

ACI 131.2R-17

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

Reported by ACI Committee 131



American Concrete Institute
Always advancing



Documents

Document Sharing Hub



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

Copyright by the American Concrete Institute, Farmington Hills, MI. All rights reserved. This material may not be reproduced or copied, in whole or part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the written consent of ACI.

The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI via the errata website at <http://concrete.org/Publications/DocumentErrata.aspx>. Proper use of this document includes periodically checking for errata for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided “as is” without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Participation by governmental representatives in the work of the American Concrete Institute and in the development of Institute standards does not constitute governmental endorsement of ACI or the standards that it develops.

Order information: ACI documents are available in print, by download, on CD-ROM, through electronic subscription, or reprint and may be obtained by contacting ACI.

Most ACI standards and committee reports are gathered together in the annually revised ACI Manual of Concrete Practice (MCP).

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
Phone: +1.248.848.3700
Fax: +1.248.848.3701

www.concrete.org

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

Reported by ACI Committee 131

Christopher D. Brown, Chair

Allan P. Bommer, Secretary

Mark Douglas Agee
Daniel D. Berend
Richard H. Birley
Daniel Bittrich
Brady G. Buckley
Barry B. Butler
Peter J. Carrato

Jeffrey N. Cochrane
James T. Davy
Charles M. Eastman
Dennis J. Fontenot
Sidney Freedman
David A. Grundler Jr.
Michael Gustafson

Michael G. Hernandez
Harrison Rolfe Jennings
Julian Kang
William M. Klorman
Andrew R. Lloyd
Ronald L. O'Kane
Andrew Pinneke

Joseph C. Sanders
William J. Shebetka
Carl Taylor
John B. Turner
Peter Zdziebloski

Special acknowledgement and thanks to D. Yang, Research Scientist at the Digital Building Laboratory in the Georgia Institute of Technology, for his contributions to this guide.

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.

CONTENTS

CHAPTER 1—INTRODUCTION AND SCOPE, p. 2

- 1.1—Introduction, p. 2
- 1.2—Scope, p. 3

ACI Committee Reports, Guides, and Commentaries are intended for guidance in planning, designing, executing, and inspecting construction. This document is intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. The American Concrete Institute disclaims any and all responsibility for the stated principles. The Institute shall not be liable for any loss or damage arising therefrom.

Reference to this document shall not be made in contract documents. If items found in this document are desired by the Architect/Engineer to be a part of the contract documents, they shall be restated in mandatory language for incorporation by the Architect/Engineer.

CHAPTER 2—DEFINITIONS, p. 3

CHAPTER 3—REVIEW OF INDUSTRY FOUNDATION CLASSES CONCEPTS, p. 3

- 3.1—Industry Foundation Classes, p. 3
- 3.2—Entities and occurrences, p. 3
- 3.3—Attributes, p. 4
- 3.4—Property sets, p. 4
- 3.5—Relationships, p. 4
- 3.6—Entity diagrams, p. 4

CHAPTER 4—COMMON MODELING REQUIREMENTS, p. 5

- 4.1—General, p. 5
- 4.2—IfcRoot attributes, p. 5
- 4.4—IfcProduct, ObjectPlacement, and IfcRelContainedInSpatialStructure, p. 5
- 4.5—IfcTypeProduct and IfcProduct, p. 5

CHAPTER 5—PROJECT, SITE, AND BUILDING, p. 6

- 5.1—Conceptual modeling, p. 6
- 5.3—IfcSite, p. 7

CHAPTER 6—REINFORCEMENT MATERIAL MODELING, p. 8

- 6.1—Conceptual modeling, p. 8
- 6.2—IfcMaterial, p. 8

ACI 131.2R-17 was adopted and published October 2017.

Copyright © 2017, American Concrete Institute

All rights reserved including rights of reproduction and use in any form or by any means, including the making of copies by any photo process, or by electronic or mechanical device, printed, written, or oral, or recording, for storage, retrieval, reproduction or for use in any knowledge or retrieval system or device, unless permission in writing is obtained from the copyright proprietor.

Documents

Document Sharing Hub



CHAPTER 7—REINFORCING BAR MODELING, p. 9

- 7.1—Conceptual modeling, p. 9
- 7.2—IfcReinforcingBarType, p. 10
- 7.3—IfcReinforcingBar, p. 12

CHAPTER 8—WELDED-WIRE REINFORCEMENT MODELING, p. 18

- 8.1—Conceptual modeling, p. 18
- 8.2—IfcReinforcingMeshType, p. 18
- 8.3—IfcReinforcingMesh, p. 19

CHAPTER 9—BAR COUPLER MODELING, p. 20

- 9.1—Conceptual modeling, p. 20
- 9.2—IfcMechanicalFastenerType, p. 20
- 9.3—IfcMechanicalFastener, p. 21

CHAPTER 10—BAR TERMINATOR MODELING, p. 22

- 10.1—Conceptual modeling, p. 22
- 10.2—IfcDiscreteAccessoryType, p. 22
- 10.3—IfcDiscreteAccessory, p. 23

CHAPTER 11—ACCESSORY MODELING, p. 24

- 11.1—Conceptual modeling, p. 24
- 11.2—IfcDiscreteAccessoryType, p. 24
- 11.3—IfcDiscreteAccessory, p. 26

CHAPTER 12—CALLOUT AND CAGE MODELING, p. 27

- 12.1—Conceptual modeling, p. 27
- 12.3—IfcElementAssembly for cages, p. 29

CHAPTER 13—BUNDLE AND RELEASE MODELING, p. 29

- 13.1—Conceptual modeling, p. 29
- 13.3—IfcGroup for releases, p. 30

CHAPTER 14—REFERENCES, p. 31

- Authored documents, p. 31

APPENDIX A—INDUSTRY FOUNDATION CLASSES INSTANCE DIAGRAMS, p. 32

- A.1—Standard Industry Foundation Classes instance diagrams, p. 32
- A.2—Selected diagrams, p. 33

APPENDIX B—EXAMPLES, p. 39

- B.1—Selected example files, p. 39
- B.2—Example 1—Single straight bar, p. 39
- B.3—Example 2—Single straight bar with forged head, p. 42

