that are a part of the structural domain, including concrete construction, and is therefore a useful reference for this effort.

How does the process begin and what activities need to occur to achieve the development of an exchange standard? The process begins with the establishment of the workgroup, its Chair and the formulation of the IDM. Within the IDM the workgroup will need to define the user requirements and business processes involved and the exchange requirements involved. These two fundamental tasks are discussed in the following section.

4 Model View Definition is the technical exchange definition for use by software developers.

▶ Program Phase: Business Process Maps

The business process maps are used to illustrate the exchange points and the general information that would be handed off at those points. It is organized into rows and columns, with the rows representative of the actors or disciplines involved and the columns (sometimes referred to as "swim lanes") representing the exchange points or project phases[5]. The "High Level" business process diagram[6] developed for ATC-75 is shown in Figure 2:

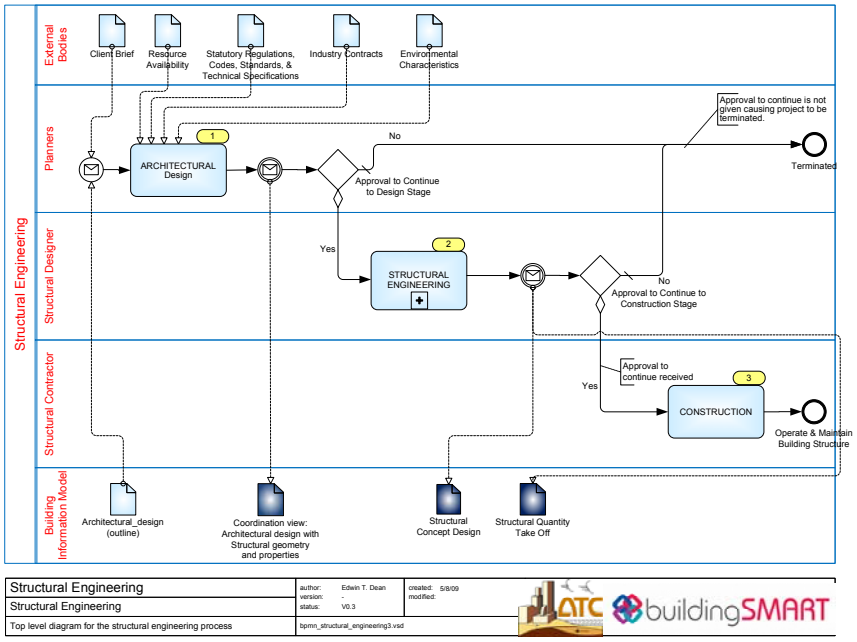


Figure 2: High Level Business Process Diagram

▶ Programming and Design Phase: Exchange Requirement Matrices

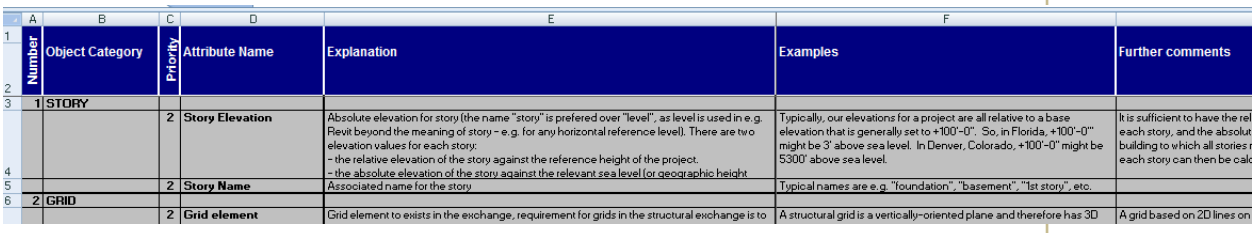
The ATC-75 project developed matrices[7] (spreadsheets) that provided a bridge of exchange attributes between practitioners and software programmers, illustrating the fundamental data types involved in the exchanges. The matrix is structured to keep the practitioners thinking in discrete engineering terms, as well as provide the foundation for software programmers to translate the practitioners' data groups into the programming language necessary for software implementation. For each goal, an attributes spreadsheet (see Appendices) has been started to seed the discussion; again, the working group is challenged to tailor and expand the attributes listed as they see fit. The working group will also be responsible for defining the process maps[8] that illustrate the business use cases for the exchanges.

In order to guide discussion and output toward an end product that will be easy to integrate to software, each working group will need to retain a software programmer or consultant familiar with IFCs to work with the templates provided and establish the IFC binding to correspond with the exchange requirements.

5 The phasing is defined in Omniclass, Table 31 (www.omniclass.org)
6 Note this diagram did not illustrate swim lanes as it is representative of a high-level, overall system diagram.
7 Information Delivery Manual (IDM), Exchange Requirements (ERs) and IFC Binding

The ATC-75 project developed a system of very general process maps illustrating the exchange points and a system of matrices or spreadsheets[9] used to format the exchange requirements. There are two spreadsheets provided for the working group's use. The first, *"Exchange Requirements"*, is a document that acts as a conversation between the practitioners and the software programmer, guiding the development of the attribute data in ways that are clear and useful for software implementation.

On the "Exchange Requirements" spreadsheet, the definition of the attribute is succinctly stated in plain language. Examples of the kind of data the attribute would encompass and any further notes for clarification are included on this page. This is the starting point, and the programmer involved in each effort will be able to ask for further information or clarification to make the intent clear enough for programming uses. The majority of the working group's effort should be focused on identifying attributes to be discussed, reaching agreement on a strict yet widely applicable definition of the attributes, and providing examples and notes to make the intent for each attribute clear.



	A	B	C	D	E	F	
1	Number	Object Category	Priority	Attribute Name	Explanation	Examples	Further comments
3	1	STORY					
4			2	Story Elevation	Absolute elevation for story (the name "story" is prefered over "level", as level is used in e.g. Revit beyond the meaning of story – e.g. for any horizontal reference level). There are two elevation values for each story. – the relative elevation of the story against the reference height of the project. – the absolute elevation of the story against the relevant sea level (or geographic height	Typically, our elevations for a project are all relative to a base elevation that is generally set to +100'-0". So, in Florida, +100'-0" might be 3' above sea level. In Denver, Colorado, +100'-0" might be 5300' above sea level.	It is sufficient to have the rel each story, and the absolut building to which all stories r each story can then be calc
5			2	Story Name	Associated name for the story	Typical names are e.g. "foundation", "basement", "1st story", etc.	
6	2	GRID					
			2	Grid element	Grid element to exists in the exchange, requirement for grids in the structural exchange is to	A structural grid is a vertically-oriented plane and therefore has 3D	A grid based on 2D lines on

Figure 3 Exchange Requirements Matrix

Rows:

- There is one row for each attribute
- Rows are grouped by the Object Category

Columns *(as formatted in Appendices B through F):*

A. Number – Numeric identifier

B. Object Category – overarching group of attributes, such as "column"

C. Priority – consensus by the working group, order of urgency of implementation

D. Attribute Name

E. Explanation – practitioners' language, succinct description of the attribute

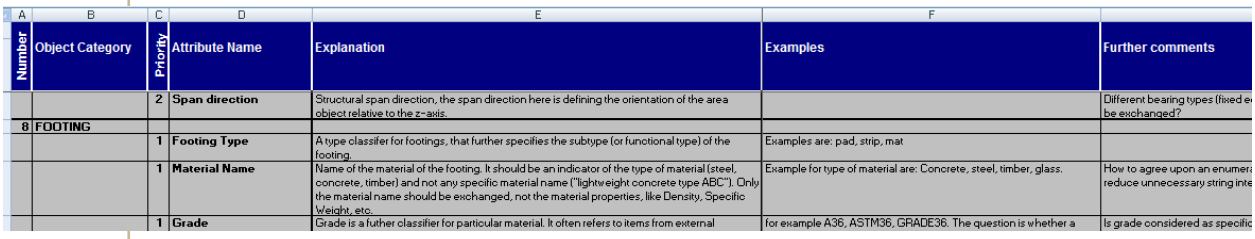
F. Examples – illustrative verbal or graphic examples of the attribute.

G. Further Comments – a place for any general remarks or additional illuminating statements. (In the provided spreadsheet, this column, called Open Questions, is a place for the software programmer to exchange questions and answers about each attribute with the practitioners group)

8 NBIMS has adopted the Business Process Modeling Notation (BPMN) published at www.bpmn.org as their process representation tool.

9 The spreadsheets are set up in an Excel workbook, formatted on individual worksheets.

The second work sheet is the "IFC2x3[10] Binding". This spreadsheet is a finished document that contains the data in a format that can be provided to software vendors for their use in implementing the IFCs as developed. It identifies how the attribute data is related to existing IFC data categories; if further development in IFC is required to adequately capture the data that is identified here. It should not be assumed that the current IFC lacks the necessary data sets; instead, every effort should be made to identify ways to use existing data sets to satisfy needs, where at all possible.



A	B	C	D	E	F	
Number	Object Category	Priority	Attribute Name	Explanation	Examples	Further comments
		2	**Span direction**	Structural span direction, the span direction here is defining the orientation of the area object relative to the z-axis.		Different bearing types (fixed e be exchanged?
8	**FOOTING**					
		1	**Footing Type**	A type classifer for footings, that further specifies the subtype (or functional type) of the footing.	Examples are: pad, strip, mat	
		1	**Material Name**	Name of the material of the footing. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass.	How to agree upon an enumer reduce unnecessary string inte
		1	**Grade**	Grade is a futher classifier for particular material. It often refers to items from external	for example A36, ASTM36, GRADE36. The question is whether a	Is grade considered as specific

The work represented in this tab should be a collaboration between the software programmer and the practitioner group. In the binding spreadsheet, the first four columns ('A' through 'D') are the same as those populated by the practitioners in the Exchange Requirements, and these form the link between the two formats.

Figure 4 IFC Binding Matrix

Remaining columns are populated by the programmer, and are drawn from the Exchange Requirements Spreadsheet as follows:

Columns *(as formatted in Appendices B through F):*

H. IFC Representation of the Exchange – how the exchange is (or is not) currently captured in IFC

I. Status of IFC implementation, model view definition, certification process – assessment of whether current IFC capabilities with respect to the attribute are enforced in compliance certification

J. MVD name – the Model View Definition that relates to the attribute. The MVDs will be loaded on to the international registry housed at the IFC Solutions Factory. The ATC-75 MVDs can be located there at ATC-001 (http://www.blis-project.org/IAI-MVD/).

K. Recommendations for ATC-75 implementation – this category would be altered to reflect the name of the current project and goal (i.e., ATC-81 Geometry implementation) and discuss recommendations in accordance with project goals; this may entail different treatment of current IFC information or further development of IFC

L. Recommendation for further IFC development – in the case that IFC does not address the attribute, recommended further development is captured here

10 IFC2x3 was released in 2/2006 and was the "current" IFC version at the time of the ATC-75 project. IFC2x3 is still the current version; however, IFC2x4 is a release candidate (RC1) in 5/2010.

The full workbook has been provided as Appendix B, which represents the matured work of the earlier ATC-75 project and shows an example of how this work process is to be utilized. In that workbook, the "IFC Implementation" tab is a reporting tool for the software vendors involved to document their implementation of each of the attributes discussed. The "Figs" tabs hold examples of the intended data to be captured in each attribute, meant as reference for the programmers and possibly to be provided to practitioners.

The Appendices provided with this plan contain a "starter" working document, populated with suggested attributes. The software programmer involved with each Goal should create the additional tabs contained in the example workbook, suited to the attributes the working group chooses to address, in order to mature the work to the level required for making any changes to the IFC format.

Coordination/Integration

Coordination with NBIMS and coordination and integration amongst the various project workgroups that are undertaken to meet the goals will be a critical activity. For these projects SDC will serve as the coordinating entity and will designate a representative. Projects will need to include in their program physical meetings and updates, at least biannually, along with more regular electronic and teleconference interchanges. The workgroup chairs will be responsible for providing the updates to the SDC designated representative for coordination with NBIMS and any other SDC project workgroups. NBIMS maintains a "Project" web site where projects can be registered and coordinated with other potentially related efforts and it may be beneficial for SDC to establish a similar means to coordinate and monitor projects and products.

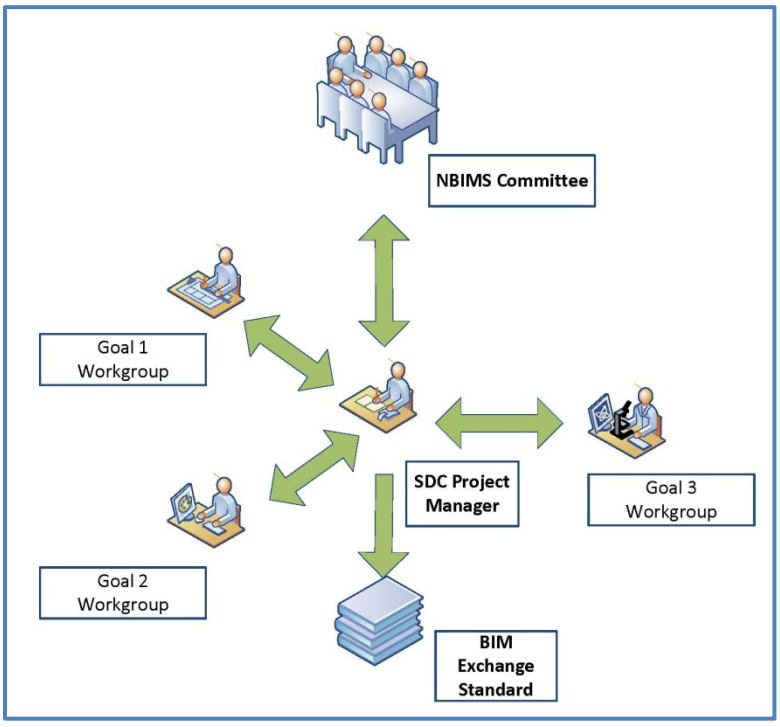


Figure 5: Coordination View

STRATEGIC PLAN

The strategic planning session was held to bring together a broad group of industry representatives from design, detailing, fabrication, manufacturing and construction. The focus of the planning was to identify critical interoperability objectives and formulate a strategy to increase the access to the tremendous productivity and quality benefits that can be harnessed for industry. This Strategic Plan was developed from the work of this session. The mission of the planning session was to develop a comprehensive report that describes current state of the industry, attribute exchange priorities, and a strategy for implementing effective IFC exchanges.

The key outcome was the selection and detailed development of each goal. Four aspects of each goal were identified, as well as key contacts for seeking champions. The goals were discussed in the context of developing standards of describing and capturing information about particular areas of information in reinforced concrete construction. Potential champions were identified for each goal. The champion would take on the work of developing the strategies for describing and working with the information that falls into the category.

GOALS

The goals in this section are those that were deemed through consensus of the participants at the strategic planning session to be of highest priority to the practitioners. Those goals that were discussed, but considered a lower or longer-range priority are discussed in the Other Goals section. The attribute worksheets for each goal are available in the appendix.

Table 1: Strategic Planning Goals

GOAL		CHAMPION
1.	Geometry	American Concrete Institute (ACI) ▶ AC 131 Committee
2.	Reinforcement	Concrete Reinforcing Steel Institute (CRSI) ▶ CRSI EPC, BIM Task Force ▶ Post-Tensioning Institute (PTI)
3.	Concrete Materials	National Ready Mix Concrete Association (NRMCA)
4.	Project Management	American Society of Concrete Contractors (ASCC)
5.	Formwork	American Concrete institute (ACI) ▶ AC 131/347 Committees

The time it takes to fulfill the successful completion of each of these goals will be dependent on many factors, chief among them are the availability and commitment of industry subject matter experts, IFC consultants and funding levels to support development. In broad strokes it is estimated that each of these goals will take between 36 to 54 months to execute. These general time frames assume only a very limited funding level to support a largely-volunteer process. These durations could be substantially shortened, possibly in half, if funding is available to drive a faster-paced and more directed process, which would be the desired means of executing the strategic plan. It is the strong opinion of those involved in the planning that these tools are needed by this industry now and the long duration of a largely voluntary process is not acceptable. The PMC feels it is crucial that the Champions be diligent in pursuing funding to provide the means for accomplishing these goals in the short run. There is also a level of interdependency between these goals. Completing the Geometry and Reinforcement IFCs will be necessary to establish elements for the Quantity and Formwork goals, for example. The potential schedule time line is illustrated in Figure 6.

