ATC-75

Development of IFCs for the Structural Domain

Work Session 001 Report

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Initial Release

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The ATC-75 Project Management Committee (PMC) held the first of three planned work sessions. The primary objectives of this work session was to formulate the User Requirements / Business Process (UR/BP), define and prioritize the object category attributes for IFC exchanges, establish Model View Definition Formats, and plan the work required to reach the next work session.

This work session report summarizes the issues discussed and broad conclusions and directions reached by the PMC in those discussions.

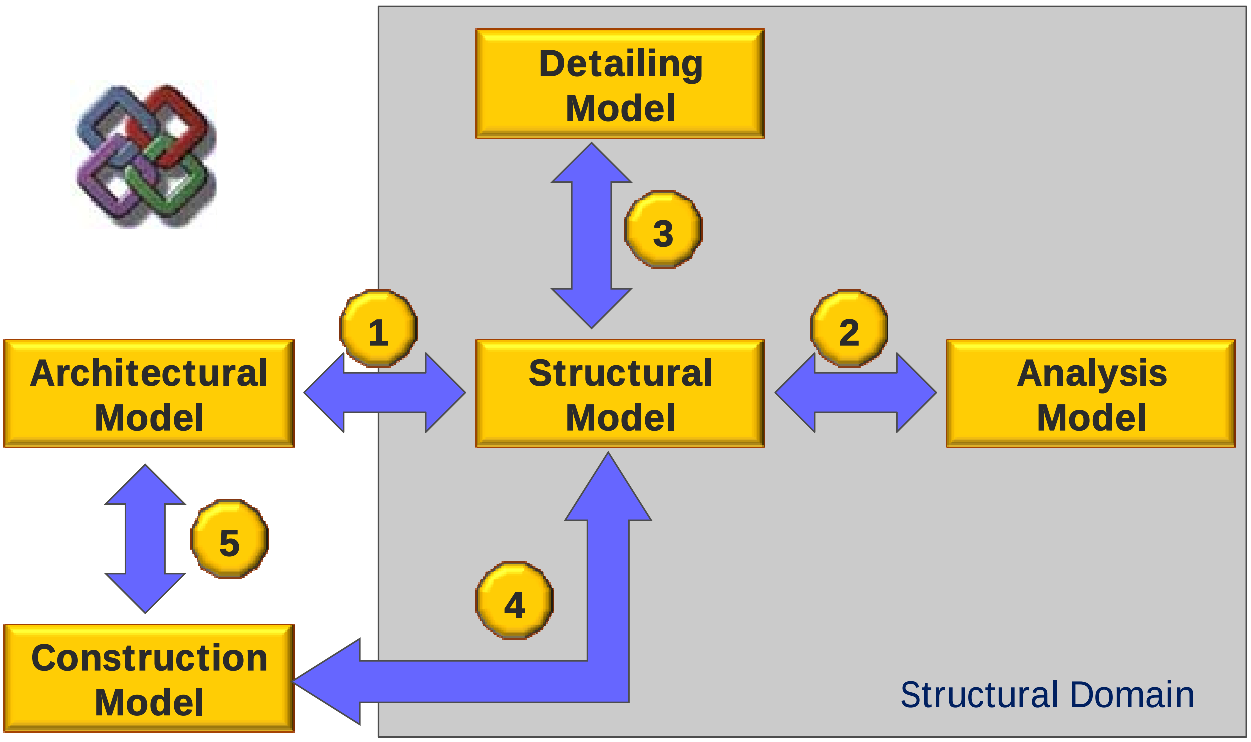

Figure 1: IFC Exchange Pathways

Test Bed for IFC Exchange

The PMC has developed a Test Bed Model. The structural test bed model is intended to incorporate a rich diversity of structural element types with a broad geometric complexity. Its role is to provide a robust test of IFC transfers. The model is generated *natively* in three BIM models, Tekla (v13), Revit (v2008) and Bentley Structures[1] (v). Each of the models is then used to generate an IFC output that is imported into three broad categories of software: (1) other BIM programs, (2) a variety of analysis software packages and (3) into a generic IFC viewer. The purposes of each of these export-import, IFC transfers is to test, for each of 8 defined object categories, i.e. columns, beams, braces, etc… the results of the exchange. In the case of the transfer to the generic viewer the objective is to test the fidelity of the IFC generated[2]. The tactic used in generating the IFC exchanges was taken as that of a pragmatic "average" user executing the exchanges through the various pull down menu options afforded for this purpose. This approach was used to better gauge the practical exchange applications that would be expected in actual practice. A number of the software representatives are now examining the exchange faults to determine if they are the result of export, import or miss-application.