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-

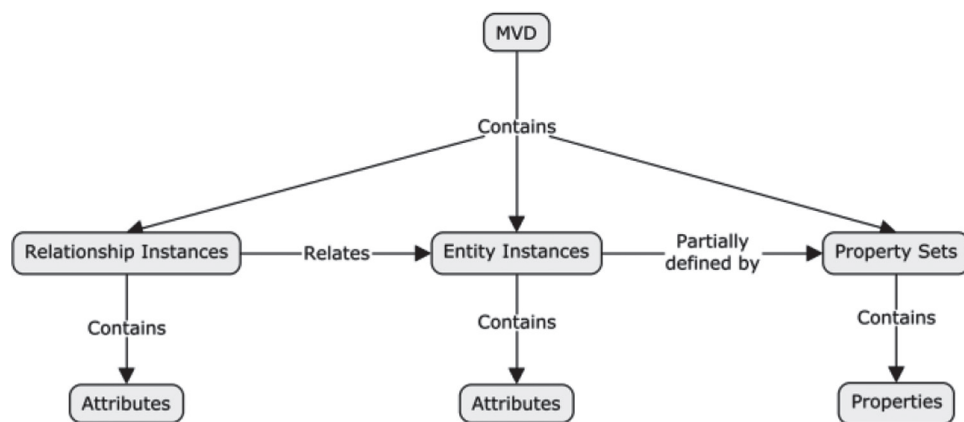


Fig. 3.1—Simplified view of IFC data concepts.

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 usage (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 usage.

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:

- GlobalId—a globally unique identifier
- OwnerHistory—information relating to the current owner and last modifier of the object
- Name—human-readable label
- Description—human-readable description

Attributes may be thought of as properties, but the term “properties” is not used to avoid confusion with property sets, which are described in the following section. Attributes have clearly specified data types that are sometimes more restrictive than the data types available in programming languages; for example, *IfcPositiveLengthMeasure* is an attribute type that limits its values to lengths greater than

zero. Each instance has its own set of values for the attributes. Attributes are one of the types of characteristics that are inherited in the IFC entity hierarchy.

Model view definitions (MVDs) such as the one described in this guide cannot define new attributes, but can choose which attributes are valid in an exchange and can constrain an attribute's usage.

3.4—Property sets

Property sets are the extensibility mechanism provided by IFC for dynamically defining properties and their values. Each property set defines one or more properties with a name and a value type. Property sets are implemented through the *IfcPropertySet* entity. *IfcPropertySet* is related to entities by the *IfcRelDefinesByProperties* relationship. By convention, property sets have a name beginning with “Pset_.”

Model view definitions (MVDs) such as the one described in this guide can define new property sets and specify how they are used. Many property sets are defined in this exchange.

3.5—Relationships

Relationships are IFC entities that have the purpose of relating entities to each other and defining the characteristics of their relationship. Relationships can either be 1-to-1 (1 entity related to 1 entity) or 1-to-many (1 entity related to multiple entities). Relationships entity names begin with “IfcRel”. There are also ternary relationships such as *IfcRelConnectsWithRealizingElements*.

As is the case with other entities, model view definitions (MVDs) such as the one described in this guide cannot define new relationships, but can choose which relationships are valid in an exchange and can constrain some aspects of their usage.

3.6—Entity diagrams

In this document, EXPRESS-G (ISO 10303-11) diagrams are used to illustrate the relationships between IFC entities. Figure 3.6 shows an example of these diagrams; to navigate from From_Entity_Name to To_Entity_Name, Attribute_Name is used.

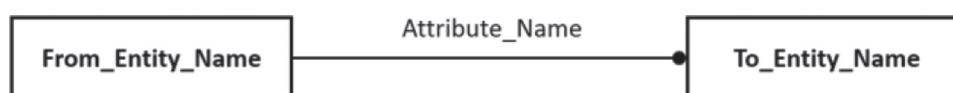


Fig. 3.6—EXPRESS-G diagram.

Table 4.2—IfcRoot attribute usage

Attribute name	Type	Usage	Required or optional
GlobalId	IfcGloballyUniqueId	Unique identifier	Required
OwnerHistory	IfcOwnerHistory	Ownership of object	Optional
Name	IfcLabel*	Human-readable label	Optional
Description	IfcText*	Human-readable description	Optional

*The IfcLabel and IfcText types are referenced frequently in this guide. The difference between them is primarily usage. IfcLabel is intended to be used as a human-readable identifier whereas IfcText is intended for other human-readable information.

Table 4.3—Pset_ACI_ItemStatus Usage

Property name	Type	Usage	Required or optional
LOD	IfcInteger	The level of development of this item, according to BIMForum (2015)	Optional
Status	IfcLabel	Workflow status of the modeled item, such as “For Fabrication”	Optional
StatusDate	IfcDate	Date the status was determined	Optional

CHAPTER 4—COMMON MODELING REQUIREMENTS

4.1—General

Modeling approaches that are common to most entities in this exchange are described in this chapter. Section 4.2 describes the usage of attributes common to all items, 4.3 describes the usage of property sets common to all elements, 4.4 describes the geometric placement of physical elements, and 4.5 describes the use of products and types.

4.2—IfcRoot attributes

All items modeled in this exchange are represented using entities that are subtypes of IfcRoot. Table 4.2 defines the usage of attributes defined in IfcRoot. IfcRoot attributes are part of every item in the exchange and are therefore not repeated or discussed further in the item-specific chapters that follow.

4.3—Status and level of development

All IfcElements, such as IfcReinforcingBar, IfcReinforcingMesh, IfcMechanicalFastener, and IfcDiscreteAccessory, modeled in this exchange may use the property set Pset_ACI_ItemStatus to provide information related to the element’s level of development (LOD) and status. Table 4.3 defines the usage of properties in Pset_ACI_ItemStatus.

For model-size efficiency, it is assumed that this property set will be widely shared by elements in the model with identical status information, but sharing is not required.