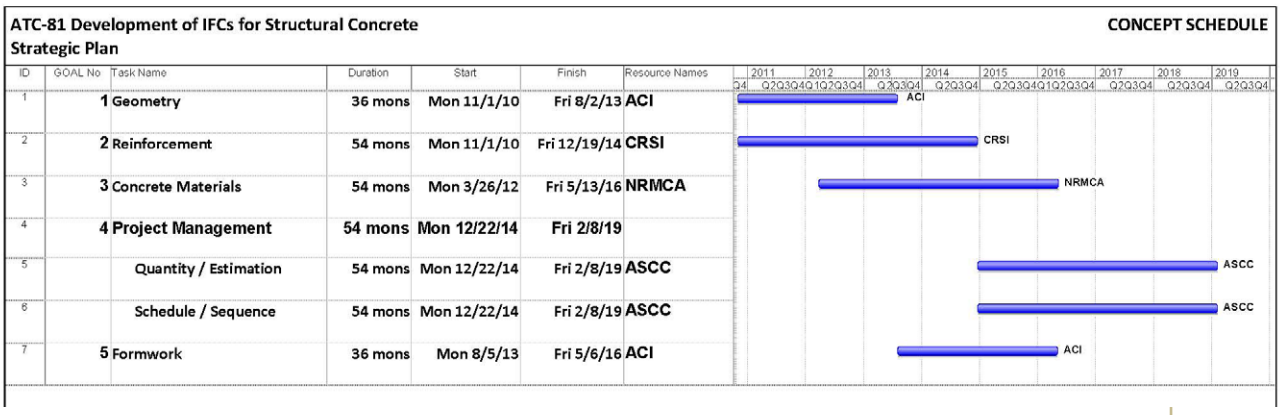


Figure 6 Goal Schedule Time Line

The costs associated with executing each of these goals could also vary significantly. If much of the effort is undertaken by volunteer committees the costs can be held relatively low, however, these sorts of volunteer efforts tend to take significantly longer. Funding for these efforts would provide the means to better direct the work effort, command the focus of industry participants and IFC consultants and achieve a faster development turnaround time. The actual cost of any of these efforts will be dependent on the scope the workgroup undertakes, the size of the group engaged and the level of in-kind contribution involved, among many other factors. For this reason the strategic plan does not establish any fixed monetary amounts, as this would not be realistic, but provides an assessment of relative cost between each of the goals.

The following section contains a detailed discussion of each of the prioritized goals.

1. Geometry

Recommended Champion: American Concrete Institute (ACI)

ACI Committee 131 - Building Information Modeling, would provide the workgroup to fulfill this goal.

Definition: The geometry of concrete shapes is potentially complex and therefore difficult to capture. The fluid nature of the medium and a lack of standard shapes and naming means that practitioners have developed their own ways of modeling shapes and calculating sizes and volumes. It is suggested that the champion develop a naming standard for shapes and a standard for describing dimensions, and use these standards in the development of the attributes spreadsheet for use in IFC maturation. An example of the types of questions to be considered would be: in a monolithic slab and beam structure, what are the cross sections of the slab and beams? Are they overlapping or disjoint? How does one compute concrete volume if they are overlapping? How does on compute structural properties if they are disjoint?

Attributes: The attributes shown in the working spreadsheet are suggested attributes, meant to be a starting point for discussion. The champion should review, edit and expand this list to all that are necessary to accurately capture geometry of concrete shapes.

Time Frame: It is estimated that this effort will require approximately 36 to 54 months of work by a committee of practitioners and a software programmer familiar with IFCs.

Cost: $

▶ 2. Reinforcement

Suggested Champion: Concrete Reinforcing Steel Institute (CRSI) / Post-Tensioning Institute (PTI)

> *The CRSI Engineering Practice Committee (EPC), BIM Task Force would lead the formation of the workgroup for this goal*

Definition: Similar to shape geometry, reinforcing is difficult to describe uniformly. The lack of standard shapes and naming means that here, too, practitioners have developed their own ways of modeling and naming reinforcement. It is suggested that the champion develop a naming standard for shapes and a standard for describing dimensions, and use these standards in the development of the attributes spreadsheet for use in IFC maturation.

Attributes: The attributes shown in the working spreadsheet are suggested attributes, meant to be a starting point for discussion. The champion should review, edit and expand this list to all that are necessary to accurately capture reinforcing.

Time Frame: It is estimated that this effort will require approximately 54 to 72 months of work by a committee of practitioners and a software engineer familiar with IFCs.

Cost: $$

▶ 3. Concrete Materials

Suggested Champion: National Ready Mixed Concrete Association (NRMCA)

Definition: Concrete materials are not currently consistently described.

Although there are aspects of the concrete mix that are considered to be proprietary information, a general description can be developed that specifies the mix either by aggregate type and ratio, strength, slump, air, water, supplementary cementing materials (SCM), cure time, CO2 (Green House Gas), aggregate type(s), ad-mixtures and any number of other important variables that will need to be specified, tracked or segregated for engineering, QA-QC, take-off/estimating or other documentation. It is suggested that the champion determine what type of information needs to be conveyed and a method for describing concrete materials that can be consistently implemented by practitioners.

Attributes: The attributes shown in the working spreadsheet are suggested attributes, meant to be a starting point for discussion. The champion should review, edit and expand this list to all that are necessary to accurately capture adequate description of concrete materials.

Time Frame: It is estimated that this effort will require approximately 54 to 72 months of work by a committee of practitioners and a software engineer familiar with IFCs.

Cost: $$

4. Project Management

A. Quantity/Estimation

Suggested Champion: American Society of Concrete Contractors (ASCC)

Definition: Quantity estimation for CIP structural concrete should work to incorporate all of the elements that go into the final permanent concrete structure. This may include the concrete, reinforcing bar, post tension tendons, headed shear stud reinforcement, water-stop, embeds, penetrations and other items. It will also be desirable to have form work, scaffolding, and other temporary but essential components of the structural concrete installation included.

Quantities of permanent materials, temporary materials, and labor must be location-specific and traceable.

Quantity should not be limited to the material components. Labor is many times an even more variable and critical cost component to the estimating process. It is all-important that the geometry replicate the sequence of work and build the model based upon the accurate stop-start sequences of work. This will allow the model to account for (and depict if desired) the sequence of work that takes place on the project. This is a key element of the modeling process that applies to all efforts, but is critical for the labor and constructability components of the Project Management scope.

Attributes: The attributes shown in the working spreadsheet are suggested attributes, meant to be a starting point for discussion. The champion should review, edit and expand this list to all that are necessary to accurately capture quantity and estimating data.

Time Frame: It is estimated that this effort will require approximately 54 to 72 months of work by a committee of practitioners and a software programmer familiar with IFCs.

Cost: $$$

B. Schedule/Sequence (See Quantity/Estimation)

Suggested Champion: American Society of Concrete Contractors (ASCC)

Definition: By standardizing the naming, geometry and quantity data types for concrete and rebar shapes practitioners can add additional user defined attributes which will allow for scheduling, sequencing, consumption and resources information to be attached to the geometry, which in turn can be used to schedule and sequence construction, fabrication, facilities management and maintenance. It is suggested that the champion develop scheduling and sequencing standards for describing CIP concrete elements in the development of the attributes spreadsheet for use in IFC maturation.

Attributes: The attributes shown in the working spreadsheet are suggested attributes, meant to be a starting point for discussion. The champion should review, edit and expand this list to all that are necessary to accurately capture quantity and estimating data.

Time Frame: It is estimated that this effort will require approximately 54 to 72 months of work by a committee of practitioners and a software programmer familiar with IFCs.

Cost: $$$

▶ 5. Formwork

Suggested Champion: American Concrete Institute (ACI)

> *ACI Committee 131 - Building Information Modeling, in conjunction with the support of ACI Committee 347 - Formwork for Concrete, would provide the workgroup to fulfill this goal.*

Definition: Formwork determines a great deal of the construction process and cost for any project. A uniform method of describing formwork is needed in order for BIM software to intelligently handle the data. Shapes, finishes and supports are among the categories of data for which the champion would develop standards and descriptions.

Attributes: The attributes shown in the working spreadsheet are suggested attributes, meant to be a starting point for discussion. The champion should review, edit and expand this list to all that are necessary to accurately capture quantity and estimating data.

Time Frame: It is estimated that this effort will require approximately 36 to 54 months of work by a committee of practitioners and a software programmer familiar with IFCs.

Cost: $$

OTHER GOALS

The next tier of goals is as broad-reaching and vitally important as the first five discussed in the previous section. As those foundation goals are completed, it is hoped that the champions will be motivated to take on new goals, capitalizing on the success of the partnerships and methods established in their work. The next set of goals is comprised of:

OTHER GOALS
Facilities Maintenance Data
▸ Date of commissioning, equipment make, model, serial number, date of equipment, manufacture, product data, photograph, maintenance history, cost information
Tolerances
▸ Minimum, maximum, fit-up to dissimilar materials and systems (i.e. steel, glass, curtain walls systems)
Labor Requirements (Resource-loaded Scheduling)
▸ Consumption rates by crew make up, material utilizations, lean construction, CPM, LBMS
Submittals/RFIs/Product Data
▸ Model management both visual and 2d from the BIM Quality Control/Testing ▸ User Defined Attributes
Placing/Top Surface Finishes
▸ Visual Representations
Composite Members
Code Checking

CONCLUSION

The champion for each of the goals set forth in this plan has a unique opportunity to guide the industry for years to come. Today's work will become tomorrow's standard practice, and the more developed the standard is, the more powerfully new tools can be brought to bear. The promise of BIM is well known; it is with endeavors like these that that promise is made real. Public domain work in IFCs by large and open groups of practitioners yields results that are democratic and undisputed, and can be confidently implemented by software providers across disciplines. The cast-in-place concrete industry is at a unique juncture where their investments in BIM technology can build on the momentum of change occurring in design and construction delivery methods and contribute to dramatic increases in efficiency, quality and sustainability of our built environment.

APPENDIX A: Project Reference Links

APPENDIX B: Example Exchange Requirements Workbook, ATC-75

APPENDIX C: Geometry Attributes Matrix

APPENDIX D: Reinforcement Attributes Matrix

APPENDIX E: Concrete Materials Attributes Matrix

APPENDIX F: Project Management Attributes Matrix

APPENDIX G: Formwork Attributes Matrix

A general overview and all document links can be found on the ATC website, which has an ATC-81 project page located here:

http://www.atcouncil.org/index.php?option=com_content&view=article&id=206&Itemid=138

For specific documents, click on the links below:

TASK 1: STRATEGIC PLANNING RESEARCH

SDC Survey
http://www.atcouncil.org/pdfs/ATC-81/ATC-81.3_%20BIMSurveyResults.pdf

Reinforced Concrete BIM Consortium Domain Report
http://www.atcouncil.org/pdfs/ATC-81/ATC-81.4_TeklaSurvey2007.pdf

Interview Summaries
http://www.atcouncil.org/pdfs/ATC-81/ATC-81.2_SummaryofInterviews_revised27APR10.pdf

White Paper
http://www.atcouncil.org/pdfs/ATC-81/ATC-81.5_WhitePaper.pdf

TASK 2: STRATEGIC PLANNING SESSION

Session Report
http://www.atcouncil.org/pdfs/ATC-81/ATC-81_StrategicPlanningSessionReport_20Jul10.pdf

APPENDIX A: Project Reference Links

ADDITIONAL REFERENCES

American Concrete Institute
www.concrete.org

American Society of Concrete Contractors
www.ascconline.org

American Society of Professional Estimators
www.aspenational.org

Applied Technology Council
www.atcouncil.org

ATC-75 Development of IFCs for the Structural Domain
http://www.atcouncil.org/index.php?option=com_content&view=article&id=92&Itemid=54

Building Smart Alliance
www.buildingsmartalliance.org

Charles Pankow Foundation
http://www.pankowfoundation.org

IFC Solutions Factory
http://www.blis-project.org/IAI-MVD

National BIM Standard
http://www.buildingsmartalliance.org/index.php/nbims

National Ready Mixed Concrete Association
www.nrmca.org

OmniClass
http://www.omniclass.org

RMC Research & Education Foundation
http://www.rmc-foundation.org

Strategic Development Council
http://www.concretesdc.org

APPENDIX B: Example Exchange Requirements Workbook, ATC-75

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Further comments
1	**STORY**					
		2	**Story Elevation**	Absolute elevation for story (the name "story" is prefered over "level", as level is used in e.g. Revit beyond the meaning of story - e.g. for any horizontal reference level). There are two elevation values for each story: - the relative elevation of the story against the reference height of the project. - the absolute elevation of the story against the relevant sea level (or geographic height datum)	Typically, our elevations for a project are all relative to a base elevation that is generally set to +100'-0". So, in Florida, +100'-0"' might be 3' above sea level. In Denver, Colorado, +100'-0" might be 5300' above sea level.	It is sufficient to have the relative elevation as an explicit measure for each story, and the absolute "above see level" elevation once at the building to which all stories references. The absolute elevation of each story can then be calculated by the receiving system.
		2	**Story Name**	Associated name for the story	Typical names are e.g. "foundation", "basement", "1st story", etc.	
2	**GRID**					
		2	**Grid element**	Grid element to exists in the exchange, requirement for grids in the structural exchange is to have a 3D grid, based on grid planes.	A structural grid is a vertically-oriented plane and therefore has 3D characteristics. A grid system is a collection of 3D planes. However this could be simulated by multiple 2D grids assigned to the stories in a building.	A grid based on 2D lines on a base plane is already needed in the exchange. A full 3D grid based on planes, rather then lines, is not widely supported by software. So 2D lines are sufficient but must be in multiple grid planes (at varying elevations) that define levels in order to get a "3D grid"
		2	**Grid layout**	Geometric layout of the grid, set of horizontal and vertical planes with intersection between them.		
		2	**Grid numbering**	A string attached to each grid plane (or line) representing the plane (or line) label.	E.g. "A", "B", "1", "2", etc.	
		2	**Reference to story**	Reference to the story where the grid planes (or lines) appears on.		The 2D gid is assigned to each story where it is valid. For now, it is necessary to copy the grid to each story.
3	**COLUMN**					
		1	**Column axis**	Definition axis of the column, used e.g. for determining the Cardinal point and as a first assumption for the linear structural member representing the column for structural analysis.		
		1	**Profile Name**	Name of the profile (or cross section) of the column. The naming convention, when applicable, should follow AISC naming convention.	Profile name is a string that represents a standard naming convention from a manual, handbook, or other external references. It is common in steel industry by using a AISC or CISC standard profile name. Some precast profiles have standard naming conventions, but most concrete profiles are not standarized. Name examples are (W14X90, 24X24).	For non-AISC profiles, is it required to also pass the profile table (or profile standard) name. Currently the best way to pass the profile information is by including it into a property set.
		1	**Material Name**	Name of the material of the column. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass	We need to agree upon an enumeration of applicable type of material to reduce unecessary string interpretation.
		1	**Grade**	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	Is grade considered as specific property of material, or of the element (or profile)? Is just a grade value sufficient, or a value with reference to a standard?
		1	**Length**	*Member length, it is software generated value that may be redundent to the length parameter embedded in the geometry representation.* There are different length measurements, best described as quantities: - logical length between two joints - physical length of the actual column body Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	The logical length is a real length measure between the two joints and equal to the length of the column axis. The physical length is the length of the extrusion body (not taking cut-out's etc. into account). Having explicit real values is particularly important, if the geometry is not an extrusion (e.g. a boundary representation).	Is there a specific definition of how the length is measured? Is it the physical or cut length, or the logical length between two joints?
		1	**Roll**	*Member roll, software generated value that may be redundent to the placement and placement orientation parameters embedded in the geometric representation.* Roll is the rotation of the column profile (and body) about a vertical axis for columns. Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	For example, for a 24x30 cast-in-place column, you have to know the orientation or roll of the column to know if the 30" dimension is pointing along x-axis or the y-axis (or somewhere in between).	Roll is handled for analytical models, but not (yet) for physical models, is it needed for physical models as well?
		1	**Cardinal point**	Offset of profile from longitudinal axis, essentially, it is the justification of the cross-section relatively to the working line between the two end joints. *Note: propose to rename it from insertion point to cardinal point (to make it similar to the CIS/2 concept).*	Cardinal point "lower-left", "center-right", etc.	
		1	**Element ID**	Unique identifier for element Note: Element ID is only for indexing model elements and used to uniquely identify elements that may have identical properties (length, profile, etc.). Element ID is typically defined by the modeling tool and the user should not be able to change this to ensure uniqueness.		is it a piecemark for structural steel? However, piecemarks are not necessarily unique across the entire model. Their might be many identical assemblies with the same parts with the same piecemarks. Or is it a GUID - a unique software ID that keeps identify across applications?

