DEVELOPMENT OF AN OBJECT LIBRARY
FOR A DESIGN SUPPORT SYSTEM

by

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Architecture

(ABSTRACT)

This thesis describes the development of an object library for a design support system presently being developed by the Fine Tools Group of the Architecture faculty. The object library is conceived as a library of 'types' based on the premise that a major part of design solution is accomplished by reference to prior solutions. It contains graphical representations of physical objects that make up a building, wherein each object representation possesses the capability of being depicted as a building component or as a building product. The proposed object library is organized by a typology. The usage of terms in the typology, in turn, is controlled by a thesaurus which reflects an ordering of terms used to form object descriptors and contains classifiers derived from the CSI and CI/SfE classification systems.
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# Table of Contents

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Typology and Design</td>
<td>4</td>
</tr>
<tr>
<td>Fine Design System: A Design Support System</td>
<td>6</td>
</tr>
<tr>
<td>Person-Object Spectrum</td>
<td></td>
</tr>
<tr>
<td>Strategic Placement</td>
<td></td>
</tr>
<tr>
<td>Tactical Placement</td>
<td></td>
</tr>
<tr>
<td>Object Library</td>
<td>10</td>
</tr>
<tr>
<td>Concepts on Object Representation</td>
<td></td>
</tr>
<tr>
<td>The Object Library and the Typology</td>
<td></td>
</tr>
<tr>
<td>The Typology and the Thesaurus</td>
<td></td>
</tr>
<tr>
<td>Framework for the Development of the Object Library</td>
<td></td>
</tr>
<tr>
<td>Typology</td>
<td>23</td>
</tr>
<tr>
<td>Object Descriptors</td>
<td></td>
</tr>
<tr>
<td>Descriptor Relationships</td>
<td></td>
</tr>
<tr>
<td>Form of Object Descriptors</td>
<td></td>
</tr>
<tr>
<td>Object Descriptor Format</td>
<td></td>
</tr>
<tr>
<td>Thesaurus</td>
<td>35</td>
</tr>
<tr>
<td>Thesaurus Descriptors</td>
<td></td>
</tr>
<tr>
<td>Descriptor Relationships</td>
<td></td>
</tr>
<tr>
<td>Descriptor Format</td>
<td></td>
</tr>
</tbody>
</table>
Object Storage and Retrieval 47

Object Storage

Object Retrieval

Conclusion 50

Object Library Development

Typology and Thesaurus Development

The Fine Design System and the Object Library

Bibliography 55

Appendix A CSI Classification System 59
Appendix B CI/SfB Classification System 65
Appendix C Typological Listings 70
Appendix D Thesaurus Listings 78
Appendix E Indexing Samples 93
Appendix F Sample Searches 95

Vita 102
# Table of Figures

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1</td>
<td>Person-Object Spectrum</td>
<td>7</td>
</tr>
<tr>
<td>Figure 2</td>
<td>Strategic Placement in Design</td>
<td>8</td>
</tr>
<tr>
<td>Figure 3</td>
<td>Tactical Placement in Design</td>
<td>9</td>
</tr>
<tr>
<td>Figure 4</td>
<td>Main Functions of the Typology</td>
<td>14</td>
</tr>
<tr>
<td>Figure 5</td>
<td>Typology Organization</td>
<td>17</td>
</tr>
<tr>
<td>Figure 6</td>
<td>Main Functions of the Thesaurus</td>
<td>19</td>
</tr>
<tr>
<td>Figure 7</td>
<td>Framework for the Development</td>
<td>22</td>
</tr>
<tr>
<td></td>
<td>of the Object Library</td>
<td></td>
</tr>
<tr>
<td>Figure 8</td>
<td>Structure for the Development</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>of the Typology</td>
<td></td>
</tr>
<tr>
<td>Figure 9</td>
<td>Generic-Specific Relationship</td>
<td>26</td>
</tr>
<tr>
<td>Figure 10</td>
<td>Whole-Part Relationships</td>
<td>27</td>
</tr>
<tr>
<td>Figure 11</td>
<td>Joint-Object Relationship</td>
<td>23</td>
</tr>
<tr>
<td>Figure 12</td>
<td>Thesaurus Descriptors and Classifiers</td>
<td>36</td>
</tr>
<tr>
<td>Figure 13</td>
<td>Descriptor Relationships</td>
<td>37</td>
</tr>
<tr>
<td>Figure 14</td>
<td>Fine Design System Library, Macro-Typology, and Macro-Thesaurus</td>
<td>53</td>
</tr>
</tbody>
</table>
INTRODUCTION

Design is a creative agent of change, wherein a major part of design solution is accomplished by reference to prior solutions. It is basically a decision-making process wherein designers tend to rely on formulated 'type' solutions as a means of deriving alternatives, options, and opportunities needed in making design decisions. The Fine Tools Group of the Architecture faculty at Virginia Tech is presently developing an integrated design support system intended to cater to the need to build and access a knowledge base of 'type' solutions.

The Fino Design System is a component-based system which allows the assemblage of components from a library to represent a building. The library is organized by a spectrum of component types which spans the range of information needed for design and includes the following categories: Persons, Purposes, Activities, Functions, and Objects. The purpose of this thesis is to propose a plan for the development of an object library as part of the Fine Design System, with the intention that it be used as a guide in developing other libraries of the design support system.
The proposed object library contains graphical representations of physical objects that make up a building, wherein each object representation in the library possesses the capability of being depicted as a building component contained in project files or as a building product contained in producer (manufacturer) files. The library is managed by a typology which provides a means of organizing the 'objects' in the library and contains descriptors that identify these 'objects'. The descriptors contained in the typology are referred to object descriptors.

Due to the ambiguous nature of terms used by the building industry to define building components and products, the usage of terms in the typology is controlled by a thesaurus. A thesaurus is a collection of selected words and functions as a specialized vocabulary of a given field, such as architecture or construction. There are basically two kinds of thesauri, namely: the free-form and the structured thesaurus. The free-form thesaurus is one wherein the user gradually builds the system's vocabulary. The structured thesaurus, on the other hand, provides the user with a previously organized set of terms for indexing purposes.
Since the building industry presently adopts classification systems (such as CSI and CI/SfB) to organize building/construction information, it is possible to build a structured thesaurus based on the terminology derived from these classification systems. The proposed thesaurus is one that provides an initial set of terms derived from the CSI and CI/SfB classification systems to be used in forming object descriptors and allows the inclusion of new terms into its structure.