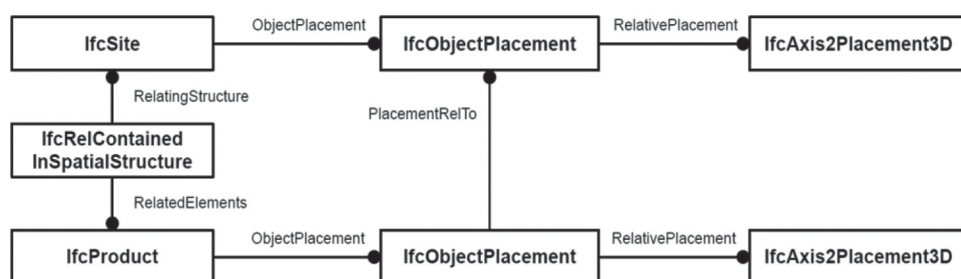
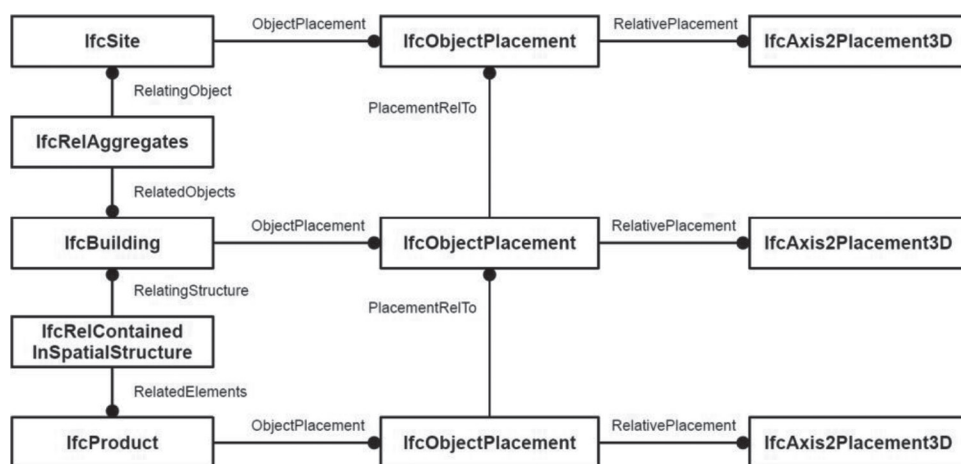
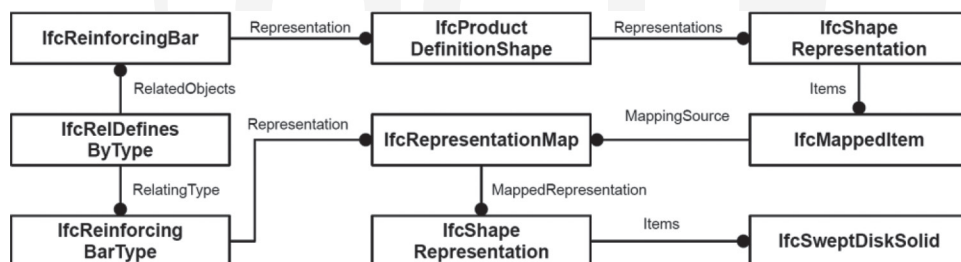
4.4—IfcProduct, ObjectPlacement, and IfcRelContainedInSpatialStructure

All physical components modeled in this exchange are represented using entities that are subtypes of IfcProduct. These components are positioned relative to either the IfcSite (“world coordinates”) or an IfcBuilding, if any. All items are positioned relative to the IfcSite with one limited exception; all items contained in an IfcBuilding are positioned relative to the same reference and may be positioned relative to the IfcBuilding that contains them. The positioning is defined using the ObjectPlacement attribute of IfcProduct. Placement relative to the IfcSite is shown in Fig. 4.4a; placement relative to an IfcBuilding is shown in Fig. 4.4b.

In addition to relative positioning, IFC supports the concept of containment to allow a hierarchy of spatial regions that contain items. This exchange uses the IfcRelContainedInSpatialStructure relationship to define the containment and the IfcSite and IfcBuilding entities to define the spatial zones. An IfcProduct can either be contained in the IfcSite (as shown in Fig. 4.4a) or contained in an IfcBuilding (as shown in Fig. 4.4b).

4.5—IfcTypeProduct and IfcProduct

All physical items included in this exchange are represented with IfcProduct subtypes (such as IfcReinforcingBar) that reference IfcTypeProduct subtypes (such as IfcReinforcingBarType) to define their primary attributes and geometry. IfcTypeProduct subtypes act as templates. This modeling strategy clearly identifies commonalities, reduces duplicate information, and leads to smaller IFC files. IfcRelDefinesByType defines the primary relationship between the product and the type, as shown in Fig. 4.5.

Fig. 4.4a—Placement and containment relative to *IfcSite*.Fig. 4.4b—Placement and containment relative to *IfcBuilding*.Fig. 4.5—*IfcProduct-IfcTypeProduct* relationships (using *IfcReinforcingBar* as example).

The geometry of the *IfcTypeProduct* is defined through an *IfcRepresentationMap* and an *IfcRepresentation* with the *RepresentationType* of “body”. The geometry of the *IfcProduct* is defined through an *IfcProductDefinitionShape*, an *IfcShapeRepresentation*, and an *IfcMappedItem*. The relationship of these entities is shown in Fig. 4.5.

CHAPTER 5—PROJECT, SITE, AND BUILDING

5.1—Conceptual modeling

In the model exchange described in this guide, *IfcProject*, *IfcSite*, and *IfcBuilding* provide the hierarchical and spatial organization of the model. There is exactly one *IfcProject* and exactly one *IfcSite*. There may be zero or more *IfcBuildings*. The relationships of *IfcProject* and *IfcSite* are shown in Fig. 5.1a and 5.1b and described in Table 5.1a.

If one or more instances of *IfcBuilding* exist, their relationship to *IfcSite* is as shown in Fig. 5.1b and described in

Table 5.1b. The relationship between *IfcSite* and *IfcBuilding* has also been discussed in 4.3.

5.2—IfcProject

IfcProject is used to represent the context in which the information is being exchanged, typically a construction project. There is always exactly one *IfcProject* instance in any IFC model. In addition to the attributes described in 4.2, the attributes defined in Table 5.2 are used for *IfcProject*.