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Further comments
		2	**Schedule Mark**	Identifier for scheduling same profile elements Note: Schedule marks do not need to be unique. Schedule mark is typically defined by the user and named based on the elements location on a grid and/or the properties of that element (depth, length, number of reinforcing bars, etc.).	This is generally a short string that is provided on a plan adjacent to a column (for example "CC12"). The "CC12" is then defined in the column schedule. It is generally used as a unique identifier in the plans. So, a CC12 would be at a specific gridline (or gridlines) and is not the same as a CC11 or other mark.	Unsure whether this is different to the ELEMENT ID and if both identifiers are needed.
		2	**Base Reference Story**	*Base location, reference to the story where the start point of the column resists. Start point is the lower point of the column axis.*	This is e.g. a level as defined in "0. Level", from which the member starts, could we have an example drawing? CLICK FOR SCREEN SHOT EXPLANATION	
		2	**Top Reference Story**	*Top location, reference to the story where the end point of the column resists. End point is the upper point of the column axis.*	This is e.g. a level as defined in "0. Level", at which the member ends. could we have an example drawing? CLICK FOR SCREEN SHOT EXPLANATION	
		2	**Base Offset**	*Offset from base level*	This is a length describing the distance above a given level where a column starts. For example, steel columns when spliced are generally cut ~4'-0" above a floor level. So, the column above the splice would have a +4'-0" offset at its start.	Does this information has to be exchanged as redundent additional offset value, as it is already captured in the column position.
		2	**Top Offset**	*Offset from top level*	Also a length. In the example in the cell above, the lower column would have a top offset of +4'-0".	Does this information has to be exchanged as redundent additional offset value, as it is already captured in the column position and column geometry.
4	**BEAM**					
		1	**Beam Axis**	Definition axis of the beam, used e.g. for determining the Cardinal point and as a first assumption for the linear structural member representing the column for structural analysis.		
		1	**Profile Name**	Name of the profile (or cross section) of the beam. The naming convention, when applicable, should follow AISC naming convention.	Profile name is a string that represents a standard naming convention from a manual, handbook, or other external references. It is common in steel industry by using a AISC or CISC standard profile name. Some precast profiles have standard naming conventions, but most concrete profiles are not standarized. Name examples are (W14X90, 24X24).	For non-AISC profiles, is it required to also pass the profile table (or profile standard) name?
		1	**Material Name**	Name of the material of the beam. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass	How to agree upon an enumeration of applicable type of matierial to reduce unecessary string interpretation?
		1	**Grade**	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	Is grade considered as specific property of material, or of the element (or profile)? Is just a grade value sufficient, or a value with reference to a standard?
		1	**Length**	*Member length, it is software generated value that may be redundent to the length parameter embedded in the geometry representation.* There are different length measurements, best described as quantities: - logical length between two joints - physical length of the actual column body Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	The logical length is a real length measure between the two joints and equal to the length of the column axis. The physical length is the length of the extrusion body (not taking cut-out's etc. into account). Having explicit real values is particularly important, if the geometry is not an extrusion (e.g. a boundary representation).	Is there a specific definition of how the length is measured? Is it the physical or cut length, or the logical length between two joints?
		1	**Roll**	*Member roll, software generated value that may be redundent to the placement and placement orientation parameters embedded in the geometric representation.* Roll is the rotation of the column profile (and body) about a vertical axis for columns. Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	For example, for a 24x30 cast-in-place column, you have to know the orientation or roll of the column to know if the 30" dimension is pointing along x-axis or the y-axis (or somewhere in between).	Roll is handled for analytical models, but not (yet) for physical models, is it needed for physical models as well?
		1	**Cardinal point**	Offset of profile from longitudinal axis, essentially, it is the justification of the cross-section relatively to the working line between the two end joints. *Note: propose to rename it from insertion point to cardinal point (to make it similar to the CIS/2 concept).*	Cardinal point "lower-left", "center-right", etc.	
		1	**Element ID**	Unique identifier for element Note: Element ID is only for indexing model elements and used to uniquely identify elements that may have identical properties (length, profile, etc.). Element ID is typically defined by the modeling tool and the user should not be able to change this to ensure uniqueness.		is it a piecemark for structural steel? However, piecemarks are not necessarily unique across the entire model. Their might be many identical assemblies with the same parts with the same piecemarks. Or is it a GUID - a unique software ID that keeps identify across applications?

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Further comments
		2	**Schedule Mark**	Identifier for scheduling same profile elements Note: Schedule marks do not need to be unique. Schedule mark is typically defined by the user and named based on the elements location on a grid and/or the properties of that element (depth, length, number of reinforcing bars, etc.).	This is generally a short string that is provided on a plan adjacent to a column (for example "CC12"). The "CC12" is then defined in the column schedule. It is generally used as a unique identifier in the plans. So, a CC12 would be at a specific gridline (or gridlines) and is not the same as a CC11 or other mark.	Unsure whether this is different to the ELEMENT ID and if both identifiers are needed.
		2	**Base Reference Story**	*Base location, reference to the story where the start point of the beam resists. Start point is the lower point of the column axis.*	This is e.g. a level as defined in "0. Level", from which the member starts.	
		2	**Vertical Start Offset**	*Start offset in z direction,* Same concept as vertical end offset but for the beam start point. The end offset is measured to the axis (or reference line) of the beam.	See figure for explanation	A beam, provided it is horizontal, would have a base offset from the story (distance between it's bottom face and the story level, so what is the vertical start offset as additional value?
		2	**Vertical End Offset**	*End offset in z direction, v*ertical end offset is the offset distance of a beam endpoint from the insertion point (cardinal point) of that beam. The end offset is measured to the axis (or reference line) of the beam.	See figure for explanation	A beam, provided it is horizontal, would have a base offset from the story (distance between it's bottom face and the story level, so what is the vertical end offset as additional value?
5	**BRACE**					
		1	**Brace Axis**	Definition axis of the brace, used e.g. for determining the Cardinal point and as a first assumption for the linear structural member representing the column for structural analysis.		
		1	**Profile Name**	Name of the profile (or cross section) of the beam. The naming convention, when applicable, should follow AISC naming convention.	Profile name is a string that represents a standard naming convention from a manual, handbook, or other external references. It is common in steel industry by using a AISC or CISC standard profile name. Some precast profiles have standard naming conventions, but most concrete profiles are not standarized. Name examples are (W14X90, 24X24).	For non-AISC profiles, is it required to also pass the profile table (or profile standard) name?
		1	**Material Name**	Name of the material of the beam. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass	How to agree upon an enumeration of applicable type of matieral to reduce unecessary string interpretation?
		1	**Grade**	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	Is grade considered as specific property of material, or of the element (or profile)? Is just a grade value sufficient, or a value with reference to a standard?
		1	**Length**	*Member length, it is software generated value that may be redundent to the length parameter embedded in the geometry representation.* There are different length measurements, best described as quantities: - logical length between two joints - physical length of the actual column body Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	The logical length is a real length measure between the two joints and equal to the length of the column axis. The physical length is the length of the extrusion body (not taking cut-out's etc. into account). Having explicit real values is particularly important, if the geometry is not an extrusion (e.g. a boundary representation).	Is there a specific definition of how the length is measured? Is it the physical or cut length, or the logical length between two joints?
		1	**Roll**	*Member roll, software generated value that may be redundent to the placement and placement orientation parameters embedded in the geometric representation.* Roll is the rotation of the column profile (and body) about a vertical axis for columns. Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	For example, for a 24x30 cast-in-place column, you have to know the orientation or roll of the column to know if the 30" dimension is pointing along x-axis or the y-axis (or somewhere in between).	Roll is handled for analytical models, but not (yet) for physical models, is it needed for physical models as well?
		1	**Cardinal point**	Offset of profile from longitudinal axis, essentially, it is the justification of the cross-section relatively to the working line between the two end joints. *Note: propose to rename it from insertion point to cardinal point (to make it similar to the CIS/2 concept).*	Cardinal point "lower-left", "center-right", etc.	
		1	**Element ID**	Unique identifier for element Note: Element ID is only for indexing model elements and used to uniquely identify elements that may have identical properties (length, profile, etc.). Element ID is typically defined by the modeling tool and the user should not be able to change this to ensure uniqueness.		is it a piecemark for structural steel? However, piecemarks are not necessarily unique across the entire model. Their might be many identical assemblies with the same parts with the same piecemarks. Or is it a GUID - a unique software ID that keeps identify across applications?
		2	**Schedule Mark**	Identifier for scheduling same profile elements Note: Schedule marks do not need to be unique. Schedule mark is typically defined by the user and named based on the elements location on a grid and/or the properties of that element (depth, length, number of reinforcing bars, etc.).	This is generally a short string that is provided on a plan adjacent to a column (for example "CC12"). The "CC12" is then defined in the column schedule. It is generally used as a unique identifier in the plans. So, a CC12 would be at a specific gridline (or gridlines) and is not the same as a CC11 or other mark.	Unsure whether this is different to the ELEMENT ID and if both identifiers are needed.
		2	**Base Reference Story**	Base location, reference to the story where the start point of the brace resists. Start point is the lower point of the brace axis.	This is e.g. a level as defined in "0. Level", from which the member starts.	
		2	**Top Reference Story**	Top location, reference to the story where the end point of the brace resists. End point is the upper point of the brace axis.	This is e.g. a level as defined in "0. Level", at which the member ends.	

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Further comments
		2	**Vertical Start Offset**	End offset in z direction Offset of the start from the base reference story, offset is measured from the axis or reference line.	see figures for brace	
		2	**Vertical End Offset**	Start offset in z direction Offset of the end from the top reference story, offset is measured from the axis or reference line.	see figures for brace	
6	**WALL**					
		1	**Thickness**	Dimensional thickness of the wall, applicable to standard wall, having a unique, not-changing thickness along the wall axis. Note: Typically, structural engineering packages doesn't support multiple layers for wall objects. We would define two walls separately.		
		1	**Material Name**	Name of the material of the wall. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass Note: It assumes that structural walls are single layer walls	How to agree upon an enumeration of applicable type of matierial to reduce unecessary string interpretation?
		1	**Grade**	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	Is grade considered as specific property of material, or of the element (or profile)? Is just a grade value sufficient, or a value with reference to a standard?
		1	**Wall Axis**	Definition of the wall axis, used e.g. for determining the Alignment and as a first assumption for the linear structural member representing the wall for structural analysis.		
		1	**Alignment**	Alignment of the wall body relative to the wall axis.	Values could be an enumeration, like centerline, interior, exterior face, or an absolute value.	
		2	**Base Reference Story**	*Base location, reference to the story where the start point of the wall resists. Base story is where the wall axis resists.*	This is e.g. a level as defined in "0. Level", from which the member starts.	
		2	**Top Reference Story**	*Top location, reference to the story where the end point of the column resists. End point is the upper point of the column axis.*	This is e.g. a level as defined in "0. Level", at which the member ends.	
		2	**Base Offset**	*Offset from base level*	This is a length describing the distance above a given level where a wall starts.	Does this information has to be exchanged as redundent additional offset value, as it is already captured in the column position.
		2	**Top Offset**	*Offset from top level*	This is a length describing the distance above (or below) a given level where a wall ends.	Does this information has to be exchanged as redundent additional offset value, as it is already captured in the column position and column geometry.
		2	**Load bearing**	Attribute associated to the wall as a disciplinary setting, indicates that the wall is designed to be load bearing.	Boolean value TRUE or FALSE for the wall.	
7	**SLAB**					
		1	**Thickness**	Dimensional thickness of the slab applicable to standard slab, having a unique, not-changing thickness. The thickness is the perpendicular thickness between the two upper/lower faces, not the extrusion thickness. Note: Typically, structural engineering packages doesn't support multiple layers for slab objects. We would define two walls separately.		
		1	**Material Name**	Name of the material of the slab. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass Note: It assumes that structural slabs are single layer slabs.	How to agree upon an enumeration of applicable type of matierial to reduce unnecessary string interpretation?
		1	**Grade**	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	Is grade considered as specific property of material, or of the element (or profile)? Is just a grade value sufficient, or a value with reference to a standard?
		2	**Base Reference Story**	*Base location, reference to the story where the slab resists.*	This is e.g. a level as defined in "0. Level", from which the member starts.	
		2	**Base Offset**	*Offset from base story level. Base story offest is measured to the reference plane of the slab.*	This is a length describing the distance above a given story where the slab reference level is located.	Does this information has to be exchanged as redundent additional offset value, as it is already captured in the column position.
		2	**Span direction**	Structural span direction, the span direction here is defining the orientation of the area object relative to the z-axis.		Different bearing types (fixed edge, one-way, two-way, ...) are not to be exchanged?
8	**FOOTING**					
		1	**Footing Type**	A type classifer for footings, that further specifies the subtype (or functional type) of the footing.	Examples are: pad, strip, mat	
		1	**Material Name**	Name of the material of the footing. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass.	How to agree upon an enumeration of applicable type of matierial to reduce unnecessary string interpretation?

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Further comments
		1	**Grade**	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	Is grade considered as specific property of material, or of the element (or profile)? Is just a grade value sufficient, or a value with reference to a standard?
		2	**Top Reference Story**	Top location, reference to the story where the end point of the footing resists. End point is the upper face of the footing. Note: Similar to top reference story for columns. See screen shot in column section above.	Quote: *"I don't understand how it would be queried from the shape. Is the footing object defined by multiple end joints? As opposed to having, say, a center point, a length, width, thickness and orientation?"*	
		2	**Bottom Elevation**	*Dimensional elevation or thickness of the footing*	Quote: *"I don't understand how it would be queried from the shape. Is the footing object defined by multiple end joints? As opposed to having, say, a center point, a length, width, thickness and orientation?"*	
9	**PILE**					
		1	**Pile Type**	A type classifer for pile, that further specifies the subtype (or functional type) of the footing.	Example are: pile, caisson	
		1	**Material Name**	Name of the material of the pile. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass.	How to agree upon an enumeration of applicable type of matierial to reduce unnecessary string interpretation?
		1	**Grade**	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	Is grade considered as specific property of material, or of the element (or profile)? Is just a grade value sufficient, or a value with reference to a standard?
		2	**Top Reference.Story**	Dimensional elevation Note: Similar to top reference story for columns. See screen shot in column section above.	*Quote: "This is just like the top and bottom levels above for columns. I don't see how this is queried from the shape."*	
		2	**Bottom Elevation**	*Dimensional elevation or thickness of the pile*	*Quote: "This is just like the top and bottom levels above for columns. I don't see how this is queried from the shape."*	

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		2	**Vertical End Offset**	*The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets 1) offset of the local placements of the building story and the building element + 2) offset of the base level of the building element to its local placement) and coordinate transformations.*	The information itself (reference to storey, relative placement to storey and placement of brace extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			
6	**WALL**					Wall diagram		
		1	**Thickness**	The thickness of a wall can be stored in two ways: 1) as element quantity - *NominalWidth* (see also IAI definition of *IfcWall*) 2) For standard walls (definable with vertical extrusion and single/constant thickness) the thickness can be deduced from the material definition. It is agreed that the material of standard walls is defined by *IfcMaterialLayerSetUsage* and *IfcMaterialLayerSet* , which define the Alignment and the total Thickness of the wall. Please note that *IfcMaterialLayerSet.TotalThickness* is a derived attribute and thus not stored in an IFC file (it is defined as sum of all layer thicknesses). Consequently, reading IFC files means to calculate the total thickness from the wall layers -> *TotalThickness =* *IfcMaterialLayerSet.MaterialLayers[1].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[2].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[..].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[n].LayerThickness;*	IfcWallStandardCase + IfcMaterialLayerSetUsage is part of the coordination view.	1) "Simple Quantity" (NominalWidth) or 2) "Material Layer Definition" (sum of all layer thicknesses)		
		1	**Material Name**	Material is defined for each layer. In case of a single layer wall there is only one instance of *IfcMaterial* capturing the material name. For single layer walls the material name can be accessed as follows: *IfcWallStandardCase.(INV)HasAssociations ->* *IfcRelAssociatesMaterial.RelatingMaterial ->* *IfcMaterialLayerSetUsage.ForLayerSet ->* *IfcMaterialLayerSet.MaterialLayers[1] ->* *IfcMaterialLayer.Material -> IfcMaterial*	Support of *IfcMaterial.Name* is part of the coordination view and enforced. A separate field for the material category is not yet provided.	*VBL-345* VBL-265	Support of material name added to implementation scope as an enforcement of the coordination view.	Add a second attribute in IFC2x4 to differentiate a user name for any material and the material category.
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference* .	Not part of the coordination view. Can be added for this testbed.	"Material Grade"	Support of material classification added to implementation scope.	
		1	**Wall Axis**	Additional *IfcShapeRepresentation* with *RepresentationType* = Axis. The *IfcGeometricRepresentationItem* is a single *IfcPolyline* (or *IfcTrimmedCurve* with *BaseCurve IfcLine* , or *IfcCircle*)		"Axis Definition"		