The goal of this thesis is to build the framework by which the Object Library may be developed as part of the Fine Design System. The objectives are to describe the overall structures of the typology and thesaurus in relation to the object library, and to describe how all three elements can be used for information storage and retrieval. It is the intention that this thesis be adopted as a guide in the actual development of the object library as well as the other four libraries of the Fine Design System.
TYPOLOGY AND DESIGN

Design is simply a creative agent of change. McGinty defines design as the activity of generating proposals that change something that already exists into something that is better. This is the ideal concept of design. However, the final product of design is not necessarily "something that is better", but rather "something that has changed." Thus, design is defined as the process of transforming something that exists into something other than what exists. Since "what exists" is dependent on what the designer knows to exist, the design process can be described as being not only a transformation process but also a learning process.

Design is basically a decision-making process wherein a major part of design solution is accomplished by reference to prior solutions. Schon describes design as an interplay between "repertoires of broadly usable design knowledge" and "the perceived uniqueness of a design situation." This statement suggests that the designer keys knowledge from specific design situations to generic versions of those situations and invokes those generic situations in order to deal with current specific situations.
Typology plays a key role in developing the knowledge base of generic design situations. It is defined as the classification of objects wherein the term 'type' refers to the class of objects with similar characteristics defined by a set of criteria. Schon describes design knowledge as being embodied in types, and "types should be seen as particulars that function in a general way, or as general categories that have the 'fullness' of particulars." Designers tend to rely on formulated 'type' solutions as a means of deriving alternatives, options, and opportunities needed in making design decisions.

Based on the preceding discussion on the essentiality of typology in design, there is a need to build and access a knowledge base of 'type' solutions. The Fine Design System caters to this need by providing a library of 'types' that supports the design process. The following chapters present key concepts pertaining to the development of the Fine Design System as well as the development of the Object Library, the Typology, and the Thesaurus as components of this design support system.
THE FINE DESIGN SYSTEM: A Design Support System

The Fine Design System is a component-based system which allows the assemblage of components from a library to represent a building. The library is conceived as a library of 'types' from which information relating to standard and conventional organizations, procedures and solutions to building problems are retrieved.

Person-Object Spectrum

The library is organized by a spectrum of component types which spans the range of information required in design. Based on the premise that design is achieved by dealing with Object types, to provide Function types, which can support Activity (or Behavior) types, which can accomplish Purpose types of the Person types for whom the design is intended, the component categories adopted by the Fine Design System are those found in the Person-Object Spectrum [Wade 77]. Thus, the Fine Design System can be perceived as containing five libraries of Person types, Purpose types, Activity types, Function types and Object types.
Based on the General Reference Model (GRM) developed for AEC Product Data, the building process can be described in terms of six building stages, namely: the building as required, as designed, as planned, as built, as used, and as demolished. Since design is initiated by a perceived need to transform something that exists into something other than what exists, it can be characterized essentially as the difference between the 'building as used' and the 'building as required'. This difference, in turn, can be described in detail by the component categories adopted by the Fine Design System.

Figure 1  Person-Object Spectrum
Strategic Placement

Design, as a decision-making activity, invokes three other activities, namely: learning, analyzing, and programming. Learning refers to the acquisition of relevant information required for design; analyzing is the act of evaluating design proposals or solutions; and programming refers to generating a dynamic model which is capable of accepting internal or purpose changes (e.g. building program revisions). The proposed design support system consists of four principal working environments, supporting the four kinds of activities characterizing the design process: designing, learning, analyzing, and programming. Movement between these four environments is referred to by the Fine Tools Group as strategic placement.

![Diagram](image)

Figure 2 Strategic Placement in Design
Tactical Placement

Another kind of "movement" within the design process is that of tactical placement, wherein the designer's thoughts and actions are focused somewhere along the Person-Object spectrum, somewhere along the Scale spectrum, and somewhere along the Constraint spectrum. Along the Person-Object spectrum, the designer can be dealing with the purposes of the user or the physical arrangement of the fully realized building. Along the Scale spectrum, the designer can be working at an inclusive site scale or at a detailed room scale. Along the Constraint spectrum, the designer can be dealing with the organization and interrelationships of all the systems in a building or with a single system in isolation.

![Diagram showing the relationship between Person-Object, Scale, and Constraint spectrums.]

Figure 3  Tactical Placement in Design
OBJECT LIBRARY

The Object Library is conceived as a library of 'types' in the form of graphical representations of physical objects, wherein each 'object' in the library can be used to depict a building component or a building product. The aim of this thesis is to build the framework by which the Object Library may be developed as part of the Fine Design System, by describing how 'objects' in the library are to be identified, organized, and retrieved for design purposes.

Concepts on Object Representation

The building (or any physical unit) can be defined as a 'joining' of components to form an assembly or an arrangement. The concept of the building as an assembly implies the joining of components by physical connectors such as bolts and nails. The concept of the building as an arrangement implies the functional connectivity between its components to support the activities of its users such as a bathroom's proximity to a bedroom. In both cases, the building or any 'physical object' can be defined by its joints and the components or parts being joined.
Consider two distinct cases: the physical connection between a column and a beam versus the functional connectivity between a door and a light switch. The physical connection between the column and the beam can be defined by the method used to adjoin the two elements (by physical connectors or by gravity) and the geometric configuration formed in abutting one against the other. While physical connections indicate adjacency, functional connections indicate proximity. The functional connection between the door and the light switch can be described by identifying the location of one element in relation to the other. This kind of connection generally results from the need to cater to the activities (or behavior) of persons (or institutions). In some instances, like in the case of a table and a chair bolted together (e.g. classroom desk/chair), it is possible to describe both the physical and functional connections between the two elements.

Therefore, it is presumed that the term 'object' in relation to the contents of the Object Library pertains to representations of physical objects as assemblies and/or arrangements. Note that 'objects' can be represented as being object types (e.g. concrete column) and/or joint types (e.g. the union of a concrete column and a steel beam).
Based on this premise, it is possible to have joint types depicted in an object type and a joint type as depicting two or more object types. Consider the case of the classroom desk/chair as an 'object' in the library. The desk + chair combination itself is an object type. It also depicts the joining of two object types (the desk and the chair) as its component parts and can thus be considered as a joint type. Therefore, an 'object' can be identified as being both an object type and a joint type, and can be retrieved as being one or the other. Note that as a joint type, the 'object' can be linked to two other 'objects' in the library.

Since 'objects' in the library are related to each other, there is a need to organize the contents of the Object Library in such a way that each 'object' is identified as being an object type and/or a joint type and is defined in terms of its relationship to other 'objects'. The proposed Typology, in conjunction with the Thesaurus, caters to this need to organize and identify the 'objects' contained in the library as well as define the relationships between these 'objects'. The following sections describe the functions of the Typology and the Thesaurus in relation to the Object Library.
The Object Library and the Typology

A typology is defined as the classification of objects wherein the term 'type' is a class of objects with similar characteristics defined by a set of criteria. Since the Object Library is conceived as a library of types, the Typology's main function is to organize the Object Library by defining the 'objects' contained in the library and identifying the relationships between them. Each 'object' contained in the library has a corresponding object descriptor in the Typology that identifies the 'object'.