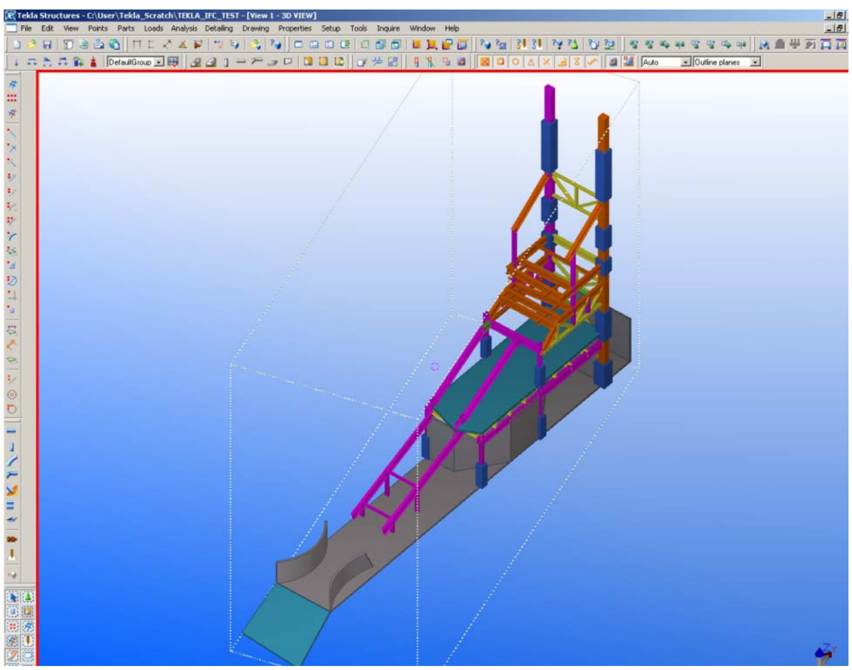

Figure 2: Perspective View of Test Bed Model

The results of all of the IFC transfer tests are being compiled in a test bed report that defines the details of the model, IFC exchange and the process used. The results are compiled in a comprehensive electronic

[1] It was agreed at the work session that E. Hatfield would also create a Bentley Structural model of the test bed.

[2] R. Lipman, NIST also has an IFC extraction program that operates in excel to provide visibility of the specifics of the IFC export content. This program is available for download at http://cic.nist.gov/vrml/cis/download/IFC_Excel.zip

spreadsheet that interactively ties the test with summary result, including graphical illustration of the IFC transfer issues encountered. Gaining a broad quantifiable assessment of the state of current IFC exchanges is imperative for understanding where exchange fidelity is lacking and what improvements are needed in order to support software interoperability. The active support of the software representatives develops a working process to examine and resolve the present IFC exchange disconnects and build toward development of robust IFC exchange protocols.

Business Process / User Requirements

The BP/UR is being developed to define the business use cases for the IFC exchanges. The highest priority is being given to the exchange of geometry and element properties. This focus was affirmed by the work session participants. While the exchange of geometry was found to be fairly complete, the loss of property data in a number of the IFC exchanges was quite profound. The exchange of geometry and property data transcends all of the exchanges within the structural domain between the structural model and the analysis and detailing models and outside the structural domain with the architectural and construction model. For this reason the reliable exchange of this data is the most basic of information that must be shared and is justifiable the highest priority.

The Business Processes and Business Rules as a pilot document to formalize existing practices and establish a precedent for how data will be exchanged in the future throughout the life of a project. It should serve to state what the expectations of the industry of structural engineering are, and leave it to the software providers to accommodate as they see fit. The Business Rules will define what is relevant to and expected of a specific data element.