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		1	**Alignment**	The wall body is defined by *IfcShapeRepresentation* with *RepresentationType* = Body. The *IfcGeometricRepresentationItem* is a swept solid representation or a CSG. Both representation types, the wall axis and the body representation, use the same coordinate system (*IfcWall.ObjectPlacement*) enabling to deduce the alignment of the wall body relative to the wall axis. Alternatively, the alignment can be read (without geometric calculations) from the material layer settings (*IfcMaterialLayerSetUsage.OffsetFromReferenceLine)*. The reference line is the wall axis. The offset is given for the selected axis (*IfcMaterialLayerSetUsage.LayerSetDirection)* and direction (*IfcMaterialLayerSetUsage.DirectionSense*).		"Material Layer Definition" (OffsetFromReferenceLine)		
		2	**Base Reference Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
		2	**Top Reference Story**	May evaluate the containment information and the spatial structure. Requires to follow some references and may to check the geometry (length and offset of the wall, reference high of the building storeys).	Not currently supported in the coordination view, the IFC relationship, IfcRelReferencedInSpatialStructure would support it, but would need to be added to the coordination view.	*"Spatial Reference"*	Propose an addition to the view definition with an implementation guideline for capturing the top reference storey.	
		2	**Base Offset**	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets (1) offset of the base reference to the local placement of the building story + 2) offset of the local placements of the building story and the building element + 3) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			
		2	**Top Offset**	see Base Offset and Top Reference.Story	*depends on the clarification of the above requirements*			
		2	**Load bearing**	Stored in the property set *Pset_WallCommon*, with the name LoadBearing = TRUE or FALSE.		"Single Value Property Definition"		
7	**SLAB**					Slab diagram		

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		1	**Thickness**	The thickness of a slab can be stored in two ways: 1) as element quantity - *NominalWidth* (see IAI definition of *IfcSlab*) 2) For standard slabs (constant thickness along the extrusion direction) the thickness can be deduced from the material definition. It is agreed that the material of standard slabs is defined by *IfcMaterialLayerSetUsage* and *IfcMaterialLayerSet* , which define the Alignment and the total Thickness of the slab. Please note that *IfcMaterialLayerSet.TotalThickness* is a derived attribute and thus not stored in an IFC file (it is defined as sum of all layer thicknesses). Consequently, reading IFC files means to calculate the total thickness from the slab layers *-> TotalThickness =* *IfcMaterialLayerSet.MaterialLayers[1].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[2].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[..].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[n].LayerThickness;*	Included in the coordination view for the correct setting of material layer definitions. Use of single quantity is part of the quntity take-off addon view.	1) *"Simple Quantity"* (NominalWidth) or 2) *"Material Layer Definition"* (sum of all layer thicknesses)	Include and verify it.	
		1	**Material Name**	Material is defined for each layer. Single layer slabs have only one instance of *IfcMaterial* and thus only one material name. The material name can be accessed as follows: *IfcWallStandardCase.(INV)HasAssociations ->* *IfcRelAssociatesMaterial.RelatingMaterial ->* *IfcMaterialLayerSetUsage.ForLayerSet ->* *IfcMaterialLayerSet.MaterialLayers[1] ->* *IfcMaterialLayer.Material -> IfcMaterial*		*VBL-345* VBL-265	Include and verify it.	
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference* .		*"Material Grade"*		
		2	**Base Reference Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, ...) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	*"Spatial Container"*	Include and verify it.	
		2	**Base Offset**	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets (1) offset of the base reference to the local placement of the building story + 2) offset of the local placements of the building story and the building element + 3) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			
		2	**Span direction**	Currently there is no attribute for storing the span direction(s).			do not include - requires IFC schema additions	recommend the addition of a span direction attribute to IFC
8	**FOOTING**					Footing diagram		

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		1	**Footing Type**	Defined by *IfcFooting.PredefinedType* ; following types are available: - FOOTING_BEAM - PAD_FOOTING - PILE_CAP - STRIP_FOOTING - USERDEFINED - NOTDEFINED	Included in the coordination view, but correct setting of the pile enumeration not enforced.		Check the current setting ot the pile type in IFC exchanges for benchmarking.	
		1	**Material Name**	*IfcMaterial.Name* - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)		*VBL-345* VBL-265	Include and verify it.	
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference* .		"Material Grade"		
		2	**Top Reference Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story). Note: it is the reference storey (the term "top" is not preserved in the exchange)	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
		2	**Bottom Elevation**	Equal to the extrusion lenght parameter of the footing				
9	**PILE**					Pile diagram		
		1	**Pile Type**	Defined by IfcPile.PredefinedType; following types are available: - COHESION - FRICTION - SUPPORT - USERDEFINED - NOTDEFINED	Included in the coordination view, but correct setting of the pile enumeration not enforced.		Check the current setting ot the pile type in IFC exchanges for benchmarking.	
		1	**Material Name**	*IfcMaterial.Name* - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)		*VBL-345* VBL-265	Include and verify it.	
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference* .		"Material Grade"		
		2	**Top Reference.Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story). Note: it is the reference storey (the term "top" is not preserved in the exchange)	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
		2	**Bottom Elevation**					

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
1	**STORY**					**Story diagram**		
		2	**Story Elevation**	It is available as derived information from IFC. *IfcSite.Elevation* is the elevation about sea level using WGS84 *IfcBuilding.ElevationOfRefHeight* = Elevation above sea level of the reference height used for all storey elevation measures = all story elevation are given relative to this height. *IfcBuildingStorey.Elevation* = Elevation of the particular story against this reference height = Total height of story is *Elevation + ElevationOfRefHeight*	entities are part of the coordination view and certification, provision of these attributes is however not enforced.	Site + Building + BuildingStorey + SpatialDecomposition	add the support for geographic locations (latitude, longitude, elevation above sea level to the implementation scope as an enforcement of the coordination view.	
		2	**Story Name**	*IfcBuildingStorey.Name* , a string value to store the user/system defined name of the story. "Name" defined the story designator, In addition a "LongName" for a full text can be provided.	part of Coordination view and certification. Should already be in scope of all implementations.	*VBL-025* VBL-171	add to implementation scope as an enforcement of the coordination view.	
2	**GRID**					**Grid diagram**		
		2	**Grid element**	*IfcGrid* entity in IFC is a line based grid consisting of pairs/rows of 2D lines in u, v directions.	currently the support of grids is not enforced in the coordination view, add support for *IfcGrid* to the coordination view (as it is needed for coordination).		verify support for IfcGrid assigned to different storeys	add a new entity IfcGrid3D to IFC2x4
		2	**Grid layout**	not yet supported				
		2	**Grid numbering**	supported for 2D grids, based on grid lines. Supported as *IfcGridAxis.AxisTag*				
		2	**Reference to story**	supported for 2D grids, based on grid lines. Supported as *IfcGrid.(INV)ContainedInStructure*				
3	**COLUMN**					**Column diagram**		
		1	**Column axis**	Additional *IfcShapeRepresentation* with *RepresentationType* = Axis. The *IfcGeometricRepresentationItem* is a single *IfcPolyline* (or *IfcTrimmedCurve* with *BaseCurve IfcLine* , or *IfcCircle*)	Currently not enforced in the coordination view.	*"Axis Definition"*		
		1	**Profile Name**	For all parametric profiles and all extrusion based profiles it is currently provided as a single string value - IfcProfileDef.ProfileName. Need some additional agreement where a section designator (plus eventually a section table name) goes in IFC file for any type of geometry representation, e.g. in case of BREP or SurfaceModels.	The entity *IfcProfileDef* (it's subtypes) is already required as part of the Coordination view and certification. Filling the attribute ProfileName (with sensible values) is however not yet enforced. It should be enforced, if such information is available in the authoring tool.	*"Profile Definition"* - see also *"Single Value Property Definition"*	use the "Profile Definition" agreement for all SweptSolid's. Agree to use AISC naming convention as far as applicable. Add to implementation scope as an enforcement of the coordination view.	add a general place to find a profile name and section table name independently of the profile geometry. For now profile names should be passed as a property set, as it cannot be added to a brep column. Better support to be added in IFC2x4
		1	**Material Name**	*IfcMaterial.Name* - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)	Support of *IfcMaterial.Name* is part of the coordination view and enforced. A separate field for the material category is not yet provided.	*VBL-345* VBL-265	Support of material name added to implementation scope as an enforcement of the coordination view.	Add a second attribute in IFC2x4 to differentiate a user name for any material and the material category.
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference* .	Not part of the coordination view. Can be added for this testbed.	*"Material Grade"*	Support of material classification added to implementation scope.	

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		1	**Length**	Lenght is perceived in IFC as a quantity, i.e. it is a measurement taken from the geometry that should be exchanged in addition to the geometric representation. Such quantities should be added for downstream applications (not having an own geometric kernel). In this use case it could be expected from the receiving application to reestablish: - (physical) length from the extrusion length - logical length from the length of the axis representation Simple Quantity (using *IfcQuantityLength* with the Name 'Length'), optionally a "LogicalLength" can be supported in addition.	export of quantities are part of the "QTO view", which is an add on to the coordination view (and not a part). export of an additional axis representation of the column is currently optional in the coordination view.	*"Simple Quantity"* also see QTO implementation guide.	Export of quantities is in scope of the QTO addon view. It should be added to implementation scope.	
		1	**Roll**	Roll is a redundent information given in addition to the geometric representation, but helpful for analysing the model, it should be provided as a property, similar to the Span property in Pset_ColumnCommon	Currently not part of the Pset_ColumnCommon, should be added as a new property. Can be added for this testbed.	*"Single Value Property Definition"*	Single Value Property Definition (principle of property definition that is needed here, property name would be 'Roll' with an value of the type IfcPlaneAngleMeasure; IfcPropertySet.Name = 'Pset_ColumnCommon')	add Roll to Pset_ColumnCommon for IFC2x4
		1	**Cardinal point**		The cardinal point is currently not supported in IFC2x3, ist support is already proposed for IFC2x4.	- not in 2x3 -	not included, new schema IFC2x4 is required to support it.	add CardinalPoint to IFC2x4 as part of the new material-profile definition.
		1	**Element ID**	the element-id is not identical to the GUID, it is a unique number, given by the exporting software system, like a handle. The IFC representation is *IfcColumn.Tag* - see ist definition: *Tag : The tag (or label) identifier at the particular instance of a product, e.g. the serial number, or the position number. It is the identifier at the occurrence level.*	Currently supported in an ambiguous way, e.g. as part of the IfcColumn.Name - need to be unified.		Provide an unambiguos way to export the element ID, recommended is IfcColumn.Tag.	
		2	**Schedule Mark**	the schedule mark is also regarded as reference id, or construction type id - it is already included in IFC as Pset_ColumnCommon.Reference	Currently not supported in an unambiguous way.		Provide an unambiguos way to export the schedule mark by using Pset_ColumnCommon.Reference	
		2	**Base Reference Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, ...) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	*"Spatial Container"*	Include and verify it.	
		2	**Top Reference Story**	May evaluate the containment information and the spatial structure. Requires to follow some references and may to check the geometry (length and offset of the column, reference high of the building storeys).	Not currently supported in the coordination view, the IFC relationship, IfcRelReferencedInSpatialStructure would support it, but would need to be added to the coordination view.	*"Spatial Reference"*	Propose an addition to the view definition with an implementation guideline for capturing the top reference storey.	
		2	**Base Offset**	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets (1) offset of the base reference to the local placement of the building story + 2) offset of the local placements of the building story and the building element + 3) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			
		2	**Top Offset**	see Base Offset and Top Reference.Story	*depends on the clarification of the above requirements*			
4	**BEAM**					**Beam diagram**		

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		1	**Beam Axis**	Additional *IfcShapeRepresentation* with *RepresentationType* = Axis. The *IfcGeometricRepresentationItem* is a single *IfcPolyline* (or *IfcTrimmedCurve* with *BaseCurve IfcLine*, or *IfcCircle*)	Currently not enforced in the coordination view.	"Axis Definition"		
		1	**Profile Name**	For all parametric profiles and all extrusion based profiles it is currently provided as a single string value - IfcProfileDef.ProfileName. Need some additional agreement where a section designator (plus eventually a section table name) goes in IFC file for any type of geometry representation, e.g. in case of BREP or SurfaceModels.	The entity *IfcProfileDef* (it's subtypes) is already required as part of the Coordination view and certification. Filling the attribute ProfileName (with sensible values) is however not yet enforced. It should be enforced, if such information is available in the authoring tool.	*"Profile Definition"* - see also *"Single Value Property Definition"*	use the "Profile Definition" agreement for all SweptSolid's. Agree to use AISC naming convention as far as applicable. Add to implementation scope as an enforcement of the coordination view.	add a general place to find a profile name and section table name independently of the profile geometry. For now profile names should be passed as a property set, as it cannot be added to a brep beam. Better support to be added in IFC2x4
		1	**Material Name**	*IfcMaterial.Name* - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)	Support of *IfcMaterial.Name* is part of the coordination view and enforced. A separate field for the material category is not yet provided.	*VBL-345* VBL-265	Support of material name added to implementation scope as an enforcement of the coordination view.	Add a second attribute in IFC2x4 to differentiate a user name for any material and the material category.
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference*.	Not part of the coordination view. Can be added for this testbed.	"Material Grade"	Support of material classification added to implementation scope.	
		1	**Length**	Lenght is perceived in IFC as a quantity, i.e. it is a measurement taken from the geometry that should be exchanged in addition to the geometric representation. Such quantities should be added for downstream applications (not having an own geometric kernel). In this use case it could be expected from the receiving application to reestablish: - (physical) length from the extrusion length - logical length from the length of the axis representation Simple Quantity (using *IfcQuantityLength* with the Name 'Length'), optionally a "LogicalLength" can be supported in addition.	export of quantities are part of the "QTO view", which is an add on to the coordination view (and not a part). export of an additional axis representation of the column is currently optional in the coordination view.	"Simple Quantity" also see QTO implementation guide.	Export of quantities is in scope of the QTO addon view. It should be added to implementation scope.	
		1	**Roll**	Roll is a redundent information given in addition to the geometric representation, but helpful for analysing the model, it should be provided as a property, similar to the Span property in Pset_ColumnCommon	Currently not part of the Pset_ColumnCommon, should be added as a new property. Can be added for this testbed.	"Single Value Property Definition"	Single Value Property Definition (principle of property definition that is needed here, property name would be 'Roll' with an value of the type IfcPlaneAngleMeasure; IfcPropertySet.Name = 'Pset_ColumnCommon')	add Roll to Pset_ColumnCommon for IFC2x4
		1	**Cardinal point**		The cardinal point is currently not supported in IFC2x3, ist support is already proposed for IFC2x4.	- not in 2x3 -	not included, new schema IFC2x4 is required to support it.	add CardinalPoint to IFC2x4 as part of the new material-profile definition.
		1	**Element ID**	the element-id is not identical to the GUID, it is a unique number, given by the exporting software system, like a handle. The IFC representation is *IfcBeam.Tag* - see ist definition: *Tag : The tag (or label) identifier at the particular instance of a product, e.g. the serial number, or the position number. It is the identifier at the occurrence level.*	Currently supported in an ambiguous way, e.g. as part of the IfcBeam.Name - need to be unified.		Provide an unambiguos way to export the element ID, recommended is IfcBeam.Tag.	
		2	**Schedule Mark**		Currently not supported in an unambiguous way.		Provide an unambiguos way to export the schedule mark by using Pset_BeamCommon.Reference	