Physical properties (or attributes) such as form, dimensions, and material play vital roles in defining 'objects' as being of a certain 'object type'. It is important to note that a physical object should at least be characterized by its form and size for it to be graphically represented and considered an 'object' in the library. Consider graphically depicting a window as a rectangle. This representation may be interpreted as either a window or a door unless it is defined further (perhaps by the addition of more lines) so as to depict its being a window. Some examples of object descriptors are 'double-hung wood windows' and 'metal casement windows'.
Since an 'object' can be depicted as being either a building component or a building product, the Typology is also used to access component and product representations from Project and Producer files that are linked to 'objects' in the library. The following diagram depicts the functional relationships between the Object Library, the Typology, and the Project and Producer files.

Figure 4  Main Functions of the Typology
A Project file reflects instances of the 'object' as components (e.g. at different locations in a building), and a Producer file reflects variations of the same 'object' as products (e.g. depicting special features). A sliding window is an example of an 'object' that can be reflected as both a component and a product. A commercial building, as an example of a project, can depict several instances of sliding windows as building components. A sliding window unit can be reflected as a single unit on the first floor or as part of a ribbon window unit on the second floor. Anderson Windows, as an example of a producer or manufacturer, can supply different kinds of sliding window products from insulating to double-action windows.

By linking components and products to 'objects', it is possible to perceive each building component as being linked to a set of products contained in the Producer files and each building product as being linked to a set of components contained in the Project files. This can be particularly useful during procurement when building products that match corresponding components are selected, and during the preparation of working or shop drawings when previous installations of a product as a building component are reviewed.
A number of classification systems, such as the CSI Master Format and the CI/SfB filing system, are currently being used by Architectural, Engineering, and Construction (AEC) firms to facilitate the storage and retrieval of building/construction information. Inherent within each classification system is an ordering of terms used to define groups of building components or building products. Thus, it is possible to structure both Project and Producer files according to these classification systems.

The CSI classification system (see Appendix A) is primarily building trade-based and is, thus, useful in filing product information. At present, the McGraw-Hill Information Systems Company adopts the CSI classification system as a means of organizing building product information contained in the Sweets catalogs. The CI/SfB classification system (see Appendix B), on the other hand, is basically building system-based and offers a distinct advantage of being utilized for filing project information. Since both components and products can be linked to 'objects' in the library, it is important to note that the user's familiarity with such classification systems as a means of storing and retrieving both project and product information should be considered while developing the Object Library.
Since both products and components are linked to 'objects', we can then assume that object descriptors in the typology can be organized according to these classification systems to facilitate object storage and retrieval. The following diagram depicts the relationships between the Typology, the Project files, the Producer files and the CSI and CI/SfB classification systems.

Figure 5 Typology Organization
The Typology and the Thesaurus

Due to the ambiguous nature of terms used by the building industry to define building components, the usage of terms in the typology will be controlled by a thesaurus. A thesaurus is defined as a collection of selected words, as a specialized vocabulary of a given field such as architecture or construction. In addition to supplying the terms to be used in forming object descriptors, it controls the usage of these terms by automatically providing the preferred terms that define the 'objects'. This is deemed necessary when multiple terms or descriptors are associated with the same object (e.g. 'beam' and 'girder') and the object can only be stored and retrieved using one term.

A number of thesauri such as the Industrialization Forum (IF) Thesaurus are presently being used to store and retrieve building / construction information. However, most of their structures are not capable of handling multiple-attribute combinations to define object types such as 'metal circular pipes'. Thus, it is necessary to limit the function of the thesaurus to mainly controlling the proper usage of terms and delegating the function of defining 'objects' with the aid of the thesaurus to a typology.
Since object descriptors in the Typology can be organized according to the CSI and CI/SfB classification systems, then we can incorporate the classifiers found in these systems into the Thesaurus and link them to the appropriate terms to be used in forming object descriptors. The following diagram depicts the relationships between the Thesaurus, the Typology, and the CSI and CI/SfB classification systems.

![Diagram showing relationships between Typology, Thesaurus, and CSI/CI/SfB]
Framework for the Development of the Object Library

Based on the preceding concepts, it is possible to generate a set of conclusive statements pertaining to the functional relationships between the Object Library, the Typology, and the Thesaurus. This list, in turn, is used to generate a diagram that provides a framework for the development of the Object Library as part of the Fine Design System.

1. The Object Library is organized by a Typology that identifies the 'objects' contained in the library and defines the relationships between these 'objects'.

2. The Typology accesses component and product representations from Project and Producer files that are linked to 'objects' in the library.

3. The Project files can be structured according to the CI/SfB classification system which is characterized as being basically building system-based.
4. The Producer files can be structured according to the CSI classification system which is characterized as being basically building trade-based.

5. Object descriptors in the Typology can be organized according to the CSI and CI/SfB classification systems to facilitate object storage and retrieval.

6. The Typology is defined by a Thesaurus that provides the terms used to form object descriptors and ensures their proper usage.

7. Classifiers found in the CSI and CI/SfB systems are incorporated into the Thesaurus and linked to the appropriate terms to be used in forming object descriptors.
Figure 7 Framework for the Development of the Object Library
A typology has been defined as the classification of objects wherein the term 'type' is a class of objects with similar characteristics defined by a set of criteria. The Typology's main function is to define and organize 'objects' in the library by assigning object descriptors that identify the 'objects'. Since 'objects' in the library are in some way related to each other, the object descriptors contained in the Typology should reflect some sort of relationship to one another. This chapter proposes a structure for the development of the Typology based on the preceding concepts. It focuses on organizing the different kinds of object descriptors and their relationships.

Figure 8 Structure for the Development of the Typology
Object Descriptors

Since any physical object can be defined by its joint and the parts (or objects) being joined, it is necessary to classify each object descriptor in the Typology as being either an object type or a joint type descriptor. Attributes play an important role in defining both object and joint types.

Physical objects exhibit certain characteristics, such as form, material, and size (in terms of dimensions). Generally, an object is initially perceived as being of a certain size and form. Materials, in some cases, dictate the kind of form that characterizes an object. But, in most situations, material is perceived after the object's function is confirmed based on its form and size as 'generic attributes'. This is consistent with the way designers work. Initially, designers tend to manipulate geometric shapes in various dimensions to create or simulate an object and then assign specific attributes such as material to enhance the object's function or appearance. In some cases, the designer uses this object to form part of another object by situating the object in relation to the other parts of the larger object.
The range of object types can be divided into several levels of generality and specificity. For purposes of discussion, these levels of abstraction reflect variances of generic type and specific type objects. A generic type object is defined by its form and size. A specific type object is simply a generic type object defined further by specific properties or attributes such as its material. In cases where the designer uses an 'object' in the library to form part of a building component or product, the designer places the object in a particular location in relation to the other component parts. Instances of an 'object' refer to the actual placement of generic or specific object representations in a project or in product description.