IfcUnitAssignment of *UnitsInContext* is a collection of *IfcUnit*. Within that collection, *IfcUnits* defining the following *IfcUnitEnum* values are included:

- LENGTHUNIT
- MASSUNIT
- PLANEANGLEUNIT
- AREAUNIT
- FORCEUNIT
- PRESSUREUNIT

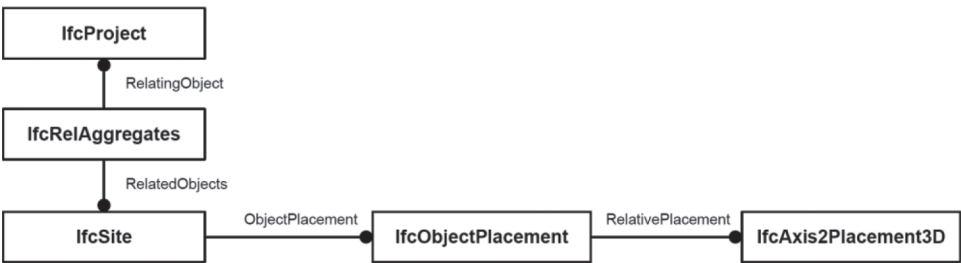


Fig. 5.1a—Spatial composition of IfcProject and IfcSite.

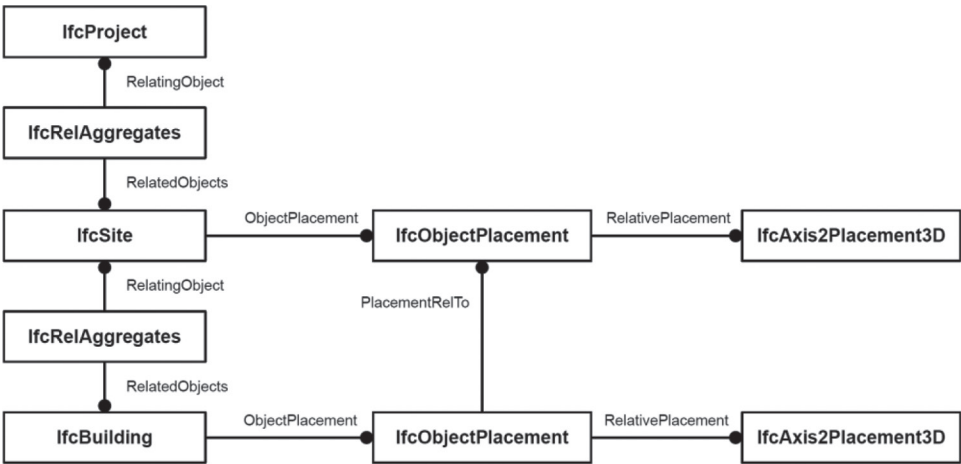


Fig. 5.1b—Spatial composition of IfcProject, IfcSite and IfcBuilding.

Table 5.1a—IfcProject-IfcSite relationship (IfcRelAggregates)

Attribute	Type	Cardinality	Required or optional
RelatedObjects	IfcSite	[1:?]	Required
RelatingObject	IfcProject	[1:1]	Required

Table 5.1b—IfcSite-IfcBuilding relationship (IfcRelAggregates)

Attribute	Type	Cardinality	Required or optional
RelatedObjects	IfcBuilding	[1:?]	Required
RelatingObject	IfcSite	[1:1]	Required

Table 5.2—IfcProject attribute usage

Attribute name	Type	Usage	Required or optional
UnitsInContext	IfcUnitAssignment	Specifies the units used in the model	Required

Table 5.3—IfcSite attribute usage

Attribute name	Type	Usage	Required or optional
CompositionType	IfcElementCompositionEnum	Always ELEMENT	Required

There are no property sets used with IfcProject.

5.3—IfcSite

IfcSite is used to represent an area of land where a project is located. There is always exactly one IfcSite instance in any IFC model for this exchange. In addition to the attributes described in 4.2, the attributes defined in Table 5.3 are used for IfcSite. There are no property sets used with IfcSite.

5.4—IfcBuilding

IfcBuilding is used to represent a structure. There may be zero or more instances of IfcBuilding in any IFC model for this exchange. In addition to the attributes described in 4.2, the attributes defined in Table 5.4 are used for IfcBuilding. There are no property sets used with IfcBuilding. There is no geometric representation of the building.

Table 5.4—IfcBuilding attribute usage

Attribute name	Type	Usage	Required or optional
CompositionType	IfcElementCompositionEnum	Always ELEMENT	Required

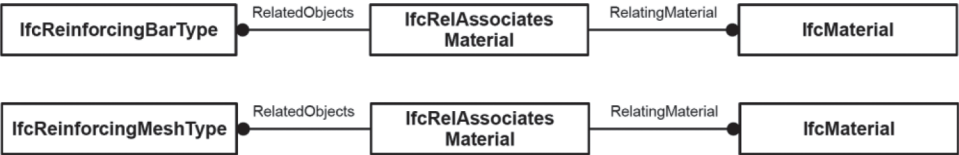


Fig. 6.1—Material relationships.

Table 6.1a—Reinforcing bar-material relationship (IfcRelAssociatesMaterial)

Attribute	Type	Cardinality	Required or optional
RelatedObjects	IfcReinforcingBarType	[1:?]	Required
RelatingMaterial	IfcMaterial	[1:1]	Required

Table 6.1b—Reinforcing mesh-material relationship (IfcRelAssociatesMaterial)

Attribute	Type	Cardinality	Required or optional
RelatedObjects	IfcReinforcingMeshType	[1:?]	Required
RelatingMaterial	IfcMaterial	[1:1]	Required

CHAPTER 6—REINFORCEMENT MATERIAL MODELING

6.1—Conceptual modeling

In the model exchange described in this guide, materials are defined only for reinforcing bars and for welded wire reinforcement, as shown in Fig. 6.1 and described in Tables 6.1a and 6.1b.