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		2	**Base Reference Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.		Propose an addition to the view definition with an implementation guideline for capturing the top reference storey.	
		2	**Vertical Start Offset**	*The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets 1) offset of the local placements of the building story and the building element + 2) offset of the base level of the building element to its local placement) and coordinate transformations.*	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.		Add an implematation guide on how to re-generate the offset exported as part of the local placement and geometric representation.	
		2	**Vertical End Offset**	*The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets 1) offset of the local placements of the building story and the building element + 2) offset of the base level of the building element to its local placement) and coordinate transformations.*	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.		Add an implematation guide on how to re-generate the offset exported as part of the local placement and geometric representation.	
5	**BRACE**			Brace is not an individual entity in IFC. A brace is represented as a IfcMemberType with PredefinedType=.BRACE. If no types are exchanged, each individual occurrence shall be an IfcMember with ObjectType='Brace'.	Labelling members as braces is currently not enforced in the coordination view. It should be enforced, if such information is available in the authoring tool.	**Brace diagram**		
		1	**Brace Axis**	Additional *IfcShapeRepresentation* with *RepresentationType* = Axis. The *IfcGeometricRepresentationItem* is a single *IfcPolyline* (or *IfcTrimmedCurve* with *BaseCurve IfcLine*, or *IfcCircle*)	Currently not enforced in the coordination view.	*"Axis Definition"*		
		1	**Profile Name**	For all parametric profiles and all extrusion based profiles it is currently provided as a single string value - IfcProfileDef.ProfileName. Need some additional agreement where a section designator (plus eventually a section table name) goes in IFC file for any type of geometry representation, e.g. in case of BREP or SurfaceModels.	The entity *IfcProfileDef* (it's subtypes) is already required as part of the Coordination view and certification. Filling the attribute ProfileName (with sensible values) is however not yet enforced. It should be enforced, if such information is available in the authoring tool.	*"Profile Definition"* - see also "*Single Value Property Definition"*	use the "Profile Definition" agreement for all SweptSolid's. Agree to use AISC naming convention as far as applicable. Add to implementation scope as an enforcement of the coordination view.	add a general place to find a profile name and section table name independently of the profile geometry. For now profile names should be passed as a property set, as it cannot be added to a brep brace. Better support to be added in IFC2x4
		1	**Material Name**	*IfcMaterial.Name* - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)	Support of *IfcMaterial.Name* is part of the coordination view and enforced. A separate field for the material category is not yet provided.	*VBL-345* VBL-265	Support of material name added to implementation scope as an enforcement of the coordination view.	Add a second attribute in IFC2x4 to differentiate a user name for any material and the material category.
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference*.	Not part of the coordination view. Can be added for this testbed.	*"Material Grade"*	Support of material classification added to implementation scope.	

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		1	**Length**	Lenght is perceived in IFC as a quantity, i.e. it is a measurement taken from the geometry that should be exchanged in addition to the geometric representation. Such quantities should be added for downstream applications (not having an own geometric kernel). In this use case it could be expected from the receiving application to reestablish: - (physical) length from the extrusion length - logical length from the length of the axis representation Simple Quantity (using *IfcQuantityLength* with the Name 'Length'), optionally a "LogicalLength" can be supported in addition.	export of quantities are part of the "QTO view", which is an add on to the coordination view (and not a part). export of an additional axis representation of the column is currently optional in the coordination view.	*"Simple Quantity"* also see QTO implementation guide.	Export of quantities is in scope of the QTO addon view. It should be added to implementation scope.	
		1	**Roll**	Roll is a redundent information given in addition to the geometric representation, but helpful for analysing the model, it should be provided as a property, similar to the Span property in Pset_ColumnCommon	Currently not part of the Pset_ColumnCommon, should be added as a new property. Can be added for this testbed.	*"Single Value Property Definition"*	Single Value Property Definition (principle of property definition that is needed here, property name would be 'Roll' with an value of the type IfcPlaneAngleMeasure; IfcPropertySet.Name = 'Pset_ColumnCommon')	add Roll to Pset_ColumnCommon for IFC2x4
		1	**Cardinal point**		The cardinal point is currently not supported in IFC2x3, ist support is already proposed for IFC2x4.	- not in 2x3 -	not included, new schema IFC2x4 is required to support it.	add CardinalPoint to IFC2x4 as part of the new material-profile definition.
		1	**Element ID**	the element-id is not identical to the GUID, it is a unique number, given by the exporting software system, like a handle. The IFC representation is *IfcBeam.Tag* - see ist definition: *Tag : The tag (or label) identifier at the particular instance of a product, e.g. the serial number, or the position number. It is the identifier at the occurrence level.*	Currently supported in an ambiguous way, e.g. as part of the IfcMember.Name - need to be unified.		Provide an unambiguos way to export the element ID, recommended is IfcMember.Tag.	
		2	**Schedule Mark**		Currently not supported in an unambiguous way.		Provide an unambiguos way to export the schedule mark by using Pset_MemberCommon.Reference	
		2	**Base Reference Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, ...) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	*"Spatial Container"*	Include and verify it.	
		2	**Top Reference Story**	May evaluate the containment information and the spatial structure. Requires to follow some references and may to check the geometry (length and offset of the column, reference high of the building storeys).	Not currently supported in the coordination view, the IFC relationship, IfcRelReferencedInSpatialStructure would support it, but would need to be added to the coordination view.	*"Spatial Reference"*	Propose an addition to the view definition with an implementation guideline for capturing the top reference storey.	
		2	**Vertical Start Offset**	*The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets 1) offset of the local placements of the building story and the building element + 2) offset of the base level of the building element to its local placement) and coordinate transformations.*	The information itself (reference to storey, relative placement to storey and placement of brace extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		2	**Vertical End Offset**	*The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets 1) offset of the local placements of the building story and the building element + 2) offset of the base level of the building element to its local placement) and coordinate transformations.*	The information itself (reference to storey, relative placement to storey and placement of brace extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			
6	**WALL**					Wall diagram		
		1	**Thickness**	The thickness of a wall can be stored in two ways: 1) as element quantity - *NominalWidth* (see also IAI definition of *IfcWall*) 2) For standard walls (definable with vertical extrusion and single/constant thickness) the thickness can be deduced from the material definition. It is agreed that the material of standard walls is defined by *IfcMaterialLayerSetUsage* and *IfcMaterialLayerSet* , which define the Alignment and the total Thickness of the wall. Please note that *IfcMaterialLayerSet.TotalThickness* is a derived attribute and thus not stored in an IFC file (it is defined as sum of all layer thicknesses). Consequently, reading IFC files means to calculate the total thickness from the wall layers -> *TotalThickness =* *IfcMaterialLayerSet.MaterialLayers[1].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[2].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[..].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[n].LayerThickness;*	IfcWallStandardCase + IfcMaterialLayerSetUsage is part of the coordination view.	1) "Simple Quantity" (NominalWidth) or 2) "Material Layer Definition" (sum of all layer thicknesses)		
		1	**Material Name**	Material is defined for each layer. In case of a single layer wall there is only one instance of *IfcMaterial* capturing the material name. For single layer walls the material name can be accessed as follows: *IfcWallStandardCase.(INV)HasAssociations ->* *IfcRelAssociatesMaterial.RelatingMaterial ->* *IfcMaterialLayerSetUsage.ForLayerSet ->* *IfcMaterialLayerSet.MaterialLayers[1] ->* *IfcMaterialLayer.Material -> IfcMaterial*	Support of *IfcMaterial.Name* is part of the coordination view and enforced. A separate field for the material category is not yet provided.	*VBL-345* VBL-265	Support of material name added to implementation scope as an enforcement of the coordination view.	Add a second attribute in IFC2x4 to differentiate a user name for any material and the material category.
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference* .	Not part of the coordination view. Can be added for this testbed.	"Material Grade"	Support of material classification added to implementation scope.	
		1	**Wall Axis**	Additional *IfcShapeRepresentation* with *RepresentationType* = Axis. The *IfcGeometricRepresentationItem* is a single *IfcPolyline* (or *IfcTrimmedCurve* with *BaseCurve IfcLine* , or *IfcCircle*)		"Axis Definition"		

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		1	**Alignment**	The wall body is defined by *IfcShapeRepresentation* with *RepresentationType* = Body. The *IfcGeometricRepresentationItem* is a swept solid representation or a CSG. Both representation types, the wall axis and the body representation, use the same coordinate system (*IfcWall.ObjectPlacement*) enabling to deduce the alignment of the wall body relative to the wall axis. Alternatively, the alignment can be read (without geometric calculations) from the material layer settings (*IfcMaterialLayerSetUsage.OffsetFromReferenceLine)*. The reference line is the wall axis. The offset is given for the selected axis (*IfcMaterialLayerSetUsage.LayerSetDirection)* and direction (*IfcMaterialLayerSetUsage.DirectionSense*).		"Material Layer Definition" (OffsetFromReferenceLine)		
		2	**Base Reference Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
		2	**Top Reference Story**	May evaluate the containment information and the spatial structure. Requires to follow some references and may to check the geometry (length and offset of the wall, reference high of the building storeys).	Not currently supported in the coordination view, the IFC relationship, IfcRelReferencedInSpatialStructure would support it, but would need to be added to the coordination view.	*"Spatial Reference"*	Propose an addition to the view definition with an implementation guideline for capturing the top reference storey.	
		2	**Base Offset**	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets (1) offset of the base reference to the local placement of the building story + 2) offset of the local placements of the building story and the building element + 3) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			
		2	**Top Offset**	see Base Offset and Top Reference.Story	*depends on the clarification of the above requirements*			
		2	**Load bearing**	Stored in the property set *Pset_WallCommon*, with the name LoadBearing = TRUE or FALSE.		"Single Value Property Definition"		
7	**SLAB**					Slab diagram		

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		1	**Thickness**	The thickness of a slab can be stored in two ways: 1) as element quantity - *NominalWidth* (see IAI definition of *IfcSlab*) 2) For standard slabs (constant thickness along the extrusion direction) the thickness can be deduced from the material definition. It is agreed that the material of standard slabs is defined by *IfcMaterialLayerSetUsage* and *IfcMaterialLayerSet* , which define the Alignment and the total Thickness of the slab. Please note that *IfcMaterialLayerSet.TotalThickness* is a derived attribute and thus not stored in an IFC file (it is defined as sum of all layer thicknesses). Consequently, reading IFC files means to calculate the total thickness from the slab layers *-> TotalThickness =* *IfcMaterialLayerSet.MaterialLayers[1].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[2].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[..].LayerThickness +* *IfcMaterialLayerSet.MaterialLayers[n].LayerThickness;*	Included in the coordination view for the correct setting of material layer definitions. Use of single quantity is part of the quntity take-off addon view.	1) *"Simple Quantity"* (NominalWidth) or 2) *"Material Layer Definition"* (sum of all layer thicknesses)	Include and verify it.	
		1	**Material Name**	Material is defined for each layer. Single layer slabs have only one instance of *IfcMaterial* and thus only one material name. The material name can be accessed as follows: *IfcWallStandardCase.(INV)HasAssociations ->* *IfcRelAssociatesMaterial.RelatingMaterial ->* *IfcMaterialLayerSetUsage.ForLayerSet ->* *IfcMaterialLayerSet.MaterialLayers[1] ->* *IfcMaterialLayer.Material -> IfcMaterial*		*VBL-345* VBL-265	Include and verify it.	
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference* .		*"Material Grade"*		
		2	**Base Reference Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, ...) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	*"Spatial Container"*	Include and verify it.	
		2	**Base Offset**	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets (1) offset of the base reference to the local placement of the building story + 2) offset of the local placements of the building story and the building element + 3) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			
		2	**Span direction**	Currently there is no attribute for storing the span direction(s).			do not include - requires IFC schema additions	recommend the addition of a span direction attribute to IFC
8	**FOOTING**					Footing diagram		

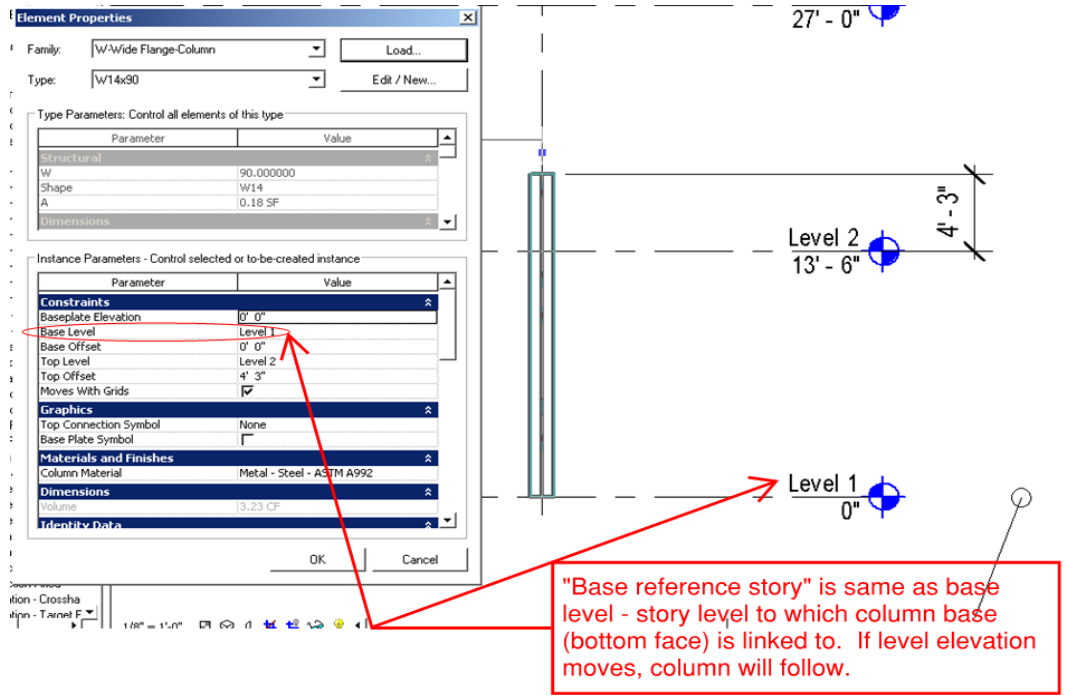
Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-75 implementation	Recommendation for further IFC development
		1	**Footing Type**	Defined by *IfcFooting.PredefinedType* ; following types are available: - FOOTING_BEAM - PAD_FOOTING - PILE_CAP - STRIP_FOOTING - USERDEFINED - NOTDEFINED	Included in the coordination view, but correct setting of the pile enumeration not enforced.		Check the current setting ot the pile type in IFC exchanges for benchmarking.	
		1	**Material Name**	*IfcMaterial.Name* - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)		*VBL-345* VBL-265	Include and verify it.	
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference* .		"Material Grade"		
		2	**Top Reference Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story). Note: it is the reference storey (the term "top" is not preserved in the exchange)	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
		2	**Bottom Elevation**	Equal to the extrusion lenght parameter of the footing				
9	**PILE**					Pile diagram		
		1	**Pile Type**	Defined by IfcPile.PredefinedType; following types are available: - COHESION - FRICTION - SUPPORT - USERDEFINED - NOTDEFINED	Included in the coordination view, but correct setting of the pile enumeration not enforced.		Check the current setting ot the pile type in IFC exchanges for benchmarking.	
		1	**Material Name**	*IfcMaterial.Name* - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)		*VBL-345* VBL-265	Include and verify it.	
		1	**Grade**	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by *IfcMaterial.(INV)ClassifiedAs* and *IfcClassificationReference* .		"Material Grade"		
		2	**Top Reference.Story**	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story). Note: it is the reference storey (the term "top" is not preserved in the exchange)	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
		2	**Bottom Elevation**					

Number	Object Category	Priority	Attribute Name	Bentley		Revit		Tekla		Digital Project		SAP 2000		Etabs	
				export	import	export	import	export	import	export	import	export	import	export	import
1	STORY														
		2	Story Elevation												
		2	Story Name												
2	GRID														
		2	Grid element												
		2	Grid layout												
		2	Grid numbering												
		2	Reference to story												
3	COLUMN														
		1	Column axis												
		1	Profile Name												
		1	Material Name												
		1	Grade												
		1	Length												
		1	Roll												
		1	Cardinal point												
		1	Element ID												
		2	Schedule Mark												
		2	Base Reference Story												
		2	Top Reference Story												
		2	Base Offset												
		2	Top Offset												
4	BEAM														
		1	Beam Axis												
		1	Profile Name												
		1	Material Name												
		1	Grade												
		1	Length												
		1	Roll												
		1	Cardinal point												
		1	Element ID												
		2	Schedule Mark												
		2	Base Reference Story												
		2	Vertical Start Offset												
		2	Vertical End Offset												
5	BRACE														
		1	Brace Axis												
		1	Profile Name												
		1	Material Name												
		1	Grade												
		1	Length												
		1	Roll												
		1	Cardinal point												
		1	Element ID												
		2	Schedule Mark												
		2	Base Reference Story												
		2	Top Reference Story												
		2	Vertical Start Offset												