Attributes can also be used to define joint types. Joining method and geometric configuration are examples of attributes describing joints as physical connections and degrees of proximity are examples of attributes describing joints as functional connections. Similarly, joint types can be divided into two levels of abstraction based on the 'object types' being joined. Generic type joints are those where objects being joined are generic types, and specific type joints are those where objects being joined are specific type objects.
Descriptor Relationships

Hierarchical relationships between 'type' descriptors can be divided into two groups: the generic-specific and the whole-part relationships. Generic-specific relationships are defined by how the designer perceives the 'object' as possessing certain characteristics (or attributes). As previously discussed, this kind of relationship defines 'object types'.

Figure 9 Generic-Specific Relationship
Whole-part relationships, on the other hand, focus on connections between objects. For purposes of discussion, this paper treats the 'object' as an assembly and focuses on physical connections as a means of depicting whole-part relationships. The following diagram depicts how a generic and specific type object can be broken down into its parts.

![Diagram of Whole-Part Relationships]

Figure 10 Whole-Part Relationships
Associative relationships between 'type' descriptors in the Typology are those between object type and joint type descriptors. As previously stated, generic joint types depict the 'joining' of generic type objects, and specific type joints depict the connection between specific object types. Therefore, an object can be linked to a joint that depicts the object as one of its parts and vice versa.

Figure 11 Joint-Object Relationship
Forms of Object Descriptors

The object descriptors contained in the Typology are in the form of compound expressions created by attaching attributes to object identifiers provided by the Thesaurus. Attributes, generally, are in the form of adjectives while object identifiers are in the form of nouns. An example of an object type descriptor is 'Window, Double-Hung, Metal' where the first term 'Window' is the identifier and the succeeding terms 'Double-Hung' and 'Metal' are attributes indicating the form and frame material of the 'object'. An example of a joint type descriptor is 'Column, Rectangular, Concrete: Beam, I-Shape, Steel' wherein the joint type is defined by descriptors of the two object types being connected.

Note that for purposes of consistency, an indexing convention has been developed to distinguish object types from joint types as well as differentiate identifiers from attributes. Identifiers in an object type descriptor precede attributes and each term is separated by a comma. In joint type descriptors, the two object type descriptors indicating the parts being connected are separated by a colon.
In generic object descriptors, form and size attribute terms follow the identifier. Specific object descriptors, on the other hand, are characterized as having form, size, and material attribute terms succeed the identifier. 'Window, Double-Hung' is an example of a generic object descriptor while 'Window, Double-Hung, Metal' is an example of a specific object descriptor. Note that in the previous examples, the object's size is assumed to be standard and is omitted from the descriptor. For purposes of discussion, this convention is used in the succeeding sections as a means of depicting object type descriptors.

Since joint descriptors identify the two object types or parts being connected, the object descriptors in generic joint descriptors that are separated by the colon are generic object descriptors. Specific joint descriptors, on the other hand, are characterized as having specific object descriptors separated by the colon. Based on the previous example, 'Column, Rectangular : Beam, I-Shape' is considered a generic joint descriptor while 'Column, Rectangular, Concrete : Beam, I-Shape, Steel' is considered a specific joint descriptor. Note that the joint's attribute is omitted from the descriptor in the preceding examples for purposes of discussion.
Object Descriptor Format

Candidate object or descriptors function as main entries in the Typology, with 'indicators' accompanying each main entry term. Indicators usually function as explanations or comments and are utilized for the purpose of determining the descriptor's proper usage. The indicators in the proposed Typology function mainly as classifiers, defining the context in which the descriptors should be used in relation to others. In the Typology, it is necessary to identify each term as an object type or a joint type descriptor, and as a generic type or a specific type.

<table>
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<th>Indicators</th>
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<tr>
<td>OSPEC</td>
<td>Object (Specific) Type Term</td>
</tr>
<tr>
<td>JGEN</td>
<td>Joint (Generic) Type Term</td>
</tr>
<tr>
<td>JSPEC</td>
<td>Joint (Specific) Type Term</td>
</tr>
</tbody>
</table>

Examples:
OGEN       Beam, I-Shape
OSPEC      Beam, I-Shape, Steel
JGEN       Beam, I-Shape : Column, Rectangular
JSPEC      Beam, I-Shape, Steel : Column, Square, Concrete
In addition to the indicator, each main entry has attached to it at least one cross-reference term. Cross-reference terms are main entries themselves but are linked to other entries by means of hierarchical and associative relationships. Each term is preceded by a notation indicating the kind of cross-reference.

Hierarchical Cross-References:

- WT   Whole Term
- PT   Part Term
- GEN  Generic Type Term
- SPEC Specific Type Term

Associative Cross-References:

- OBJ  Object Type Term
- JNT  Joint Type Term
The following chart depicts possible relationships between kinds of main entry and cross-reference terms.

**CROSS-REFERENCES**

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<td>Specific Term (SPEC)</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>

**Associative:**

<table>
<thead>
<tr>
<th>Term Type</th>
<th>OGEN</th>
<th>OSPEC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Object Type Term (OBJ)</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>Joint Type Term (JNT)</td>
<td>x</td>
<td>x</td>
</tr>
</tbody>
</table>
Appendix C depicts three forms of typological listings: an alphabetic listing of main entries, an alpha-hierarchical listing of main entries, and an alpha-relational listing of main entries with cross-references attached. The following depicts an example of an object descriptor reflecting the inclusion of main entry and cross-reference terms.

Example of an Object Descriptor:

OGEN  Door, Swinging
WT    Door Assembly, Swinging
SPEC  Door, Swinging, Glass
      Door, Swinging, Metal
      Door, Swinging, Wood
JNT   Door, Swinging : Door Frame, Rabbeted
THESAURUS

A thesaurus has been defined as a collection of selected words, as a specialized vocabulary of a given field such as architecture or construction. The proposed Thesaurus contains basically two types of descriptors that describe physical objects, namely: identifiers (terms that define objects and joints) and attributes (terms that define characteristics associated with these objects and joints). These two kinds of terms can be broken down further into four groups, namely: object identifiers, joint identifiers, object attributes, and joint attributes. Thesaurus descriptors are used mainly for purposes of forming object descriptors contained in the Typology and not for purposes of defining 'objects' contained in the Object Library.

