Guide to Use of Industry Foundation Classes in Exchange of Reinforcement Models

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This guide provides a protocol for the exchange of data related to reinforcing steel between software applications. This guide presents a human-readable list of reinforcing steel entities, attributes, property sets, and relationships, with sufficient specificity so that the format and syntax for machine-readable exchanges based on Industry Foundation Classes (IFC) can be employed, enhanced, or developed. This specific set of exchange requirements is referred to as a model view definition (MVD). Material and geometric attributes, property sets, and relationships, both required and optional, that address most reinforced concrete applications for buildings and nonbuilding structures are presented. This guide is intended to be used by building information modeling (BIM) software developers to assist in the development of consistent and accurate exchanges of reinforcing steel information between applications.

Keywords: attribute; building information modeling; model view definition; Industry Foundation Classes; reinforcing steel.

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CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

This guide provides a model view definition (MVD) that describes both minimum and optional exchange requirements for concrete reinforcement models through the use of Industry Foundation Classes (IFC). The MVD is intended to be used by software developers to create interoperable applications that will allow reinforcement detailers, reinforcement fabricators, and others to exchange detailed reinforcement models between all participants in the concrete construction supply chain. The terminology and concepts used in this guide are those of the intended audience: software developers creating and modifying software applications that produce or consume reinforcement models.

The National BIM Standard-United States (NBIMS-US) (NIBS 2007) defines standard and efficient terminology and semantics to be exchanged in building information models to support various business-use cases throughout architecture, engineering, construction, and operations projects. The project committee responsible for developing the NBIMS-US is a committee of the buildingSMART alliance, a council of the National Institute of Building Sciences (NIBS). The NBIMS-US establishes the standard process to develop the NIBS standard. The development process includes four phases:

1. *Program*—Defines information exchange requirements that may be standardized by developing process models and defining specifications and business rules for each exchange. An example of an information exchange is the transfer of data in context between various entities along the concrete supply chain—for example, from the architect to the structural engineer. In this phase, a process model that identifies the required tasks, the information exchanges that take place in the project lifecycle, the actors (those entities such as engineers and reinforcing bar detailers who develop or use information), and the software applications that are the senders and recipients of these exchanges, is developed. The information exchanges are defined by exchange models, which specify the functional requirements (content) of data exchanges to be implemented. When the process models and exchange models are combined, they form an information delivery manual (IDM). This IDM serves as the overall functional requirements specification for one or more exchanges.
2. *Design*—Develops exchange requirement models and qualitative MVD.
3. *Construct*—Develops software implementation specifications for MVD and facilitates product testing and certification of information exchanges.
4. *Deploy*—Provides generic and product-specific building information modeling (BIM) guides, validates data exchange, and extends the complexity of information that can be included in the BIM data.

ACI 131.1R addressed portions of the first and second of these four phases, Program and Design, by establishing a flowchart (an IDM) for data exchange across the concrete design and supply chain. This document addresses portions of the second and third of these phases, Design and Construct, for the reinforcing steel portion of concrete data exchanges. Entities, attributes, property sets, and relationships, both required and optional, are presented that can be used to employ, enhance, and develop data exchange standards. These exchange requirements make up the MVD for reinforcing steel.

This guide is organized as follows. Chapter 3 reviews the IFC concepts upon which the MVD has been developed. Chapter 4 describes modeling concepts that are used for all information exchanged. Chapter 5 describes the modeling of projects, sites and buildings. Chapters 6, 7, and 8 describe modeling of reinforcement materials, reinforcing bars, and welded-wire reinforcement, respectively. Chapters 9, 10, and 11 describe modeling of bar couplers, bar terminators, and other reinforcement accessories, respectively. Chapters 12 and 13 describe grouping of bars into callouts, cages, bundles, and releases. Appendix A shows standard IFC instance diagrams for the exchange, and Appendix B provides examples of the MVD in use.

1.2—Scope

This guide is intended to be used in conjunction with IFC 2x4 (IFC4), Addendum 1 (buildingSMART International 2015). This guide provides human-readable description of entities, attributes, property sets, and relationships for reinforcing steel used in buildings and nonbuilding structures, that can be used by software developers to prepare machine-readable data exchange protocols. Geometry, position, attributes, and other information are provided for reinforcing bars, welded-wire reinforcement, bar couplers, bar terminators, and other items that are commonly included in reinforcement models. In addition, information related to the bundling of bars for shipment and the tracking of releases is included.

This guide describes the MVD that is used in the exchange of reinforcement information, but does not provide detailed descriptions of IFC syntax and modeling requirements. buildingSMART International (2013) provides that information.

A level of development (LOD) specification (BIMForum 2015; American Institute of Architects 2013) is a reference that enables practitioners in the architecture, engineering, and construction industry to specify and articulate, with a high level of clarity, the content and reliability of building information models at various stages in the design and construction process. Data exchanges described in this guide vary from preliminary modeling of reinforcing steel to fabrication-ready information to drive computer-controlled shop equipment. This range of LODs supported by this exchange is from 300 to 400, described as follows.

a) LOD 300: The model element is graphically represented within the model as a specific system, object, or assembly in terms of quantity, size, shape, location, and orientation. Nongraphic information may also be attached to the model element.

b) LOD 350: In addition to the information provided by LOD 300, interfaces with other building systems are provided for the modeled element.

c) LOD 400: In addition to the information provided by LOD 350, detailing, fabrication, assembly, and installation information are provided for the modeled element.

CHAPTER 2—DEFINITIONS

Many IFC terms, such as IfcRoot and IfcPositiveLengthMeasure, are used in this guide. These terms all have detailed definitions that can be found in the official IFC4 documentation (buildingSMART International 2013).

ACI provides a comprehensive list of definitions through an online resource, "ACI Concrete Terminology", https://www.concrete.org/store/productdetail.aspx?ItemID=CT13. Definitions provided herein complement that source.

bundle—a set of reinforcing bars tied or otherwise packaged together to facilitate shipping and related logistics.

cage—a rigid assembly of reinforcement ready for placing in position.

callout—placing drawing label describing the requirements for a bar or group of bars at an individual location.

Industry Foundation Classes—platform-neutral open data model for construction and facilities management developed by buildingSMART; published as ISO 16739.

information delivery manual—documentation that captures the business process and includes detailed specifications of the information that a user fulfilling a particular role would need to provide at a particular point within a project.

model view definition—formal subset of Industry Foundation Classes designed to satisfy particular data exchange requirements, typically as defined in an information delivery manual.

release—set of reinforcement and accessories, typically of a specific area of a project, that is approved for fabrication and delivery.

template—definition that is intended to be applied to multiple instances of an item.

CHAPTER 3—REVIEW OF INDUSTRY FOUNDATION CLASSES CONCEPTS

3.1—Industry Foundation Classes

Industry Foundation Classes (IFC) is a vendor-neutral data model that is used for exchanging and sharing information among various participants in a building construction or facility management project. This chapter briefly describes the core concepts of the IFC data model. Full descriptions of IFC are available through buildingSMART International (2015).

A model view definition (MVD) restricts the usage of IFC to a predictable subset to facilitate dependable and efficient exchanges of IFC data in a specified use case. Without the constraints applied by MVDs, it is difficult to write fully compatible software applications.

IFC data can be conceptually considered as a hierarchy, as shown in Fig 3.1.

3.2—Entities and occurrences

Entity data types are the primary data structures of Industry Foundation Classes (IFC). An entity defines a type of physical or conceptual item that may or may not exist in the real world. It is a named data structure that corresponds closely to a "class" in most object-oriented programming languages (with the exception of the lack of "methods" in an entity). In object-