In order to accelerate the development of a function IFC exchange a strategy was developed to effect an IFC exchange for the highest priority object categories. The project has so far been structured around specific use cases in relation to the Business Processes and Business Rules diagram under development. The IFC exchange cases were to be developed from this set. The group decided on an approach first developing a general/universal use case, which requires basic geometric properties exchange with 100% fidelity. This use case will be treated as a first-phase project, with T. Liebich developing model view definitions and the software vendors attempting to accommodate the new definitions in a testing phase in November 2008. The team will supply definitions to T. Liebich as soon as possible and he will work to create the new files by June 2008, which will be provided to the software vendors at that time. Once the data has been handed off to T. Liebich, the PMC will begin the next use case.

Exchanges between the physical and analytical model is not included in business process. It was thought that the exchange with analytical modeling software is unrealistic until the first level of basic geometry and property exchange is achieved. There are also reservations at the idea of automatic exchange of information into the physical model, and noted that most engineers prefer to keep a watch on the implications of variable changes rather than allow software to make automatic changes. Additionally, current practice many times dictates that several models be maintained simultaneously, and they each contain specific sets of data. Combined, they become too large to manage and use productively, and much of the information they contain is irrelevant to users of the physical model. Additionally there is often information to be updated in a physical model that is not important in an analytical model. There are various barriers to the exchange of data between the physical and analytical models. Primarily, there is not a 1:1 ratio of information in the two types of models.