The identifier and attribute terms in the Thesaurus can be classified under one or more categories reflected in classification systems, such as CSI and CI/SfE. These categories are incorporated into the Thesaurus as classifiers. Note that these classifiers are considered non-descriptors and are to be used mainly for purposes of retrieving 'objects'.
Object descriptors in the Typology are formed by combining terms contained in the Thesaurus. The following diagram depicts the two types of Thesaurus descriptors (identifiers and attributes) in relation to object descriptors contained in the Typology, as well as their relationship to classifiers derived from the CSI and CI/SfB Classification systems.

Figure 12  Thesaurus Descriptors and Classifiers
Since object descriptors contained in the Typology reflect hierarchical and associative relationships, descriptors in the Thesaurus should reflect similar relationships. This chapter proposes a structure for the development of the Thesaurus based on the preceding concepts. It focuses on organizing the different kinds of Thesaurus descriptors by defining their relationships.

Figure 13 Descriptor Relationships
Thesaurus Descriptors

Terms used to identify object types correspond to object identifiers found in the Thesaurus. The identification of connections between object types correspond to joint identifiers, wherein a joint is either a physical or functional connection between two objects. Joints depicting connections between three or more objects can be conceived as being sets of two-object joints. The terms 'column', and 'beam' are examples of object identifiers while the term 'column : beam' is an example of a joint identifier.

Since attributes play an important role in defining 'types', they are included in the Thesaurus as object attributes and joint attributes. Object attributes, as discussed, are those describing an object's form, material, and size (in terms of dimensions). Note that it is possible to combine attribute terms to form composites, such as 'metal + wood', 'concrete + wood', and so on. Joint attributes are those describing the joining method employed and geometric configuration of physical connections, as well as those describing the degrees of proximity of functional connections.
The Thesaurus contains non-descriptors as candidate terms which refer to the appropriate identifier and attribute terms as preferred (descriptor) terms. Examples of non-descriptors are:

1. Synonymous terms (e.g. 'beam' = 'girder') wherein one term represents the other as the preferred term;

2. Abbreviations or symbols (e.g. 'door' = 'DR') wherein the term (or word) acts as the preferred term as opposed to its notation; and

3. Classifiers derived from the CSI and CI/SfB classification systems.

Descriptor Relationships

Hierarchical relationships between Thesaurus descriptors can be divided into two basic groups: the whole-part and the broad-narrow relationships. Whole-part relationships generally focus on the object as an assembly and are defined by how the designer views the object in terms of its breakdown into component parts.
This kind of relationship also exists in joints, especially in cases where two objects abut each other at different points. The connection between the door and the door frame, for example, consists of the joints between the top rail and the header, the lock stile and the lock jamb, the hinge stile and the hinge jamb. Note that part-part relationships refer to physical connections between objects and are defined by the joint identifiers.

Broad-narrow relationships, on the other hand, represent relative degrees of specificity in a class of concepts belonging to a particular generic group. In effect, this kind of relationship aids in defining generic-specific relationships between object descriptors found in the Typology. Chairs and tables, for example, are furnishings. Doors and windows are considered openings while structural and mechanical systems are considered building systems. Broad-narrow relationships also apply in defining levels of specificity between attribute terms. Metal, for example, belongs to the group of building materials, and steel is a member of the group of metals. Both whole-part and broad-narrow hierarchical relationships depict a 1:1 or more relationship from a higher to a lower level term.
There are basically three kinds of associative relationships that can be derived from the four descriptor groups: the object-attribute, the joint-attribute and the object-joint relationships. In object-attribute and joint-attribute relationships, there exists a 1:1 or more relationship both ways. There is at least one attribute associated with each object (or joint) and there is at least one object (or joint) which may be described by an attribute. Object-joint relationships, on the other hand, depict two types of relationships. An object is assumed to be part of an assembly and can have one or more joints linked to it (1:1 or more). Since a joint is defined as a connection between two objects, each joint has two objects associated with it (1:2).

Associative relationships also exist between non-descriptors and descriptors, specifically between classifiers and their corresponding identifier or attribute terms. Classifier-descriptor relationships are characterized as being on a 1:1 or more basis. Reciprocal relationships, which are strictly on a 1:1 basis, are used to indicate preferred synonyms and to identify appropriate words associated with an abbreviation or a symbol.
Descriptor Format

The preliminary edition of the IF (Industrialization Forum) Thesaurus provides an example of a thesaurus' construction. The arrangement of terms in the proposed Thesaurus is based on concepts derived from the IF thesaurus, but differs slightly in terms of format and cross-referencing requirements. The descriptors described in the previous sections are main entries, wherein each main entry has attached to it a set of cross-reference terms depicting descriptor relationships.

Candidate terms or descriptors function as main entries in the Thesaurus, with 'indicators' accompanying each main term. Indicators usually function as explanations or comments and are utilized for the purpose of determining the descriptor's proper usage. Indicators in the IF thesaurus are in the form of Scope Notes (SN) attached to main entries for the inclusion of restrictions and recommendations. The indicators used in the proposed Thesaurus function mainly as classifiers using symbols to identify the kind of descriptor. By distinguishing identifier and attribute terms, the indicators define the context in which the descriptors should be used in relation to others.
In the Thesaurus, it is necessary to classify each main entry as a descriptor or a non-descriptor. Each descriptor is identified as being either an object term, a joint term, an object attribute term, or a joint attribute term, while each non-descriptor is identified as being either a classifier or a synonymous term / abbreviation / symbol.

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>Object Term</td>
</tr>
<tr>
<td>JT</td>
<td>Joint Term</td>
</tr>
<tr>
<td>OAT</td>
<td>Object Attribute Term</td>
</tr>
<tr>
<td>JAT</td>
<td>Joint Attribute Term</td>
</tr>
<tr>
<td>CT</td>
<td>Classifier</td>
</tr>
<tr>
<td>**</td>
<td>Non-Descriptor: Synonymous Term, Abbreviation, or Symbol</td>
</tr>
</tbody>
</table>

Examples:

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT</td>
<td>Beam</td>
</tr>
<tr>
<td>JT</td>
<td>Beam : Column</td>
</tr>
<tr>
<td>OAT</td>
<td>I-Shape</td>
</tr>
<tr>
<td>JAT</td>
<td>Perpendicular Configuartion</td>
</tr>
<tr>
<td>CT</td>
<td>Div. 5 Metal</td>
</tr>
<tr>
<td>**</td>
<td>Girder</td>
</tr>
</tbody>
</table>
In addition to the indicator, each main entry has attached to it a cross-reference term. Cross-reference terms are main entries themselves but are linked to other entries by means of hierarchical, associative, and reciprocal relationships.