Typically, each IfcMaterial will define the material and coating for many IfcReinforcingBarTypes or IfcReinforcingMeshTypes through the IfcRelAssociatesMaterial rela-

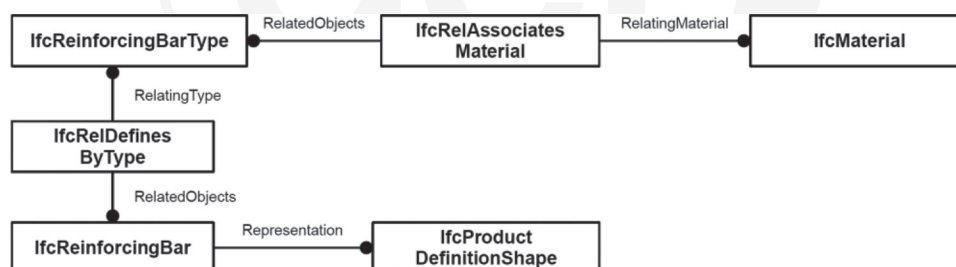
tionship. IfcReinforcingBarType is described in Chapter 7. IfcReinforcingMeshType is described in Chapter 8.

6.2—IfcMaterial

IfcMaterial is used to represent a steel material and optional coating used for reinforcing bars and reinforcing mesh. IfcMaterial has no attributes other than those defined in 4.2. The property set Pset_ACI_ReinforcingMaterial is needed to provide additional information regarding the IfcMaterial. Table 6.2 defines the properties available in Pset_ACI_ReinforcingMaterial.

Table 6.2—Pset_ACI_ReinforcingMaterial property set usage

Property name	Type	Usage	Required or optional
Specification	IfcLabel	The specification under which the material is produced. Standard names for ASTM materials use this pattern: ASTM_A615, ASTM_A706.	Required
SpecificationVersion	IfcLabel	The year or other version number for the specification. For ASTM documents, values such as “2016” and “2016A” are used.	Required
Grade	IfcPressureMeasure	Yield strength as defined in the specification	Required
Subtype	IfcLabel	Material subtype (if any) in the specification. For ASTM specs, this is currently only used for stainless steel and low-carbon chromium steel. For ASTM_A955, use alloy names such as 316.	Optional
CoatingSpecification	IfcLabel	The specification under which the coating material is produced. Standard names for ASTM materials use this pattern: ASTM_A775. Use UNCOATED when no coating is used. In rare case of proprietary coating, this field may be used to specify the coating.	Required
CoatingSpecificationVersion	IfcLabel	The year or other version number for the coating specification. For ASTM documents, values such as “2016” and “2016A” are used.	Required if CoatingSpecification is not UNCOATED
CoatingSubtype	IfcLabel	Coating subtype (if any) in the coating specification. For ASTM_A767 mass of zinc coating use: CLASS_I or CLASS_II	Optional
CoatedBeforeFabrication	IfcBoolean	True or false	Required if CoatingSpecification is not UNCOATED
RequiredOrigin	IfcLabel	Location of material origin. For countries, use the two-letter ISO 3166-1 alpha-2 names (example, US for United States)	Required (if project requires)

*Fig. 7.1—Reinforcing bar relationships.***Table 7.1a—Bar type-material relationship (IfcRelAssociatesMaterial)**

Attribute	Type	Cardinality	Required or optional
RelatedObjects	IfcReinforcingBarType	[1:?]	Required
RelatingMaterial	IfcMaterial	[1:1]	Required

Table 7.1b—Reinforcing bar-bar type relationship (IfcRelDefinesByType)

Attribute	Type	Cardinality	Required or optional
RelatedObjects	IfcReinforcingBar	[1:?]	Required
RelatingType	IfcReinforcingBarType	[1:1]	Required

CHAPTER 7—REINFORCING BAR MODELING

7.1—Conceptual modeling

In the model exchange described in this guide, reinforcing bars are modeled using a combination of IfcMaterial, IfcRe-

inforcingBarType, and IfcReinforcingBar, as shown in Fig. 7.1 and described in Tables 7.1a and 7.1b.

IfcMaterial is used to define a reinforcing bar coating and steel material, as described in [Chapter 6](#). Typically, each IfcMaterial will define the material and coating for a re-

Table 7.2a—IfcReinforcingBarType attribute usage

Attribute name	Type	Usage	Required or optional
PredefinedType	IfcReinforcingElementTypeEnum	Always NOTDEFINED	Required
NominalDiameter	IfcPositiveLengthMeasure	Nominal bar diameter	Required
CrossSectionArea	IfcAreaMeasure	Nominal bar area	Required
BarLength	IfcPositiveLengthMeasure	“Theoretical length” calculated per CRSI (2009) standards*	Required
BarSurface	IfcReinforcingBarSurfaceEnum	Always PLAIN or TEXTURED†	Required
BendingShapeCode‡	IfcLabel	Shape code name per project or regional standard	§
BendingParameters‡	[1:?] IfcBendingParameterSelect	Array of lengths, angles, or both	Optional

*Refer to Fig. 7.2a.

†While the term deformed is commonly used in North America, TEXTURED is the proper value for data of the type IfcReinforcingBarSurfaceEnum.

‡The BendingShapeCode and BendingParameters attributes are not the primary mechanism for transferring bending information, as they lack the ability to name the parameters and, hence, optional parameters cannot be skipped. ACI 315 bending shapes typically have many optional parameters.

§If the BendingParameters is provided, then the BendingShapeCode is also provided.

Table 7.2b—Pset_ACI_ReinforcingBarType property set usage

Property name	Type	Usage	Required or optional
Size	IfcLabel	Bar name per local standards Bar numbers (#4, #5, etc.) are used where appropriate for the location.	Required
BarMark	IfcLabel	Unique human-readable name as used to identify the bar type.	Optional
BarMass	IfcMassMeasure	Total mass of bar, consistent with BarLength attribute.	Optional
StartEndPrep**†	IfcLabel	Preparation required at beginning of bar to accommodate couplers, terminators, or other accessories. Also used for bar end treatments such as forged heads.	Required if special prep is needed
EndEndPrep**†	IfcLabel	Preparation required at end of bar to accommodate couplers, terminators, or other accessories. Also used for bar end treatments such as forged heads.	Required if special prep is needed

**Standard end prep values are listed in Table 7.2c. Proprietary names may be used for proprietary processes.

†“Start” and “End” are defined by the Directrix in the IfcSweptDiskSolid defining the bar shape.