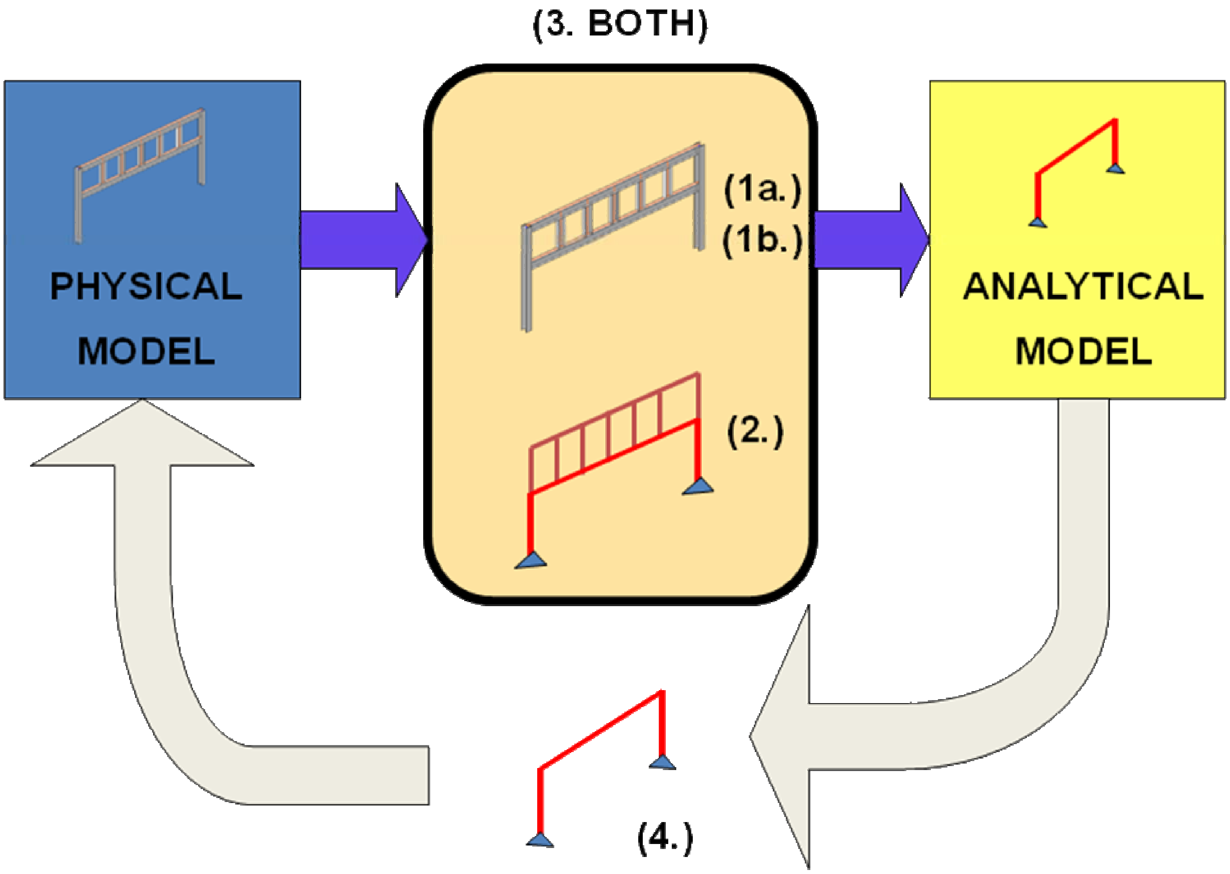

Figure 3: Analytical Model Transfer for IFC

Figure3 illustrates schematically the relationship and steps that would be required to communicate between a physical and analytical model. Typically the physical model has accurate and complete geometric information whereas the analytical representation of this geometric information may include many simplifications as shown for this Truss Frame. The physical model can produce a physical IFC representation as in 1, which then will need to be interpreted by the analytical application and with user input converted into an appropriate analytical model. Alternatively the physical model could also contain an analytical representation (Bentley and Revit approach) which can then be communicated through IFC as in 2 below. In the later case an appropriate option is to include both analytical and physical information in the IFC exchange (3) and allow the consuming application to use the model information they care about. However, as IFC is purely a data exchange format, the ability to maintain associations between the physical and analytical IFC models, or to create one from the other, would be the responsibility of the consuming application. While this project is focused on defining the structural physical model IFC requirements, the work is also ongoing (**in Europe) to establish the IFC structural analytical model MVD and data requirements.

IFC Development

The team created a spreadsheet of attributes to be exchanged and ranked them by primary, secondary, tertiary (etc) value. Those ranked as primary are considered vital to the newly constructed "basic user" case. Further breakdown of the matrix of attributes ranked them in a subset manner. The document should include both attributes that are important now and attributes that may become useful in the future. Construction scheduling information, cost estimating information, finishes and LEED parameter were some of the types of attributes proposed. Additionally, parameters will be set aside for user-defined fields are supported by some software systems. As a user-defined field these parameter are not necessarily exported, and if exported are not necessarily consistently imported.

The Exchange Requirement Definition format from Pankow Precast Concrete project will be adopted for this project. It should contain in plain language what is expected by a user in an IFC exchange. T. Liebich will not require the inclusion of the Data Type column. Object, Attributes and Remarks will suffice. The Remarks column will be populated with requirements about the Object, and does not need to be rigidly defined.

One important consideration is the consistency of IFC interpretation expectations between the various ongoing projects of this nature, for example, the Precast Concrete project whose documents are being referenced by this group. It is vital that there is agreement between the various domains, so that software vendors are able to accommodate all users. BuildingSMART is the organization that will keep the definitions in line between groups.

Dissemination Work Plan

The PMC reviewed the draft dissemination work plan, dated March 20, 2008. The basic work plan was agreed to be sound. The appendices in the document will be populated with dissemination opportunities: groups/organizations and their events, and publications and their publishing deadlines. The PMC worked in the meeting to populate the document with organizations and publications, and will specify events and publication deadlines associated with each targeted group for tracking. As the document is matured and revised, dissemination opportunities will be updated with notes about participation, publication, speaking engagements, etc., which will provide a measure for how well the project is reaching the target audiences.

Strategic Work Plan

The PMC discussed extensively the strategy for developing the IFC exchanges. The consensus of the group was to adopt a slightly different approach than was originally proposed in order to deliver definitive results in short order. The concept going forward is to push for the development o f.