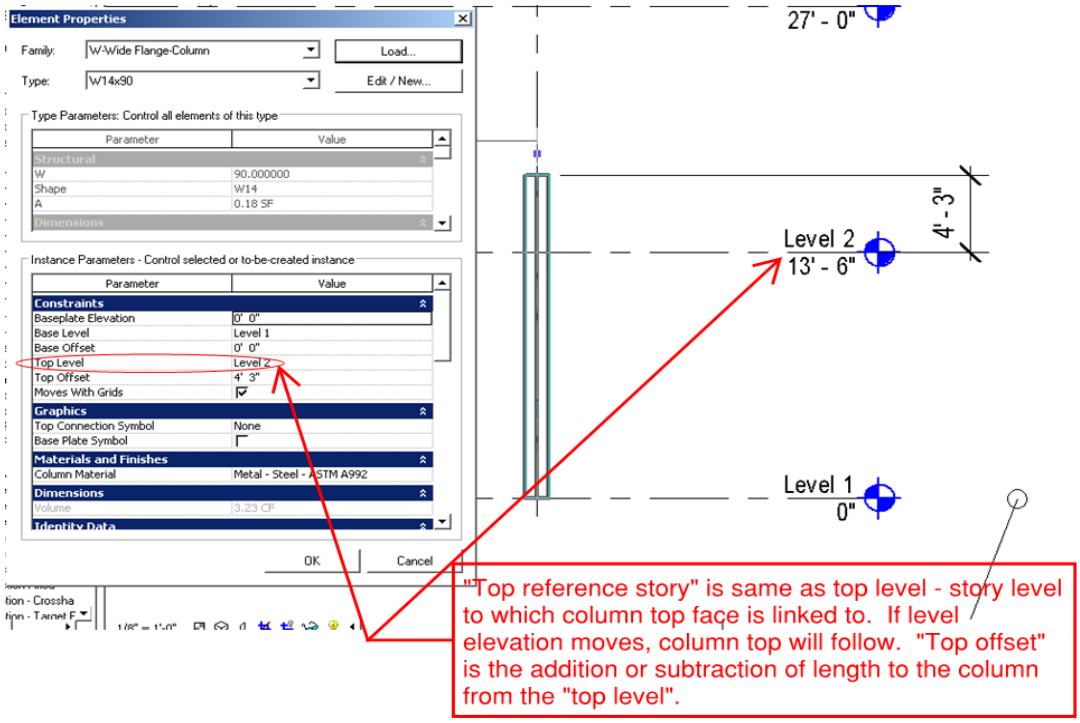
Number	Object Category	Priority	Attribute Name	Bentley		Revit		Tekla		Digital Project		SAP 2000		Etabs	
				export	import	export	import	export	import	export	import	export	import	export	import
		2	Vertical End Offset												
6	WALL														
		1	Thickness												
		1	Material Name												
		1	Grade												
		1	Wall Axis												
		1	Alignment												
		2	Base Reference Story												
		2	Top Reference Story												
		2	Base Offset												
		2	Top Offset												
		2	Load bearing												
7	SLAB														
		1	Thickness												
		1	Material Name												
		1	Grade												
		2	Base Reference Story												
		2	Base Offset												
		2	Span direction												
8	FOOTING														
		1	Footing Type												
		1	Material Name												
		1	Grade												
		2	Top Reference Story												
		2	Bottom Elevation												
9	PILE														
		1	Pile Type												
		1	Material Name												
		1	Grade												
		2	Top Reference.Story												
		2	Bottom Elevation												

