IN-LB	Inch-Pound Units
SI	International System of Units

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

Reported by ACI Committee 131

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This guide provides a protocol for the exchange of data related to concrete reinforcement between software applications. This guide presents a human-readable list of concrete reinforcement entities, attributes, property sets, and relationships, with sufficient specificity so that the format and syntax for machine-readable exchanges based on Industry Foundation Classes (IFCs) 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 the requirements of 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 concrete reinforcement information between applications.

Keywords: attribute; building information modeling; Industry Foundation Classes; model view definition; post-tensioning tendon; reinforcing bar.

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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 require-

ments for concrete reinforcement models through the use of Industry Foundation Classes (IFCs). 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.

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. Chapter 12 describes the strategy used to model post-tensioning, and Chapters 13, 14, 15, and 16 describe the details of modeling strands, ducts, anchors, and post-tensioning assemblies, respectively. Chapter 17 describes callouts and reinforcement assemblies. Chapter 18 describes bar bundles as well as releases. and Chapter 19 describes post-tensioning releases. Chapter 20 describes supplemental data that are not strictly defined by this guide. Appendix A provides examples of the MVD in use.

1.2—Scope

This guide is intended to be used in conjunction with IFC4, Addendum 1 (buildingSMART International 2015). This guide provides human-readable descriptions of entities, attributes, property sets, and relationships for reinforcement used in concrete 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, post-tensioning tendons, tendon anchors, tendon ducts, 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 (2015) 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 reinforcement to fabrication-ready information to drive computer-controlled shop equipment. The 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

1.3—Changes from ACI 131.2R-17

This guide is intended to be used by software developers who are creating and maintaining software products that may need to simultaneously support both the previous version of this document (ACI 131.2R-17) and the current version of this document. The updates in this document have been planned with the intent of minimizing the difficulties that these software developers face. The primary changes in this edition of ACI PRC-131.2-24 are:

1. The addition of post-tensioning
2. Change in the method of defining bar-bending parameters
3. Support for three-piece couplers
4. Support for more general reinforcement assemblies

A goal for the committee was that all valid ACI 131.2R-17 models will be valid ACI-PRC-131.2-24 models. Breaking changes have been avoided wherever practical. Significant changes in requirements (other than those related to the addition of post-tensioning) are highlighted in the document with “backward compatibility notes”.

CHAPTER 2—DEFINITIONS

Many IFC terms, such as IfcRoot and IfcPositiveLengthMeasure, are used in this guide. These terms have detailed definitions that can be found in the official IFC4 documentation (buildingSMART International 2015).

ACI provides a comprehensive list of definitions through an online resource, “ACI Concrete Terminology.” Definitions provided herein complement that source.

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

bundle, tendon—a set of tendons placed adjacent to each other to simplify construction or reduce con-gestion.

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.

cgs—center of gravity of prestressing steel; this abbreviation is also used for the center of gravity of non-steel prestressing materials.

data, supplemental—data that are not required to be included in a ACI PRC-131.2 exchange and is not strictly defined in this guide.

Industry Foundation Classes—platform-neutral open data model for construction and facilities management. Copyrighted buildingSMART International Limited and 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.

tendon, tightly-sheathed—a tendon assembly with a single strand encased in a duct of slightly larger dimension. The typical construction (often referred to as "monostrand" in North American markets) is HDPE sheathing (conduit) factory-extruded over a strand that has been coated with a corrosion-resistant grease.

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 use 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-oriented programming, methods are procedures or functions that are defined as part of a class. Examples of entities are IfcReinforcingBar, IfcRelAggregates, IfcMaterial, IfcCurve, and IfcMechanicalFastener. Over 700 entities are defined in IFC. All IFC entities' names start with the "Ifc" prefix.

Entities can (and almost always do) inherit characteristics from other entities; for example, IfcReinforcingBar inherits from ("is a subtype of" in IFC terminology) IfcReinforcingElement and, hence, has all the characteristics of IfcReinforcingElement in addition to the characteristics it explicitly defines. Inheritance is widely used in IFC to identify commonalities in entities and reduce duplication of definitions. The use of inheritance in IFC creates a rich hierarchy of entities.

An entity data structure is defined once in the IFC model but can be used an unlimited number of times. For example, there is one definition of IfcReinforcingBar, but that definition can be used to represent any and all actual reinforcing bars. Each use (representing a single item) is referred to as an "instance." Commonly, the entity name is used to refer to the instance; for example, "each IfcReinforcingBar may be related to an IfcGroup."

Model view definitions (MVDs) such as the one described in this guide cannot define new IFC entities but can choose which entities are valid in an exchange and can constrain some aspects of their use.

3.3—Attributes

Some characteristics of entities are defined through attributes. Attributes are defined directly in the entity definitions. For example, the IfcRoot entity has the following attributes:

(a) GlobalId—a globally unique identifier

(b) OwnerHistory—information relating to the current owner and last modifier of the object

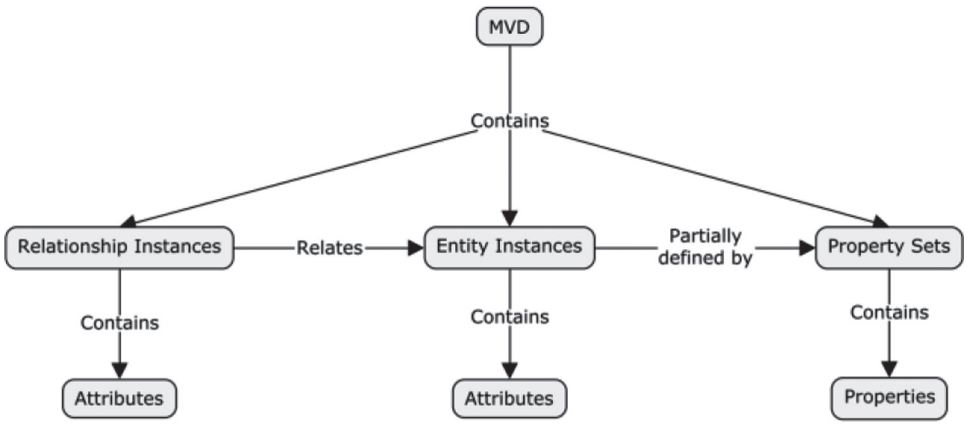

Fig. 3.1—Simplified view of IFC data concepts.