END OF REPORT

Appendix A: Work Session Participants

Appendix B: Work Session Meeting Notes

Appendix C: Object Category Attribute Priority Summary

Appendix D: Exchange Requirement Form

Appendix A: Work Session Participants

Name	Firm
Edwin Dean	Nishkian Dean (Lead Technical Consultant)
Michelle Anderson	Nishkian Dean (Lead Technical Consultant)
Francois Grobler	ASACE (Project Advisory Panel)
Thomas Liebich	aec3 (IFC Consultant)
Aaron White	Walter P. Moore (PMC – ENG)
Erleen Hatfield	Thornton-Tomasetti (PMC – ENG)
Ken Murphy	Thornton-Tomasetti (PMC – ENG)
Robert Lipman	NIST (PMC – ENG)
Hyunjoo Kim	Post-Doc Research Asst (to F. Grobler, PAP)
Chi Ng	Gehry Technologies (PMC – SW)
Frank Wang	Tekla (PMC – SW)
Raoul Karp	Bentley Systems (PMC – SW)

Appendix C: Object Category Attribute Priority Summary

Object Category	PRIORITY #	Attribute Name	Remarks, Business Rule
0. LEVEL	2	ELEVATION	Absolute elevation for floor/story
	2	LEVEL NAME	Associated name for level, foundation, basement etc.
0. GRID	2	Number	Grid number
	2	LEVELS	Level grid line appears on
1. COLUMN	1	**PROFILE (W14X90, 24X24)**	Follow AISC naming
	1	**MATERIAL**	Concrete, steel, timber
	1	**GRADE**	astm, ETC.
	1	***LENGTH***	*Member length, software generated req.*
	1	***ROLL***	*Member roll, software generated req.*
	1	**ELEMENT ID**	Unique identifier for element
	1	**INSERTION POINT**	Offset of profile from longitudinal axis
	2	*BASE REF. LEVEL*	*Base location*
	2	*TOP REF. LEVEL*	*Top location*
	2	*BASE OFFSET*	*Offset from base level*
	2	*TOP OFFSET*	*Offset from top level*
	2	SCHEDULE MARK	Identifier for scheduling same profile elements
	3	FINISH	Fireproofing, paint, primer etc.
	3	COST CODES	Placeholder for associated pricing code
	3	SEQUENCING 1,2,3	Sequence of construction for phasing
	3	FORMWORK CODE	Formwork code
	3	OPENINGS	Copes, cutouts, web openings
	3	CAMBER	Camber of column
	3	SHEAR STUDS	[40] number of studs
	3	INSPECTION CODE	Code required for inspection
	3	PRIMARY/SECONDARY	Miscellaneous or structural steel
	3	LEED DESIGNATOR	LEED information
	3	TRIM PLANES	Display of member cutbacks
	5	BASE PLATE	Type
	5	SPLICE LOCATION	Dimension above level
	5	REINFORCING	Reinforcing information
	6	RFI	Associated element RFI
2. BEAM	1	**PROFILE**	Follow AISC naming
	1	**MATERIAL**	Concrete, steel, timber
	1	**GRADE**	astm, ETC.
	1	***LENGTH***	*Cut length/actual length, software generated req.*

Object Category	PRIORITY #	Attribute Name	Remarks, Business Rule
	1	**ROLL**	Member roll
	1	**ELEMENT ID**	Unique identifier for element
	1	**INSERTION POINT**	Offset of profile from longitudinal axis
	2	REF. LEVEL	Closest reference level
	2	OFFSETS	vertical offset from level
	2	*VERTICAL END OFFSET*	*End offset in z direction*
	2	*VERTICAL START OFFSET*	*Start offset in z direction*
	2	SCHEDULE MARK	Identifier for scheduling same profile elements
	2	VERTICAL START OFFSET	Start offset in z direction
	3	FINISH	Fireproofing, paint, primer etc.
	3	COST CODES	Placeholder for associated pricing code
	3	SEQUENCING 1,2,3	Sequence of construction for phasing
	3	FORMWORK CODE	Formwork code
	3	OPENINGS	Copes, cutouts, web openings
	3	CAMBER	Camber of column
	3	SHEAR STUDS	[40] number of studs
	3	INSPECTION CODE	Code required for inspection
	3	PRIMARY/SECONDARY	Miscellaneous or structural steel
	3	LEED DESIGNATOR	LEED information
	3	TRIM PLANES	Display of member cutbacks
	3	SHEAR END	v45
	3	SHEAR START	v45
	3	START CONNECTION	Moment, fitted etc
	3	END CONNECTION	Moment, fitted etc
	5	REINFORCING	Reinforcing information
	6	RFI	Associated element RFI
3. BRACE	1	**PROFILE**	Follow AISC naming
	1	**MATERIAL**	Concrete, steel, timber
	1	**GRADE**	astm, ETC.
	1	***LENGTH***	*Cut length/actual length, software generated req.*
	1	**ROLL**	Member roll
	1	**ELEMENT ID**	Unique identifier for element
	1	**INSERTION POINT**	Offset of profile from longitudinal axis
	2	REF. LEVEL	Closest reference level
	2	*BASE REF. LEVEL*	*Base location*
	2	*TOP REF. LEVEL*	*Top location*
	2	OFFSETS	vertical offset from level
	2	*VERTICAL END OFFSET*	*End offset in z direction*