Examples for column offsets to storys

Base Reference Story

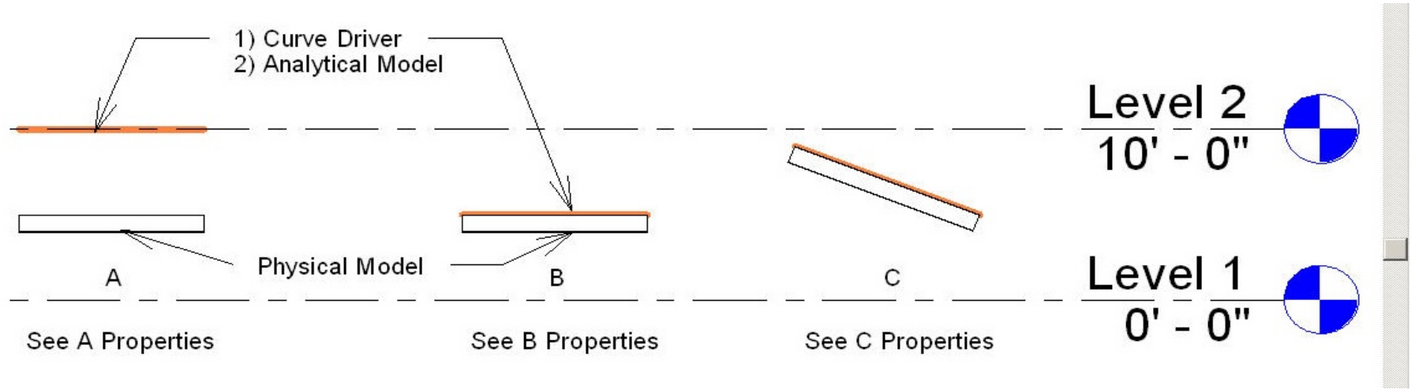


Top Reference Story

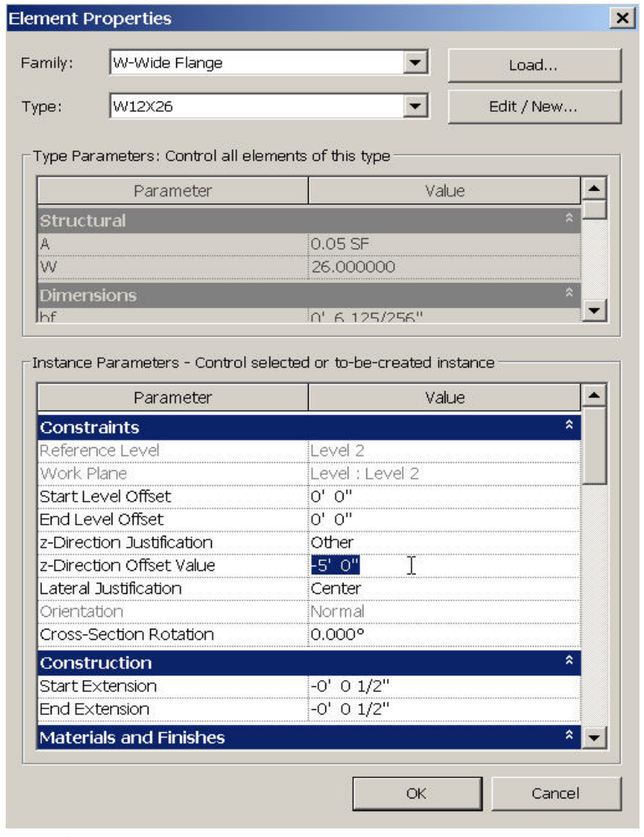


Figs Column Tab

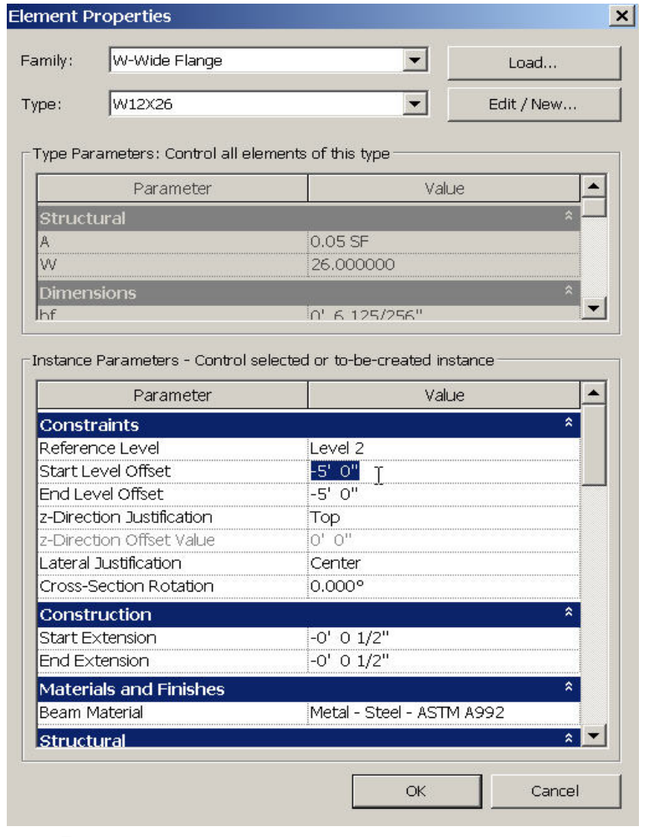
Examples for beam offsets to storys



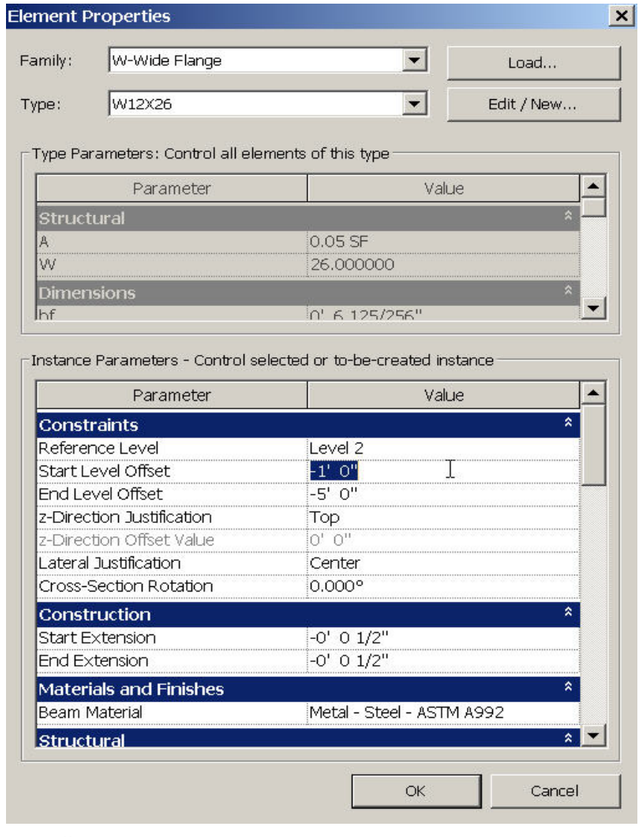
principal offset settings for beams



case A



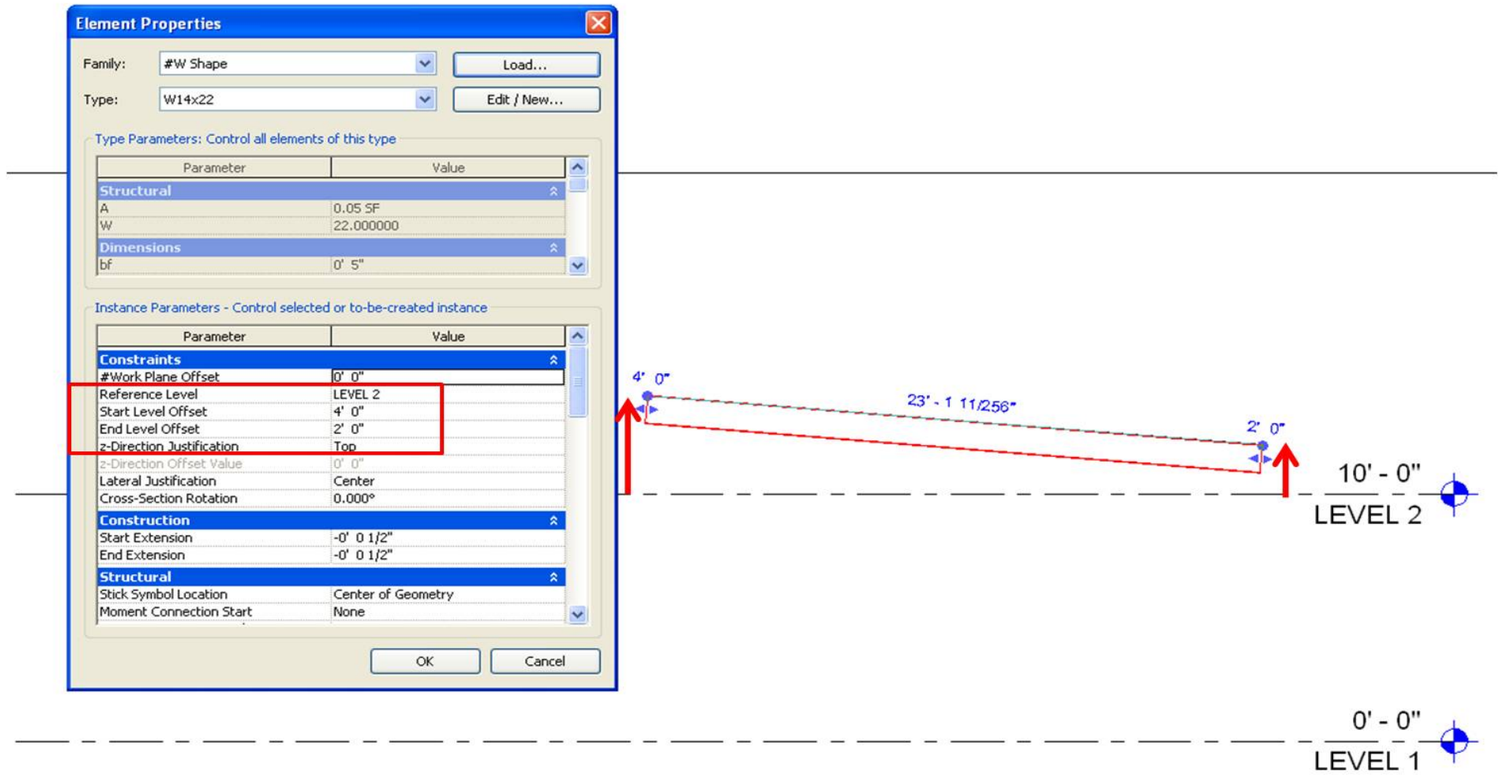
case B



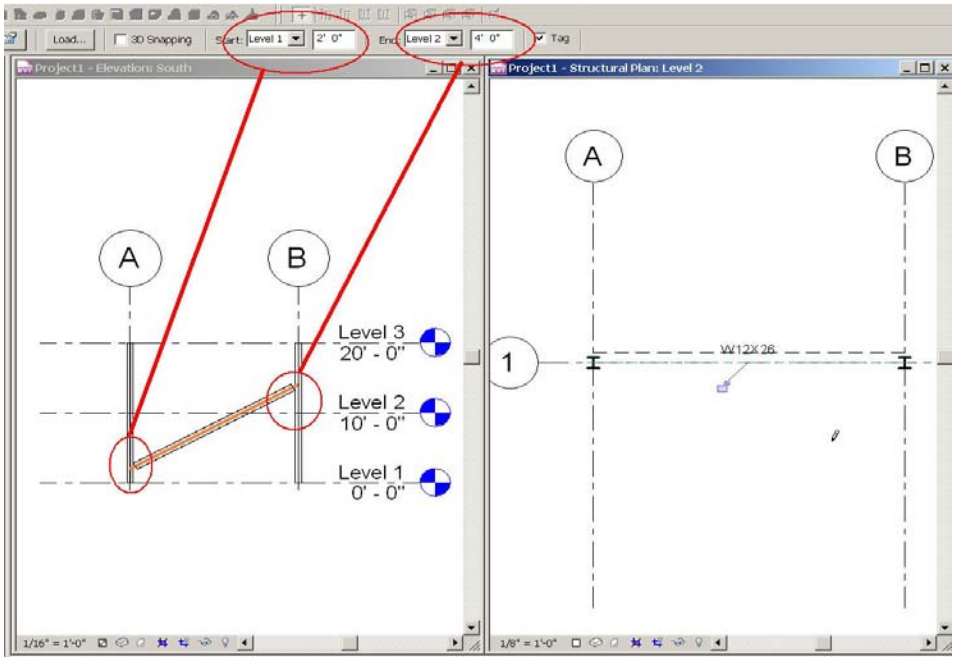
case C

Figs Beam Tab

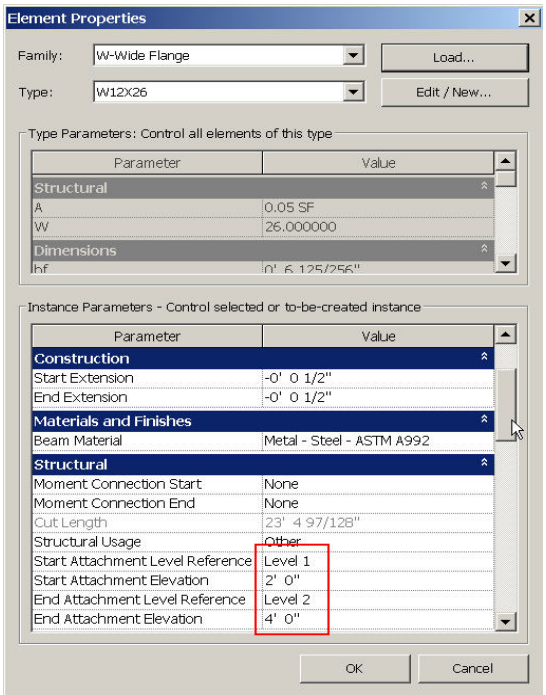
another illustration for case C



Examples for brace offsets to storys



example of storey assignments and offsets for braces



case A

Figs Brace Tab

APPENDIX C:
Geometry Attributes Matrix

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Open questions
1	**STORY**					
			Story Elevation	Absolute elevation for story (the name "story" is prefered over "level", as level is used in e.g. Revit beyond the meaning of story - e.g. for any horizontal reference level). There are two elevation values for each story: - the relative elevation of the story against the reference height of the project. - the absolute elevation of the story against the relevant sea level (or geographic height datum)	Typically, our elevations for a project are all relative to a base elevation that is generally set to +100'-0". So, in Florida, +100'-0" might be 3' above sea level. In Denver, Colorado, +100'-0" might be 5300' above sea level.	
			Story Name	Associated name for the story	Typical names are e.g. "foundation", "basement", "1st story", etc.	
2	**GRID**					
			Grid element			
			Grid layout	Geometric layout of the grid, set of horizontal and vertical planes with intersection between them.		
			Grid numbering	A string attached to each grid plane (or line) representing the plane (or line) label.	E.g. "A", "B", "1", "2", etc.	
			Reference to story	Reference to the story where the grid planes (or lines) appears on.		
3	**COLUMN**					
			Column axis	Definition axis of the column, used e.g. for determining the Cardinal point and as a first assumption for the linear structural member representing the column for structural analysis.		
			Profile Name	Name of the profile (or cross section) of the column. The naming convention, when applicable, should follow a yet-to-be-defined ACI naming convention.	Profile name is a string that represents a standard naming convention from a manual, handbook, or other external references. It is common in steel industry by using a AISC or CISC standard profile name. Some precast profiles have standard naming conventions, but most concrete profiles are not standarized. Name examples are (W14X90, 24X24).	ACI needs to define a naming convention for use.
			Material Name	Name of the material of the column. It should be an indicator of the type of material "concrete" and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: concrete, steel, timber, glass	
			Grade	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	ACI needs to define a standard naming standard for material grade.
			Length	Member length, it is software generated value that may be redundent to the length parameter embedded in the geometry representation. There are different length measurements, best described as quantities: - logical length between two joints - physical length of the actual column body Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	The logical length is a real length measure between the two joints and equal to the length of the column axis. The physical length is the length of the extrusion body (not taking cut-out's etc. into account). Having explicit real values is particularly important, if the geometry is not an extrusion (e.g. a boundary representation).	
			Roll	Member roll, software generated value that may be redundent to the placement and placement orientation parameters embedded in the geometric representation. Roll is the rotation of the column profile (and body) about a vertical axis for columns. Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	For example, for a 24x30 cast-in-place column, you have to know the orientation or roll of the column to know if the 30" dimension is pointing along x-axis or the y-axis (or somewhere in between).	
			Cardinal point	Offset of profile from longitudinal axis, essentially, it is the justification of the cross-section relatively to the working line between the two end joints. Note: propose to rename it from insertion point to cardinal point (to make it similar to the CIS/2 concept).	Cardinal point "lower-left", "center-right", etc.	
			Element ID	Unique identifier for element Note: Element ID is only for indexing model elements and used to uniquely identify elements that may have identical properties (length, profile, etc.). Element ID is typically defined by the modeling tool and the user should not be able to change this to ensure uniqueness.		
			Schedule Mark	Identifier for scheduling same profile elements Note: Schedule marks do not need to be unique. Schedule mark is typically defined by the user and named based on the elements location on a grid and/or the properties of that element (depth, length, number of reinforcing bars, etc.).	This is generally a short string that is provided on a plan adjacent to a column (for example "CC12"). The "CC12" is then defined in the column schedule. It is generally used as a unique identifier in the plans. So, a CC12 would be at a specific gridline (or gridlines) and is not the same as a CC11 or other mark.	

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Open questions
			Base Reference Story	Base location, reference to the story where the start point of the column resists. Start point is the lower point of the column axis.	This is e.g. a level as defined in "0. Level", from which the member starts. could we have an example drawing? CLICK FOR SCREEN SHOT EXPLANATION	
			Top Reference Story	Top location, reference to the story where the end point of the column resists. End point is the upper point of the column axis.	This is e.g. a level as defined in "0. Level", at which the member ends. could we have an example drawing? CLICK FOR SCREEN SHOT EXPLANATION	
			Base Offset	Offset from base level	This is a length describing the distance above a given level where a column starts. For example, steel columns when spliced are generally cut ~4'-0" above a floor level. So, the column above the splice would have a +4'-0" offset at its start.	
			Top Offset	Offset from top level	Also a length. In the example in the cell above, the lower column would have a top offset of +4'-0".	
4	**BEAM**					
			Beam Axis	Definition axis of the beam, used e.g. for determining the Cardinal point and as a first assumption for the linear structural member representing the column for structural analysis.		
			Profile Name	Name of the profile (or cross section) of the beam. The naming convention, when applicable, should follow a yet-to-be-defined ACI naming convention.	Profile name is a string that represents a standard naming convention from a manual, handbook, or other external references. It is common in steel industry by using a AISC or CISC standard profile name. Some precast profiles have standard naming conventions, but most concrete profiles are not standarized. Name examples are (W14X90, 24X24).	ACI needs to define a naming convention for use.
			Material Name	Name of the material of the beam. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass	
			Grade	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be capable to interpret all kinds of expressions.	ACI needs to define a standard naming standard for material grade.
			Length	Member length, it is software generated value that may be redundent to the length parameter embedded in the geometry representation. There are different length measurements, best described as quantities: - logical length between two joints - physical length of the actual column body Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	The logical length is a real length measure between the two joints and equal to the length of the column axis. The physical length is the length of the extrusion body (not taking cut-out's etc. into account). Having explicit real values is particularly important, if the geometry is not an extrusion (e.g. a boundary representation).	
			Roll	Member roll, software generated value that may be redundent to the placement and placement orientation parameters embedded in the geometric representation. Roll is the rotation of the column profile (and body) about a vertical axis for columns. Since these can be redundent to the geometry representation it is importent to keep them consistent and to guarantee that there is no inconsistency. They are provided in addition to the geometric representation.	For example, for a 24x30 cast-in-place column, you have to know the orientation or roll of the column to know if the 30" dimension is pointing along x-axis or the y-axis (or somewhere in between).	
			Cardinal point	Offset of profile from longitudinal axis, essentially, it is the justification of the cross-section relatively to the working line between the two end joints. Note: propose to rename it from insertion point to cardinal point (to make it similar to the CIS/2 concept).	Cardinal point "lower-left", "center-right", etc.	

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Open questions
			Element ID	Unique identifier for element Note: Element ID is only for indexing model elements and used to uniquely identify elements that may have identical properties (length, profile, etc.). Element ID is typically defined by the modeling tool and the user should not be able to change this to ensure uniqueness.		
			Schedule Mark	Identifier for scheduling same profile elements Note: Schedule marks do not need to be unique. Schedule mark is typically defined by the user and named based on the elements location on a grid and/or the properties of that element (depth, length, number of reinforcing bars, etc.).	This is generally a short string that is provided on a plan adjacent to a column (for example "CC12"). The "CC12" is then defined in the column schedule. It is generally used as a unique identifier in the plans. So, a CC12 would be at a specific gridline (or gridlines) and is not the same as a CC11 or other mark.	
			Base Reference Story	Base location, reference to the story where the start point of the beam resists. Start point is the lower point of the column axis.	This is e.g. a level as defined in "0. Level", from which the member starts.	
			Vertical Start Offset	Start offset in z direction, Same concept as vertical end offset but for the beam start point. The end offset is measured to the axis (or reference line) of the beam.	See figure for explanation	
			Vertical End Offset	End offset in z direction, vertical end offset is the offset distance of a beam endpoint from the insertion point (cardinal point) of that beam. The end offset is measured to the axis (or reference line) of the beam.	See figure for explanation	
5	**WALL**					
			Thickness	Dimensional thickness of the wall, applicable to standard wall, having a unique, not-changing thickness along the wall axis. Note: Typically, structural engineering packages doesn't support multiple layers for wall objects. We would define two walls separately.		
			Material Name	Name of the material of the wall. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass Note: It assumes that structural walls are single layer walls	
			Grade	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	ACI needs to define a standard naming standard for material grade.
			Wall Axis	Definition of the wall axis, used e.g. for determining the Alignment and as a first assumption for the linear structural member representing the wall for structural analysis.		

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Open questions
			Alignment	Alignment of the wall body relative to the wall axis.	Values could be an enumeration, like centerline, interior, exterior face, or an absolute value.	
			Base Reference Story	Base location, reference to the story where the start point of the wall resists. Base story is where the wall axis resists.	This is e.g. a level as defined in "0. Level", from which the member starts.	
			Top Reference Story	Top location, reference to the story where the end point of the column resists. End point is the upper point of the column axis.	This is e.g. a level as defined in "0. Level", at which the member ends.	
			Base Offset	Offset from base level	This is a length describing the distance above a given level where a wall starts.	
			Top Offset	Offset from top level	This is a length describing the distance above (or below) a given level where a wall ends.	
			Load bearing	Attribute associated to the wall as a disciplinary setting, indicates that the wall is designed to be load bearing.	Boolean value TRUE or FALSE for the wall.	
6	**SLAB**					
			Thickness	Dimensional thickness of the slab applicable to standard slab, having a unique, not-changing thickness. The thickness is the perpendicular thickness between the two upper/lower faces, not the extrusion thickness. Note: Typically, structural engineering packages doesn't support multiple layers for slab objects. We would define two walls separately.		
			Material Name	Name of the material of the slab. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass Note: It assumes that structural slabs are single layer slabs.	
			Grade	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	ACI needs to define a standard naming standard for material grade.
			Base Reference Story	Base location, reference to the story where the slab resists.	This is e.g. a level as defined in "0. Level", from which the member starts.	
			Base Offset	Offset from base story level. Base story offest is measured to the reference plane of the slab.	This is a length describing the distance above a given story where the slab reference level is located.	

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Open questions
			Span direction	Structural span direction, the span direction here is defining the orientation of the area object relative to the z-axis.		
7	**FOOTING**					
			Footing Type	A type classifer for footings, that further specifies the subtype (or functional type) of the footing.	Examples are: pad, strip, mat	
			Material Name	Name of the material of the footing. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass.	
			Grade	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	ACI needs to define a standard naming standard for material grade.
			Top Reference Story	Top location, reference to the story where the end point of the footing resists. End point is the upper face of the footing. Note: Similar to top reference story for columns. See screen shot in column section above.	Quote: "I don't understand how it would be queried from the shape. Is the footing object defined by multiple end joints? As opposed to having, say, a center point, a length, width, thickness and orientation?"	
			Bottom Elevation	Dimensional elevation or thickness of the footing	Quote: "I don't understand how it would be queried from the shape. Is the footing object defined by multiple end joints? As opposed to having, say, a center point, a length, width, thickness and orientation?"	
8	**PILE**					
			Pile Type	A type classifer for pile, that further specifies the subtype (or functional type) of the footing.	Example are: pile, caisson	
			Material Name	Name of the material of the pile. It should be an indicator of the type of material (steel, concrete, timber) and not any specific material name ("lightweight concrete type ABC"). Only the material name should be exchanged, not the material properties, like Density, Specific Weight, etc.	Example for type of material are: Concrete, steel, timber, glass.	
			Grade	Grade is a futher classifier for particular material. It often refers to items from external standards such as ASTM e.g. ASTM 36.	for example A36, ASTM36, GRADE36. The question is whether a standard expression is available. Receiving applicaion therefore must be cabale to interpret all kinds of expressions.	ACI needs to define a standard naming standard for material grade.
			Top Reference.Story	Dimensional elevation Note: Similar to top reference story for columns. See screen shot in column section above.	Quote: "This is just like the top and bottom levels above for columns. I don't see how this is queried from the shape."	
			Bottom Elevation	Dimensional elevation or thickness of the pile	Quote: "This is just like the top and bottom levels above for columns. I don't see how this is queried from the shape."	

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-81 implementation	Recommendation for further IFC development
1	**STORY**					Story diagram		
			Story Elevation	It is available as derived information from IFC. IfcSite.Elevation is the elevation about sea level using WGS84 IfcBuilding.ElevationOfRefHeight = Elevation above sea level of the reference height used for all storey elevation measures = all story elevation are given relative to this height. IfcBuildingStorey.Elevation = Elevation of the particular story against this reference height = Total height of story is Elevation + ElevationOfRefHeight	entities are part of the coordination view and certification, provision of these attributes is however not enforced.	Site + Building + BuildingStorey + SpatialDecomposition	add the support for geographic locations (latitude, longitude, elevation above sea level to the implementation scope as an enforcement of the coordination view.	
			Story Name	IfcBuildingStorey.Name, a string value to store the user/system defined name of the story. "Name" defined the story designator, In addition a "LongName" for a full text can be provided.	part of Coordination view and certification. Should already be in scope of all implementations.	VBL-025 VBL-171	add to implementation scope as an enforcement of the coordination view.	
2	**GRID**				Grid diagram			
			Grid element	currently the support of grids is not enforced in the coordination view, add support for IfcGrid to the coordination view (as it is needed for coordination).		verify support for IfcGrid assigned to different storeys	add a new entity IfcGrid3D to IFC2x4	
			Grid layout					
			Grid numbering					
			Reference to story					
3	**COLUMN**					Column diagram		
			Column axis	Additional IfcShapeRepresentation with RepresentationType = Axis. The IfcGeometricRepresentationItem is a single IfcPolyline (or IfcTrimmedCurve with BaseCurve IfcLine, or IfcCircle)	Currently not enforced in the coordination view.	"Axis Definition"		
			Profile Name	For all parametric profiles and all extrusion based profiles it is currently provided as a single string value - IfcProfileDef.ProfileName. Need some additional agreement where a section designator (plus eventually a section table name) goes in IFC file for any type of geometry representation, e.g. in case of BREP or SurfaceModels.	The entity IfcProfileDef (it's subtypes) is already required as part of the Coordination view and certification. Filling the attribute ProfileName (with sensible values) is however not yet enforced. It should be enforced, if such information is available in the authoring tool.	"Profile Definition" - see also "Single Value Property Definition"	use the "Profile Definition" agreement for all SweptSolid's. Add to implementation scope as an enforcement of the coordination view.	add a general place to find a profile name and section table name independently of the profile geometry. For now profile names should be passed as a property set, as it cannot be added to a brep column. Better support to be added in IFC2x4
			Material Name	IfcMaterial.Name - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)	Support of IfcMaterial.Name is part of the coordination view and enforced. A separate field for the material category is not yet provided.	VBL-345 VBL-265	Support of material name added to implementation scope as an enforcement of the coordination view.	Add a second attribute in IFC2x4 to differentiate a user name for any material and the material category.
			Grade	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by IfcMaterial.(INV)ClassifiedAs and IfcClassificationReference.	Not part of the coordination view. Can be added for this testbed.	"Material Grade"	Support of material classification added to implementation scope.	
			Length	Lenght is perceived in IFC as a quantity, i.e. it is a measurement taken from the geometry that should be exchanged in addition to the geometric representation. Such quantities should be added for downstream applications (not having an own geometric kernel). In this use case it could be expected from the receiving application to reestablish: - (physical) length from the extrusion length - logical length from the length of the axis representation Simple Quantity (using IfcQuantityLength with the Name 'Length'), optionally a "LogicalLength" can be supported in addition.	export of quantities are part of the "QTO view", which is an add-on to the coordination view (and not a part). export of an additional axis representation of the column is currently optional in the coordination view.	"Simple Quantity" also see QTO implementation guide.	Export of quantities is in scope of the QTO addon view. It should be added to implementation scope.	
			Roll	Roll is a redundent information given in addition to the geometric representation, but helpful for analysing the model, it should be provided as a property, similar to the Span property in Pset_ColumnCommon	Currently not part of the Pset_ColumnCommon, should be added as a new property. Can be added for this testbed.	"Single Value Property Definition"	Single Value Property Definition (principle of property definition that is needed here, property name would be 'Roll' with an value of the type IfcPlaneAngleMeasure; IfcPropertySet.Name = 'Pset_ColumnCommon')	add Roll to Pset_ColumnCommon for IFC2x4
			Cardinal point		The cardinal point is currently not supported in IFC2x3, ist support is already proposed for IFC2x4.	- not in 2x3 -	not included, new schema IFC2x4 is required to support it.	add CardinalPoint to IFC2x4 as part of the new material-profile definition.
			Element ID	the element-id is not identical to the GUID, it is a unique number, given by the exporting software system, like a handle. The IFC representation is IfcColumn.Tag - see ist definition: Tag : The tag (or label) identifier at the particular instance of a product, e.g. the serial number, or the position number. It is the identifier at the occurrence level.	Currently supported in an ambiguous way, e.g. as part of the IfcColumn.Name - need to be unified.		Provide an unambiguos way to export the element ID, recommended is IfcColumn.Tag.	
			Schedule Mark	the schedule mark is also regarded as reference id, or construction type id - it is already included in IFC as Pset_ColumnCommon.Reference	Currently not supported in an unambiguous way.		Provide an unambiguos way to export the schedule mark by using Pset_ColumnCommon.Reference	