**Hierarchical Cross-References:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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<tbody>
<tr>
<td>WT</td>
<td>Whole Term</td>
</tr>
<tr>
<td>PT</td>
<td>Part Term</td>
</tr>
<tr>
<td>BT</td>
<td>Broad Term</td>
</tr>
<tr>
<td>NT</td>
<td>Narrow Term</td>
</tr>
</tbody>
</table>

**Associative Cross-References:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>OT</td>
<td>Object Term</td>
</tr>
<tr>
<td>JT</td>
<td>Joint Term</td>
</tr>
<tr>
<td>OAT</td>
<td>Object Attribute Term</td>
</tr>
<tr>
<td>JAT</td>
<td>Joint Attribute Term</td>
</tr>
<tr>
<td>CT</td>
<td>Classifier Term</td>
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</tbody>
</table>

**Reciprocal Cross-References:**

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>USE</td>
<td>Preferred Term</td>
</tr>
<tr>
<td>UF</td>
<td>Non-Preferred Term</td>
</tr>
</tbody>
</table>
The following chart depicts possible relationships between kinds of main entry and cross-reference terms.

**THESAURUS MAIN ENTRY TYPES**

<table>
<thead>
<tr>
<th></th>
<th>OT</th>
<th>JT</th>
<th>OAT</th>
<th>JAT</th>
<th>CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**CROSS-REFERENCES**

**Hierarchical:**

- Whole Term (WT)  
  - x
- Part Term (PT)  
  - x
- Broad Term (BT)  
  - x  
- Narrow Term (NT)  
  - x  
- x

**Associative:**

- Object Term (OT)  
  - x  
- Joint Term (JT)  
  - x  
- Object Attribute (OAT)  
  - x  
- Joint Attribute (JAT)  
  - x  
- Classifier Term (CT)  
  - x  
- x  
- x

**Reciprocal:**

- Preferred (USE)  
  - x
- Non-Preferred (UF)  
  - x  
- x  
- x  
- x
Appendix D depicts three forms of thesaurus listings: an alphabetic listing of main entries, an alpha-hierarchical listing of main entries, and an alpha-relational listing of main entries with cross-references attached. The following is an example of a Thesaurus descriptor depicting the inclusion of main entry and cross-reference terms.

**Example of a Thesaurus Descriptor:**

<table>
<thead>
<tr>
<th>OT</th>
<th>Door</th>
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<tbody>
<tr>
<td>WT</td>
<td>Door Assembly</td>
</tr>
<tr>
<td>PT</td>
<td>Door Panel</td>
</tr>
<tr>
<td></td>
<td>Jamb</td>
</tr>
<tr>
<td></td>
<td>Stile</td>
</tr>
<tr>
<td>BT</td>
<td>Opening</td>
</tr>
<tr>
<td>JT</td>
<td>Door : Door Frame</td>
</tr>
<tr>
<td>OAT</td>
<td>Wood</td>
</tr>
<tr>
<td></td>
<td>Metal</td>
</tr>
<tr>
<td></td>
<td>Glass</td>
</tr>
<tr>
<td>UF</td>
<td>Door Sash</td>
</tr>
<tr>
<td>CT</td>
<td>Div. 8 Windows and Doors</td>
</tr>
</tbody>
</table>
OBJECT STORAGE AND RETRIEVAL

The Typology contains a set of object descriptors that identify 'objects' in the library, while the thesaurus contains a set of terms to be used in forming or identifying these object descriptors. The proposed Typology and Thesaurus are used in conjunction with each other in the storage and retrieval of 'objects'. By providing descriptors, both aid in the selection and/or confirmation of 'objects' in the library.

Object Storage

When a new 'object' is added to the Object library, a corresponding object descriptor is created. The resulting object descriptor is checked against those in the Typology to avoid duplication. The terms reflected in this descriptor are checked against those in the Thesaurus for proper usage and/or possible inclusion. Since it is also possible to select existing Thesaurus descriptors to form an object descriptor, then the inclusion of new terms into the Thesaurus aids in defining 'objects'. Appendix E illustrates indexing steps to be used in storing 'objects'.
Object Retrieval

In object retrieval, terms from the Thesaurus are used to identify the 'object' and the resulting object descriptor is checked against those that are presently in the Typology. If the object descriptor does not exist in the Typology, then the 'object' does not exist in the Object Library. It is possible to retrieve alternative 'objects' by comparing and matching terms used to form the object descriptor with those reflected as existing descriptors.

There are basically two methods of searching for an 'object': by specifying a term associated with the object or by selecting the category reflected in the CSI or CI/SfB systems in which the object belongs to. The first method, referred to here as the direct search method, allows the user to enter a term defining the 'object'. The term is then checked against descriptors contained in the Thesaurus for inclusion and proper usage. A series of descriptor lists are then displayed for selection until an object descriptor is selected. The resulting object descriptor is used to locate and extract the 'object' from the library as well as access corresponding components / products from the project / producer files.
Some construction information systems, such as SweetSearch and SweetSpec, currently use classification systems like CSI or CI/SfB for information retrieval purposes. The user's familiarity with these classification systems as a means of retrieving information should be considered while developing the Thesaurus. The categories depicted in these classification systems are to be incorporated into the Thesaurus as classifiers or non-descriptors pointing to their corresponding descriptors using the USE/UF cross-reference.

The second search method, referred to here as the classifier selection method, allows the user to select a CSI or CI/SfB category in which the 'object' belongs to. The selected category or classifier is used to locate the corresponding descriptors that are linked to it. A series of descriptor lists are then displayed for selection until an object descriptor is selected. The resulting object descriptor is used to locate and extract the 'object' from the library as well as access corresponding components/products from the project/producer files. Appendix F illustrates sample searches using the classifier selection and direct search methods.
CONCLUSION

This paper has described the framework for the development of the Object Library. It has also proposed possible structures for the Typology which defines and organizes the 'objects' in the library, and for the Thesaurus which controls the terminology used in the Typology. It is intended that the Typology, in conjunction with the Thesaurus, be used to store and retrieve object representations contained in the Object Library.

Object Library Development

The Object Library is conceptualized as containing graphical representations of physical object types. Since an 'object' is capable of being represented as a component or as a product, the 'objects' in the library are used to develop both the Project and the Producer files. It is presumed that these files contain graphical representations of components and products, with attached sets of specifications, assembly costs, installation times, and product selection data. Thus, each 'object' can be linked to these accompanying sets of component/product data.
Using the proposed framework developed for the development of the Object Library, initial effort should focus on creating the 'objects' to be contained in the library and on generating their corresponding object descriptors. The development of both the Typology and the Thesaurus are based on this initial set of 'objects'.