IfcReinforcingBarTypes through the IfcRelAssociatesMaterial relationship.

IfcReinforcingBarType is used to define template bars with a fixed size and shape. Through its IfcRelAssociatesMaterial relationship with IfcMaterial, the material of the IfcReinforcingBarType is defined. Typically, each IfcReinforcingBarType will define the shape, size, material, and coating for many IfcReinforcingBars through the IfcRelDefinesByType relationship. IfcReinforcingBar is used to define individual bars in specific positions. It is mostly defined through its IfcRelDefinesByType relationship to IfcReinforcingBarType.

7.2—IfcReinforcingBarType

IfcReinforcingBarType is used to define a template for bars with the same size, shape, and material. In addition to the attributes described in 4.2, the attributes defined in Table 7.2a are used for IfcReinforcingBarType.

The property set Pset_ACI_ReinforcingBarType is used to provide additional information regarding the IfcReinforcingBarType. Table 7.2b defines the properties available in Pset_ACI_ReinforcingBarType.

The property set Pset_ACI_BarShape may be used to provide additional information regarding the shape of the IfcReinforcingBarType. Table 7.2d defines the properties available in Pset_ACI_BarShape.

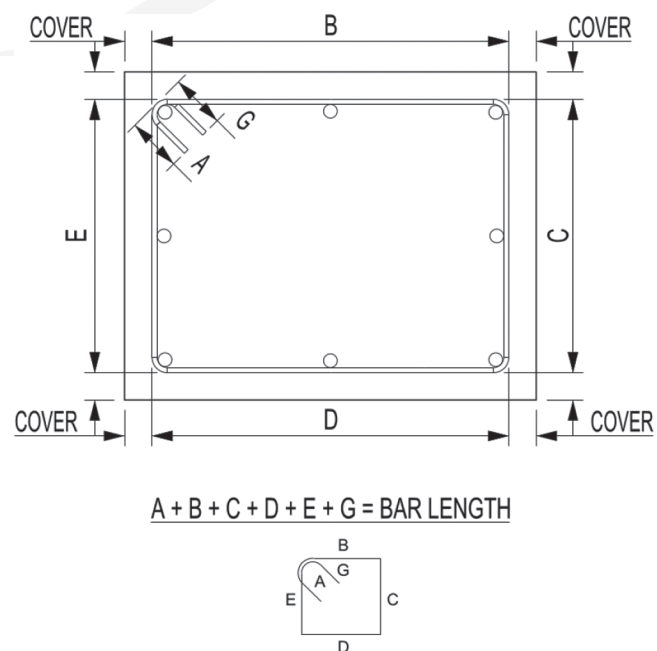


Fig. 7.2a—BarLength calculation.

Table 7.2c—Standard values for StartEndPrep and EndEndPrep

Name	Meaning
SHEAR_CUT	The most common method for cutting reinforcing bar. Uses a technique that shears the ends of the bars and does not produce clean cut end.
SAW_CUT	In this method, a saw is used to cut the bar instead of a shear. It produces a smooth, flat end on the bar. It is sometimes required for threading operations and for smooth dowels that are to be used in expansion joints.
STRAIGHT_THREAD	A standard thread used for attaching mechanical couplers and terminators is applied to the end of the bar
TAPERED_THREAD	A special, usually proprietary, tapered thread used for attaching mechanical couplers and terminators is applied to the end of the bar
SAW_CUT_STRAIGHT_THREAD	SAW_CUT combined with STRAIGHT_THREAD Some threading operations require a smooth end.
SAW_CUT_TAPERED_THREAD	SAW_CUT combined with TAPERED_THREAD Some threading operations require a smooth end.
FORGED_HEAD	End of bar is forged to provide terminator at end of bar.
FORGED_COUPLER_HEAD	End of bar is forged to provide head for coupler attachment.

Table 7.2d—Pset_ACI_BarShape property set usage

Property name	Type	Usage	Required or optional
StandardName	IfcLabel	Detailing standard identifier, such as ACI_315 BS_4466 BS_8666 RSIC	Required
StandardVersion	IfcLabel	Year of standard or other version identifier. Valid values for ACI_315: 1999 Valid values for BS_4466: 1989 Valid values for BS_8666: 2000, 2005	Required
ShapeName	IfcLabel	Name of shape per the standard	Required
DefaultInsideBendRadius	IfcPositiveLengthMeasure	Inside radius of bar bends unless otherwise specified by shape	Required
Parameters*	IfcPropertyTableValue	The parameter names are specified in the DefiningValues field. The values are specified in the DefinedValues field, using: a) IfcLengthMeasure for distances b) IfcPlaneAngleMeasure for angles c) IfcInteger for integer values d) IfcReal for nondimensional real values	Required

*Typical ACI 315 bar parameters are illustrated in Fig. 7.2b.

Table 7.2e—MappedRepresentation for IfcReinforcingBarType

Geometry type	Usage	Required or optional
IfcSweptDiskSolid	For bars	Required
IfcBooleanResult*†	For forged heads	Required
IfcBooleanResult†‡	For thread tapers	Required

*IfcBooleanResult operation is a union.

†IfcBooleanResult operation is a difference.

‡Refer to Table 7.2f for geometry modeling of SecondOperand.

The geometry of the IfcReinforcingBarType is provided by an IfcRepresentationMap set in the RepresentationMaps attribute. The options for the MappedRepresentation attribute of the IfcRepresentationMap are listed in Table 7.2e.

When a single forged head or thread taper is present, a single Boolean operation will be required. The IfcBooleanResult should have the IfcSweptDiskSolid (representing the bar) as the FirstOperand. IfcBooleanResult is the geometric

result of one three-dimensional (3D) volume being intersected with, added to, or subtracted from another 3D volume.