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-81 implementation	Recommendation for further IFC development
			Base Reference Story	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, ...) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
			Top Reference Story	May evaluate the containment information and the spatial structure. Requires to follow some references and may to check the geometry (length and offset of the column, reference high of the building storeys).	Not currently supported in the coordination view, the IFC relationship, IfcRelReferencedInSpatialStructure would support it, but would need to be added to the coordination view.	"Spatial Reference"	Propose an addition to the view definition with an implementation guideline for capturing the top reference storey.	
			Base Offset	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets (1) offset of the base reference to the local placement of the building story + 2) offset of the local placements of the building story and the building element + 3) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			
			Top Offset	see Base Offset and Top Reference.Story	depends on the clarification of the above requirements			
4	**BEAM**					Beam diagram		
			Beam Axis	Additional IfcShapeRepresentation with RepresentationType = Axis. The IfcGeometricRepresentationItem is a single IfcPolyline (or IfcTrimmedCurve with BaseCurve IfcLine, or IfcCircle)	Currently not enforced in the coordination view.	"Axis Definition"		
			Profile Name	For all parametric profiles and all extrusion based profiles it is currently provided as a single string value - IfcProfileDef.ProfileName. Need some additional agreement where a section designator (plus eventually a section table name) goes in IFC file for any type of geometry representation, e.g. in case of BREP or SurfaceModels.	The entity IfcProfileDef (it's subtypes) is already required as part of the Coordination view and certification. Filling the attribute ProfileName (with sensible values) is however not yet enforced. It should be enforced, if such information is available in the authoring tool.	"Profile Definition" - see also "Single Value Property Definition"	use the "Profile Definition" agreement for all SweptSolid's. Add to implementation scope as an enforcement of the coordination view.	add a general place to find a profile name and section table name independently of the profile geometry. For now profile names should be passed as a property set, as it cannot be added to a brep beam. Better support to be added in IFC2x4
			Material Name	IfcMaterial.Name - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)	Support of IfcMaterial.Name is part of the coordination view and enforced. A separate field for the material category is not yet provided.	VBL-345 VBL-265	Support of material name added to implementation scope as an enforcement of the coordination view.	Add a second attribute in IFC2x4 to differentiate a user name for any material and the material category.
			Grade	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by IfcMaterial.(INV)ClassifiedAs and IfcClassificationReference.	Not part of the coordination view. Can be added for this testbed.	"Material Grade"	Support of material classification added to implementation scope.	
			Length	Lenght is perceived in IFC as a quantity, i.e. it is a measurement taken from the geometry that should be exchanged in addition to the geometric representation. Such quantities should be added for downstream applications (not having an own geometric kernel). In this use case it could be expected from the receiving application to reestablish: - (physical) length from the extrusion length - logical length from the length of the axis representation Simple Quantity (using IfcQuantityLength with the Name 'Length'), optionally a "LogicalLength" can be supported in addition.	export of quantities are part of the "QTO view", which is an add-on to the coordination view (and not a part). export of an additional axis representation of the column is currently optional in the coordination view.	"Simple Quantity" also see QTO implementation guide.	Export of quantities is in scope of the QTO addon view. It should be added to implementation scope.	
			Roll	Roll is a redundent information given in addition to the geometric representation, but helpful for analysing the model, it should be provided as a property, similar to the Span property in Pset_ColumnCommon	Currently not part of the Pset_ColumnCommon, should be added as a new property. Can be added for this testbed.	"Single Value Property Definition"	Single Value Property Definition (principle of property definition that is needed here, property name would be 'Roll' with an value of the type IfcPlaneAngleMeasure; IfcPropertySet.Name = 'Pset_ColumnCommon')	add Roll to Pset_ColumnCommon for IFC2x4
			Cardinal point		The cardinal point is currently not supported in IFC2x3, ist support is already proposed for IFC2x4.	- not in 2x3 -	not included, new schema IFC2x4 is required to support it.	add CardinalPoint to IFC2x4 as part of the new material-profile definition.

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-81 implementation	Recommendation for further IFC development
			Element ID	the element-id is not identical to the GUID, it is a unique number, given by the exporting software system, like a handle. The IFC representation is IfcBeam.Tag - see ist definition: Tag : The tag (or label) identifier at the particular instance of a product, e.g. the serial number, or the position number. It is the identifier at the occurrence level.	Currently supported in an ambiguous way, e.g. as part of the IfcBeam.Name - need to be unified.		Provide an unambiguos way to export the element ID, recommended is IfcBeam.Tag.	
			Schedule Mark		Currently not supported in an unambiguous way.		Provide an unambiguos way to export the schedule mark by using Pset_BeamCommon.Reference	
			Base Reference Story	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.		Propose an addition to the view definition with an implementation guideline for capturing the top reference storey.	
			Vertical Start Offset	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets 1) offset of the local placements of the building story and the building element + 2) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.		Add an implematation guide on how to re-generate the offset exported as part of the local placement and geometric representation.	
			Vertical End Offset	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets 1) offset of the local placements of the building story and the building element + 2) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.		Add an implematation guide on how to re-generate the offset exported as part of the local placement and geometric representation.	
5	**WALL**					Wall diagram		
			Thickness	The thickness of a wall can be stored in two ways: 1) as element quantity - NominalWidth (see also IAI definition of IfcWall) 2) For standard walls (definable with vertical extrusion and single/constant thickness) the thickness can be deduced from the material definition. It is agreed that the material of standard walls is defined by IfcMaterialLayerSetUsage and IfcMaterialLayerSet, which define the Alignment and the total Thickness of the wall. Please note that IfcMaterialLayerSet.TotalThickness is a derived attribute and thus not stored in an IFC file (it is defined as sum of all layer thicknesses). Consequently, reading IFC files means to calculate the total thickness from the wall layers -> TotalThickness = IfcMaterialLayerSet.MaterialLayers[1].LayerThickness + IfcMaterialLayerSet.MaterialLayers[2].LayerThickness + IfcMaterialLayerSet.MaterialLayers[...].LayerThickness + IfcMaterialLayerSet.MaterialLayers[n].LayerThickness;	IfcWallStandardCase + IfcMaterialLayerSetUsage is part of the coordination view.	1) "Simple Quantity" (NominalWidth) or 2) "Material Layer Definition" (sum of all layer thicknesses)		
			Material Name	Material is defined for each layer. In case of a single layer wall there is only one instance of IfcMaterial capturing the material name. For single layer walls the material name can be accessed as follows: IfcWallStandardCase.(INV)HasAssociations -> IfcRelAssociatesMaterial.RelatingMaterial -> IfcMaterialLayerSetUsage.ForLayerSet -> IfcMaterialLayerSet.MaterialLayers[1] -> IfcMaterialLayer.Material -> IfcMaterial	Support of IfcMaterial.Name is part of the coordination view and enforced. A separate field for the material category is not yet provided.	VBL-345 VBL-265	Support of material name added to implementation scope as an enforcement of the coordination view.	Add a second attribute in IFC2x4 to differentiate a user name for any material and the material category.
			Grade	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by IfcMaterial.(INV)ClassifiedAs and IfcClassificationReference.	Not part of the coordination view. Can be added for this testbed.	"Material Grade"	Support of material classification added to implementation scope.	
			Wall Axis	Additional IfcShapeRepresentation with RepresentationType = Axis. The IfcGeometricRepresentationItem is a single IfcPolyline (or IfcTrimmedCurve with BaseCurve IfcLine, or IfcCircle)		"Axis Definition"		

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-81 implementation	Recommendation for further IFC development
			Alignment	The wall body is defined by IfcShapeRepresentation with RepresentationType = Body. The IfcGeometricRepresentationItem is a swept solid representation or a CSG. Both representation types, the wall axis and the body representation, use the same coordinate system (IfcWall.ObjectPlacement) enabling to deduce the alignment of the wall body relative to the wall axis. Alternatively, the alignment can be read (without geometric calculations) from the material layer settings (IfcMaterialLayerSetUsage.OffsetFromReferenceLine). The reference line is the wall axis. The offset is given for the selected axis (IfcMaterialLayerSetUsage.LayerSetDirection) and direction (IfcMaterialLayerSetUsage.DirectionSense).		"Material Layer Definition" (OffsetFromReferenceLine)		
			Base Reference Story	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, ...) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
			Top Reference Story	May evaluate the containment information and the spatial structure. Requires to follow some references and may to check the geometry (length and offset of the wall, reference high of the building storeys).	Not currently supported in the coordination view, the IFC relationship, IfcRelReferencedInSpatialStructure would support it, but would need to be added to the coordination view.	"Spatial Reference"	Propose an addition to the view definition with an implementation guideline for capturing the top reference storey.	
			Base Offset	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets (1) offset of the base reference to the local placement of the building story + 2) offset of the local placements of the building story and the building element + 3) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			
			Top Offset	see Base Offset and Top Reference.Story	depends on the clarification of the above requirements			
			Load bearing	Stored in the property set Pset_WallCommon, with the name LoadBearing = TRUE or FALSE.		"Single Value Property Definition"		
6	**SLAB**					Slab diagram		
			Thickness	The thickness of a slab can be stored in two ways: 1) as element quantity - NominalWidth (see IAI definition of IfcSlab) 2) For standard slabs (constant thickness along the extrusion direction) the thickness can be deduced from the material definition. It is agreed that the material of standard slabs is defined by IfcMaterialLayerSetUsage and IfcMaterialLayerSet, which define the Alignment and the total Thickness of the slab. Please note that IfcMaterialLayerSet.TotalThickness is a derived attribute and thus not stored in an IFC file (it is defined as sum of all layer thicknesses). Consequently, reading IFC files means to calculate the total thickness from the slab layers -> TotalThickness = IfcMaterialLayerSet.MaterialLayers[1].LayerThickness + IfcMaterialLayerSet.MaterialLayers[2].LayerThickness + IfcMaterialLayerSet.MaterialLayers[...].LayerThickness + IfcMaterialLayerSet.MaterialLayers[n].LayerThickness;	Included in the coordination view for the correct setting of material layer definitions. Use of single quantity is part of the quntity take-off addon view.	1) "Simple Quantity" (NominalWidth) or 2) "Material Layer Definition" (sum of all layer thicknesses)	Include and verify it.	
			Material Name	Material is defined for each layer. Single layer slabs have only one instance of IfcMaterial and thus only one material name. The material name can be accessed as follows: IfcWallStandardCase.(INV)HasAssociations -> IfcRelAssociatesMaterial.RelatingMaterial -> IfcMaterialLayerSetUsage.ForLayerSet -> IfcMaterialLayerSet.MaterialLayers[1] -> IfcMaterialLayer.Material -> IfcMaterial		VBL-345 VBL-265	Include and verify it.	
			Grade	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by IfcMaterial.(INV)ClassifiedAs and IfcClassificationReference.		"Material Grade"		
			Base Reference Story	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, ...) to spatial structure elements (typically the building story).	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
			Base Offset	The offset can be calculated from the element geometry. Please note that building elements (column, beam, wall, slab) are typically placed relative to their spatial container (see Base Reference.Story) so that offset calculation is often very simple. However, the most general case might requires a sum of some offsets (1) offset of the base reference to the local placement of the building story + 2) offset of the local placements of the building story and the building element + 3) offset of the base level of the building element to its local placement) and coordinate transformations.	The information itself (reference to storey, relative placement to storey and placement of column extrusion body within the object placement) is part of the coordination view. It has however not be verified nor enforced to be interpreted as vertical base offset.			

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-81 implementation	Recommendation for further IFC development
			Span direction	Currently there is no attribute for storing the span direction(s).			do not include - requires IFC schema additions	recommend the addition of a span direction attribute to IFC
7	**FOOTING**					Footing diagram		
			Footing Type	Defined by IfcFooting.PredefinedType; following types are available: - FOOTING_BEAM - PAD_FOOTING - PILE_CAP - STRIP_FOOTING - USERDEFINED - NOTDEFINED	Included in the coordination view, but correct setting of the pile enumeration not enforced.		Check the current setting ot the pile type in IFC exchanges for benchmarking.	
			Material Name	IfcMaterial.Name - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)		VBL-345 VBL-265	Include and verify it.	
			Grade	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by IfcMaterial.(INV)ClassifiedAs and IfcClassificationReference.		"Material Grade"		
			Top Reference Story	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story). Note: it is the reference storey (the term "top" is not preserved in the exchange)	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
			Bottom Elevation	Equal to the extrusion lenght parameter of the footing				
8	**PILE**					Pile diagram		
			Pile Type	Defined by IfcPile.PredefinedType; following types are available: - COHESION - FRICTION - SUPPORT - USERDEFINED - NOTDEFINED	Included in the coordination view, but correct setting of the pile enumeration not enforced.		Check the current setting ot the pile type in IFC exchanges for benchmarking.	
			Material Name	IfcMaterial.Name - it is currently the only string value applicable for material name. There is no distinction between a material name as general name and material category (steel, column, timber, etc.)		VBL-345 VBL-265	Include and verify it.	
			Grade	Currently there is no specific attribute for grade, it should be handled by material classification (grade name "36"and referenced standard "ASTM". It would be represented by IfcMaterial.(INV)ClassifiedAs and IfcClassificationReference.		"Material Grade"		
			Top Reference.Story	Is used for the containment information, i.e. the assignment of building elements (column, beam, wall, slab, …) to spatial structure elements (typically the building story). Note: it is the reference storey (the term "top" is not preserved in the exchange)	Supported by the coordination view. It might not show up in the GUI of the receiving application - in this case implementation has to be improved.	"Spatial Container"	Include and verify it.	
			Bottom Elevation					

APPENDIX D:
Reinforcement Attributes Matrix

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Open questions

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-81 implementation	Recommendation for further IFC development

APPENDIX E: Concrete Materials Attributes Matrix

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Open questions

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-81 implementation	Recommendation for further IFC development

APPENDIX F:
Project Management Attributes Matrix

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Open questions

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-81 implementation	Recommendation for further IFC development

APPENDIX G:
Formwork Attributes Matrix

Number	Object Category	Priority	Attribute Name	Explanation	Examples	Open questions

Number	Object Category	Priority	Attribute Name	IFC representation of the exchange	Status of IFC implementation, model view definition, certification process	MVD name	Recommendations for ATC-81 implementation	Recommendation for further IFC development