**Typology and Thesaurus Development**

The proposed Thesaurus and Typology have similar structures. However, the descriptors in the Typology are limited to those identifying 'objects' in the library, while descriptors in the Thesaurus include all terms used by the building industry to describe the physical objects that make up a building. The object descriptors defining the initial set of 'objects' in the library are organized for inclusion into the Typology and their hierarchical and associative relationships defined. The initial set of Thesaurus descriptors includes the terms used in these object descriptors. The Thesaurus is expanded further to include other candidate terms and classifiers from the CSI and CI/SfB systems. Thesaurus descriptors and non-descriptors are linked to each other through hierarchical, associative, and reciprocal relationships.
Whenever a new 'object' is added to the Object library, a corresponding object descriptor is created and added to those in the Typology. Any new term used in the object descriptor is checked against those in the Thesaurus for proper usage and possible inclusion.

The Fine Design System and the Object Library

The Fine Design System is supported by a library comprised of five smaller libraries of component types, one of which is the Object Library. It is the intention of this thesis that the proposed framework for the development of the Object Library be used as a guide in developing the other four libraries of the Fine Design System. The Typology and the Thesaurus described in this paper are considered to be micro-versions of the macro-typology and macro-thesaurus supporting the total system library. The following diagram depicts elements of the system library, macro-typology, and macro-thesaurus. Note that mapping between the five system libraries is accomplished through each library's micro-typology.
Figure 14  Fine Design System Library, Macro-Typology.
and Macro-Thesaurus
The concepts discussed in this paper support the concepts relating to strategic placement and tactical placement within the design process. Based on the premise that a major part of design solution is accomplished by reference to prior solutions, representations in the Object Library can be used as design 'templates' in the designing environment and as references in the learning environment. In the programming environment, these 'objects' can be used in preparing building type studies. In the analyzing environment, these 'objects' can be used to evaluate a current design solution in relation to its precedents.

Mapping between the five libraries through their corresponding micro-typologies supports the concept of movement along the Person-Object Spectrum. The concept of movement along Scale Spectrum, on the other hand, can be achieved using WT/PT cross-references (depicting whole-part relationships) between object descriptors. Movement along the Constraint Spectrum can be accomplished using the BT/NT cross-references (depicting broad-narrow relationships) between Thesaurus descriptors.
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Verheijen, G. M. A. and Van Bekkum, J. "NIAM: An
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of Information Systems Design Methodologies. North


ATTACHMENT A: CSI CLASSIFICATION SYSTEM

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<th>Division</th>
<th>Description</th>
<th>Code</th>
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<tbody>
<tr>
<td>1</td>
<td>General Requirements</td>
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<td>01010</td>
<td>Summary of Work</td>
<td></td>
</tr>
<tr>
<td>01050</td>
<td>Field Engineering</td>
<td></td>
</tr>
<tr>
<td>01100</td>
<td>Alternates/Alternatives</td>
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</tr>
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<td>01200</td>
<td>Project Meetings</td>
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<td>Submittals</td>
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<td>01400</td>
<td>Quality Control</td>
<td></td>
</tr>
<tr>
<td>01500</td>
<td>Construction Facilities and Temporary Controls</td>
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</tr>
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<td>01600</td>
<td>Material and Equipment</td>
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</tr>
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<td>01700</td>
<td>Contract Closeout</td>
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<td>Maintenance Materials</td>
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<td>Sitework</td>
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<td>02100</td>
<td>Site Preparation</td>
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<td>02200</td>
<td>Earthwork</td>
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<td>02300</td>
<td>Tunneling</td>
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<tr>
<td>02400</td>
<td>Drainage</td>
<td></td>
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<tr>
<td>02500</td>
<td>Paving and Surfacing</td>
<td></td>
</tr>
<tr>
<td>02600</td>
<td>Piped Utility Materials and Methods</td>
<td></td>
</tr>
<tr>
<td>02700</td>
<td>Piped Utilities</td>
<td></td>
</tr>
<tr>
<td>02800</td>
<td>Power and Communication Utilities</td>
<td></td>
</tr>
</tbody>
</table>
Division 3  Concrete
   03100  Concrete Formwork
   03200  Concrete Reinforcement
   03300  Cast-in-Place Concrete
   03400  Precast Concrete
   03500  Cementitious Decks
   03600  Grout
   03700  Concrete Restoration and Cleaning

Division 4  Masonry
   04100  Mortar
   04200  Unit Masonry
   04400  Stone
   04500  Masonry Restoration and Cleaning
   04600  Corrosion Resistant Masonry

Division 5  Metal
   05100  Structural Metal Framing
   05200  Metal Joists
   05300  Metal Decking
   05400  Cold-Formed Metal Framing
   05500  Metal Fabrications
   05700  Ornamental Metal
   05800  Expansion Control
   05900  Metal Finishes
Division 6  Wood & Plastic
    06100  Rough Carpentry
    06200  Finish Carpentry
    06300  Wood Treatment
    06400  Architectural Woodwork
    06500  Prefabricated Structural Plastics
    06600  Plastic Fabrications

Division 7  Thermal & Moisture Protection
    07100  Waterproofing
    07200  Insulation
    07300  Shingles and Roofing Tiles
    07400  Preformed Roofing and Siding
    07500  Membrane Roofing
    07600  Flashing and Sheet Metal
    07800  Roof Accessories
    07900  Sealants

Division 8  Doors & Windows
    08100  Metal Doors and Frames
    08200  Wood and Plastic Doors
    08300  Special Doors
    08400  Entrances and Storefronts
    08500  Metal Windows
    08600  Wood and Plastic Windows
    08800  Glazing
Division 9  Finishes
  09100  Metal Support Systems
  09200  Lath and Plaster
  09300  Tile
  09400  Terrazzo
  09500  Acoustical Treatment
  09600  Stone and Brick Flooring
  09700  Special Flooring
  09800  Special Coatings
  09900  Painting

Division 10  Specialties
  10100  Chalkboards and Tackboards
  10200  Louvers and Vents
  10300  Fireplaces and Stoves
  10500  Lockers
  10600  Partitions
  10800  Toilet and Bath Accessories
  10900  Wardrobe Specialties

Division 11  Equipment
  11100  Mercantile Equipment
  11200  Water Supply and Treatment Equipment
  11400  Food Service Equipment
  11600  Laboratory Equipment
  11800  Telecommunication Equipment
Division 12  Furnishings
   12100  Artwork
   12300  Manufactured Cabinets and Casework
   12500  Window Treatment
   12600  Furniture and Accessories
   12700  Multiple Seating
   12800  Interior Plants and Plantings

Division 13  Special Construction
   13100  Nuclear Reactors
   13200  Seisomographic Instrumentation
   13600  Utility Control Systems
   13900  Transportation Instrumentation