When multiple Boolean operations are needed (such as for thread tapers on both ends), the IfcBooleanResults will be nested in a manner that results in the bar's original IfcSweptDiskSolid representation being accessible through the recurring FirstOperands of the nested IfcBooleanResults, as shown in Fig. 7.2c through 7.2f.

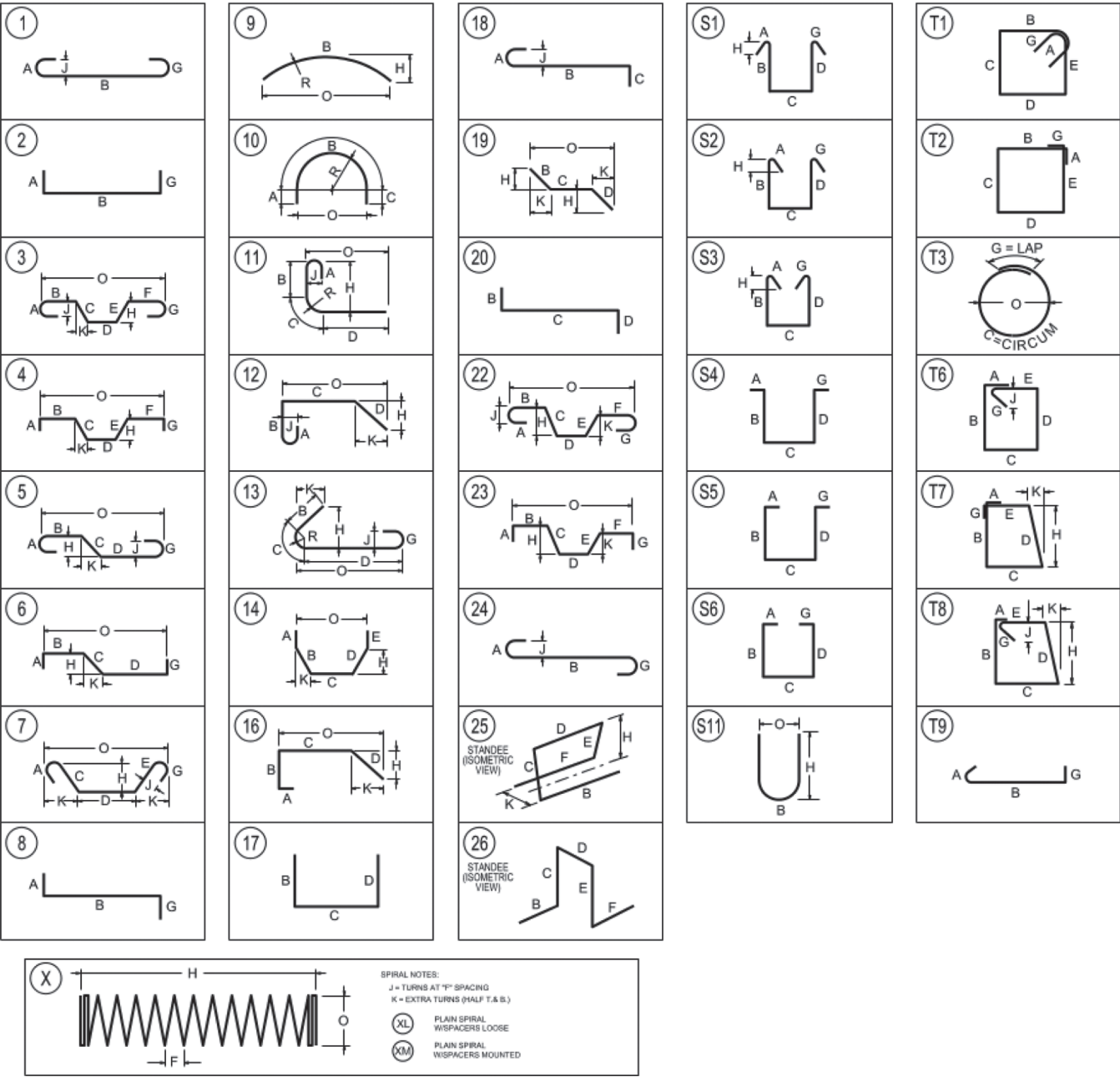


Fig. 7.2b—Pset_ACI_BarShape parameters.

Table 7.2f—Generic geometry for forged heads and tapers

Feature	Geometry type	Dimensions
Forged head	IfcRightCircularCylinder	Height = 0.75 bar diameter Radius = 1.15 bar diameter
Thread taper	IfcRevolvedAreaSolid of IfcArbitraryClosedProfileDef	Angle = 2π Profile is triangle with 6-degree slope Height = $1.5 \times$ bar diameter

7.3—IfcReinforcingBar

IfcReinforcingBar is used to represent individual bars. There is a 1:1 correspondence between a real bar and an IfcReinforcingBar. The geometry of the bar and many of its characteristics are defined via the bar’s relationship to IfcReinforcingBarType, as shown in 4.4 and 6.1. IfcRein-

forcingBars are positioned in space using the ObjectPlacement described in 4.3. In addition to the attributes described in 4.2, the attributes defined in Table 7.3a are used for IfcReinforcingBar.

It is important to note that the attributes NominalDiameter, CrossSectionArea, BarLength, and BarSurface are

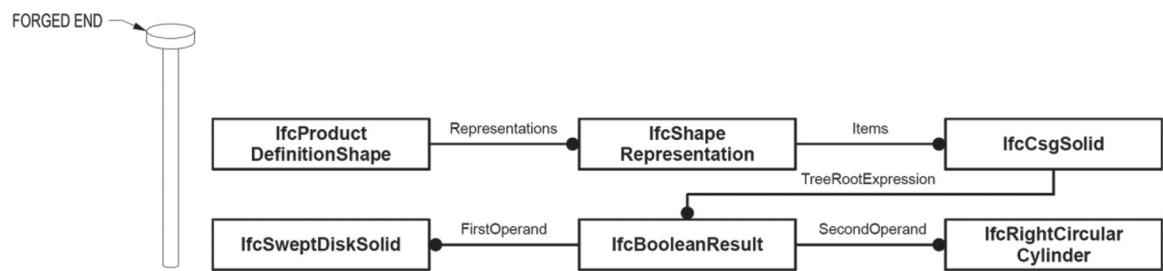


Fig. 7.2c—Representing bar with forged head with IfcBooleanResult.