Object Category	PRIORITY #	Attribute Name	Remarks, Business Rule
	2	*VERTICAL START OFFSET*	*Start offset in z direction*
	2	SCHEDULE MARK	Identifier for scheduling same profile elements
	2	VERTICAL START OFFSET	Start offset in z direction
	3	FINISH	Fireproofing, paint, primer etc.
	3	COST CODES	Placeholder for associated pricing code
	3	SEQUENCING 1,2,3	Sequence of construction for phasing
	3	FORMWORK CODE	Formwork code
	3	OPENINGS	Copes, cutouts, web openings
	3	CAMBER	Camber of column
	3	SHEAR STUDS	[40] number of studs
	3	INSPECTION CODE	Code required for inspection
	3	PRIMARY/SECONDARY	Miscellaneous or structural steel
	3	LEED DESIGNATOR	LEED information
	3	TRIM PLANES	Display of member cutbacks
	3	SHEAR END	v45
	3	SHEAR START	v45
	3	START CONNECTION	Moment, fitted etc
	3	END CONNECTION	Moment, fitted etc
	5	REINFORCING	Reinforcing information
	6	RFI	Associated element RFI
4.WALL		**THICKNESS**	Dimensional thickness
		MATERIAL	Concrete steel etc
		GRADE	astm, ETC.
		ALIGNMENT	Centerline, interior, exterior face
		BASE LEVEL	base level
		TOP LEVEL	top level
		BASE OFFSET	*Offset from base level*
		TOP OFFSET	*Offset from top level*
		BEARING/NON BEARING	disciplinary setting
5. SLAB		**THICKNESS**	dimensional thickness of slab
		MATERIAL	Concrete steel etc.
		GRADE	astm, ETC.
		DIRECTION	Structural span direction
6. FOOTING		**FOOTING TYPE**	Pad, strip, mat
		MATERIAL	Concrete, steel
		GRADE	astm, ETC.
		TOP OF FOOTING	Reference level elevation
		BOTTOM ELEVATION	Dimensional elevation
7. PILE		**PROFILE**	Pile, caisson

Object Category	PRIORITY #	Attribute Name	Remarks, Business Rule
		MATERIAL	Material associated with pile
		GRADE	Concrete, steel grade
		TOP OF PILE	*Dimensional elevation*
		BOTTOM ELEVATION	Dimensional elevation
8. CONNECTION MATERIAL		CONNECTION MATERIAL	Plates, bolts, nuts, washers, welds

Appendix E: Exchange Requirement Form

<table>
<tr><th colspan="5">Information Exchanges</th></tr>
<tr><td>Name</td><td colspan="4"></td></tr>
<tr><td>Information Exchange ID</td><td colspan="4"></td></tr>
<tr><td>Use Case ID</td><td colspan="4"></td></tr>
<tr><td>History</td><td colspan="4"></td></tr>
<tr><td>Preconditions</td><td colspan="4"></td></tr>
<tr><td>Metadata</td><td colspan="4"></td></tr>
<tr><td rowspan="2">Information Passed</td><td>Name</td><td>Data Type</td><td>Included Attributes</td><td>OmniClass</td></tr>
<tr><td colspan="4"></td></tr>
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