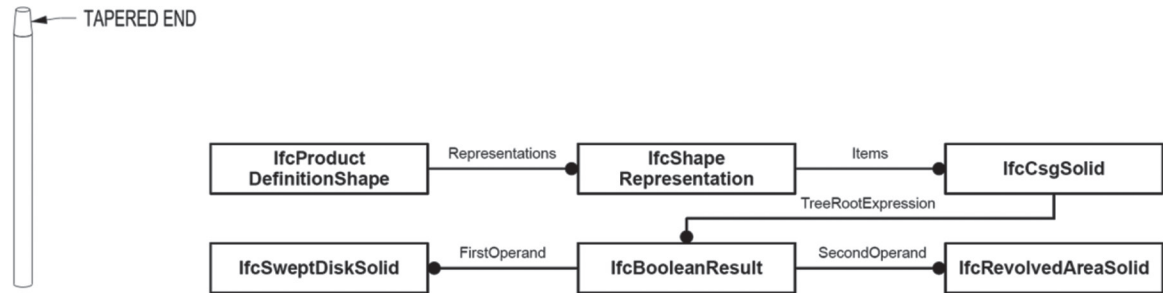


Fig. 7.2d—Representing bar with tapered end with IfcBooleanResult.

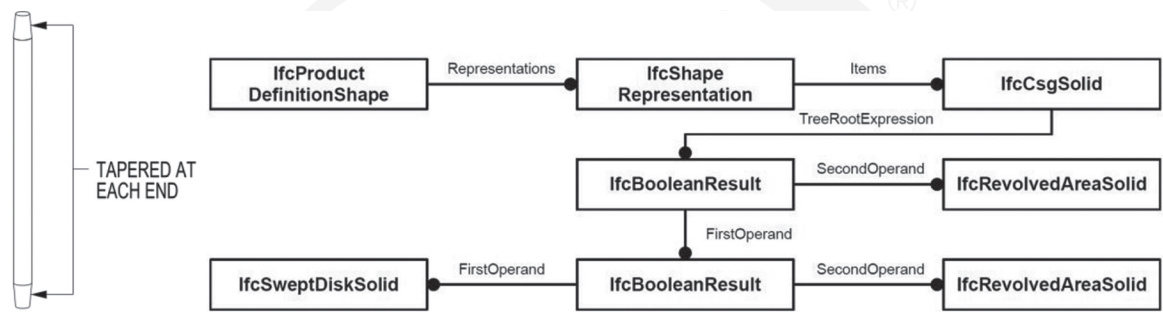


Fig. 7.2e—Representing bar with two tapered ends with IfcBooleanResult.

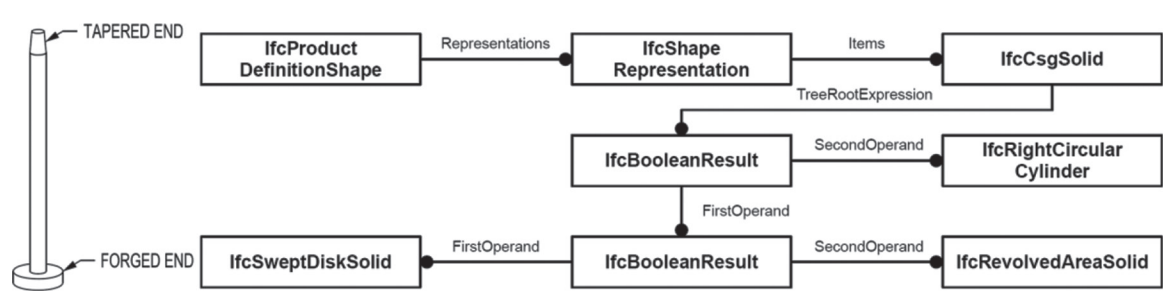


Fig. 7.2f—Representing bar with forged head and tapered end with IfcBooleanResult.

Table 7.3a—IfcReinforcingBar attribute usage

Attribute name	Type	Usage	Required or optional
ObjectType	IfcLabel	Always STRUCTURAL or NONSTRUCTURAL	Required
PredefinedType	IfcReinforcingElementTypeEnum	Always USERDEFINED	Required

Table 7.3b—Pset_ACI_ReinforcingBar property set usage

Property name	Type	Usage	Required or optional
BarElement	IfcLabel	Always one of the following: BEAM COLUMN CORBEL FOOTING PIER PILE_CAP (applies to pier caps also) SLAB WALL Refer to Table 7.3c for usage details.	Optional
BarUse	IfcLabel	Always one of the following: CORNER DOWEL HORIZONTAL LONGITUDINAL STIRRUP SUPPORT TIE TRANSVERSE TRIM VERTICAL Refer to Table 7.3d for usage details.	Optional
BarPosition	IfcLabel	May be user-defined or one of the following standard values: BOTTOM INSIDE CENTER OUTSIDE SIDE TOP Refer to Table 7.3e for usage details.	Optional

Table 7.3c—BarElement property usage

Value	Meaning
BEAM	The bar is in a beam, girder, or similar element
COLUMN	The bar is in a column or similar element
CORBEL	The bar is in a corbel or similar element
FOOTING	The bar is in a footing or similar element
PIER	The bar is in a pier, caisson, or similar element
PILE_CAP	The bar is in pile cap, pier cap, or similar element
SLAB	The bar is in a slab, ramp, or similar element
WALL	The bar is in a wall or similar element

never used, as those attributes are instead defined via the relationship to an IfcReinforcingBarType.

In addition to the property set Pset_ACI_Status described in 4.3, the property set Pset_ACI_ReinforcingBar is available to provide additional information regarding the IfcRe-

inforcingBar. Table 7.3b defines the properties available in Pset_ACI_ReinforcingBar. Tables 7.3c to 7.3e describes the usage of the BarElement, BarUse, and BarPosition properties, respectively; Fig. 7.3a to 7.3f assist in determining the appropriate usage of these properties.