Division 14  Conveying Systems
   14100  Dumbwaiters
   14200  Elevators
   14300  Hoists and Cranes
   14400  Lifts
   14500  Material Handling Systems
   14600  Turntables
   14700  Moving Stairs and Walks
   14800  Powered Scaffolding
   14900  Transportation Systems
Division 15 Mechanical
  15200 Noise, Vibration, and Seismic Control
  15300 Special Piping Systems
  15400 Plumbing Systems
  15500 Fire Protection
  15600 Power or Heat Generation
  15800 Air Distribution
  15900 Controls and Instrumentation

Division 16 Electrical
  16200 Power Generation
  16300 Power Transmission
  16400 Service and Distribution
  16500 Lighting
  16600 Special Systems
  16700 Communications
  16900 Controls and Instrumentation
Table 1: Elements

(1-) Substructure
   (10) Site Substructure
   (11) Excavation, Land Drainage
   (13) Floor Beds
   (16) Foundations
   (17) Pile Foundations

(2-) Primary Elements
   (20) Site Primary Elements
   (21) External Walls, Walls in General
   (22) Internal Walls, Partitions
   (23) Floors, Galleries
   (24) Stairs, Etc.
   (27) Roofs
(2-) Secondary Elements
   (30) Site Secondary Elements
   (31) External Openings
   (32) Internal Openings
   (33) Floor Secondary Element
   (34) Balustrades to Stairs
   (35) Suspended Ceilings
   (37) Rooflights

(4-) Finishes
   (40) Site Finishes
   (41) External Wall Finishes
   (42) Internal Wall Finishes
   (43) Floor Finishes
   (44) Stair Finishes
   (45) Ceiling Finishes
   (47) Roof Finishes

(5-) Services
   (50) Site Services
   (51) Refuse Disposal in General
   (52) Drainage
   (53) Hot and Cold Water
   (54) Gas, Compressed Air
   (55) Refrigeration
   (56) Space Heating
   (57) Ventilation and Air Conditioning
(6-) Installations
   (60) Site Installations
   (62) Power
   (63) Lighting
   (64) Communications
   (66) Transport
   (68) Security

(7-) Fixtures
   (70) Site Fixtures
   (71) Circulation Fixtures
   (72) General Room Fixtures
   (73) Culinary Fixtures
   (74) Sanitary Fixtures
   (75) Cleaning Fixtures
   (76) Storage Fixtures

(8-) Loose Equipment
   (80) Site Loose Equipment
   (81) Circulation Loose Equipment
   (82) General Room Loose Equipment
   (83) Culinary Loose Equipment
   (84) Sanitary Loose Equipment
   (85) Cleaning Loose Equipment
   (86) Storage Loose Equipment
<p>| E | Cast in Situ                        |
| F | Bricks, Blocks                     |
| G | Structural Units                   |
| H | Sections, Bars                     |
| I | Tubes, Pipes                       |
| J | Wires, Mesh                        |
| K | Quilts                             |
| L | Foils, Papers                      |
| M | Foldable Sheets                    |
| N | Overlap Sheets, Tiles              |
| P | Thick Coatings                     |
| R | Rigid Sheets                       |
| S | Rigid Tiles                        |
| T | Flexible Sheets, Tiles             |
| U | Finishing Papers, Fabrics          |
| V | Thin Coatings                      |
| X | Components                         |
| Y | Products in General                |</p>
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<td>Materials in General</td>
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Alphabetic Listing of Main Entries:

OGEN Door, Folding
OSPEC Door, Folding, Wood
OGEN Door, Sliding
OSPEC Door, Sliding, Glass
OSPEC Door, Sliding, Wood
OGEN Door, Swinging
OSPEC Door, Swinging, Glass
JSPEC Door, Swinging, Glass : Door Frame, Rabbeted, Metal
OSPEC Door, Swinging, Wood
JSPEC Door, Swinging, Wood : Door Frame, Rabbeted, Wood
JGEN Door, Swinging : Door Frame, Rabbeted
OGEN Door Assembly, Folding
OGEN Door Assembly, Sliding
OGEN Door Assembly, Swinging
OGEN Door Frame, U-Shape
OGEN Door Frame, Rabbeted
OSPEC Door Frame, Rabbeted, Metal
OSPEC Door Frame, Rabbeted, Wood
Alpha-Hierarchical Listing of Main Entries:

OGEN Door Assembly, Folding
OGEN Door, Folding
OSPEC Door, Folding, Wood
OGEN Door Frame, U-Shape
OGEN Door Assembly, Sliding
OGEN Door, Sliding
OSPEC Door, Sliding, Glass
OSPEC Door, Sliding, Wood
OGEN Door Frame, U-Shape
OGEN Door Assembly, Swinging
OGEN Door, Swingings
OSPEC Door, Swinging, Glass
OSPEC Door, Swinging, Wood
OGEN Door Frame, Rabbeted
OSPEC Door Frame, Rabbeted, Metal
OSPEC Door Frame, Rabbeted, Wood
JGEN Door, Swinging : Door Frame, Rabbeted
JSPEC Door, Swinging, Glass : Door Frame, Rabbeted, Metal
JSPEC Door, Swinging, Wood : Door Frame, Rabbeted, Wood
Alpha-Relational Listing of Main Entries / Cross-References:

OGEN  Door, Folding
      SPEC  Door, Folding, Wood
      WT    Door Assembly, Folding

OSPEC  Door, Folding, Wood
      GEN   Door, Folding

OGEN  Door, Sliding
      SPEC  Door, Sliding, Glass
            Door, Sliding, Wood
      WT    Door Assembly, Sliding

OSPEC  Door, Sliding, Glass
      GEN   Door, Sliding

OSPEC  Door, Sliding, Wood
      GEN   Door, Sliding
OGEN  Door, Swinging
SPEC  Door, Swinging, Glass
       Door, Swinging, Wood
WT    Door Assembly, Swinging
JNT   Door, Swinging : Door Frame, Rabbeted

OSPEC  Door, Swinging, Glass
GEN   Door, Swinging
JNT   Door, Swinging, Glass : Door Frame,
       Rabbeted, Metal

JSPEC  Door, Swinging, Glass : Door Frame, Rabbeted, Metal
GEN   Door, Swinging : Door Frame, Rabbeted
OBJ   Door, Swinging, Glass
       Door Frame, Rabbeted, Metal

OSPEC  Door, Swinging, Wood
GEN   Door, Swinging
JNT   Door, Swinging, Wood : Door Frame,
       Rabbeted, Wood

73
JSPEC  Door, Swinging, Wood : Door Frame, Rabbeted, Wood
GEN   Door, Swinging  : Door Frame, Rabbeted
OBJ   Door, Swinging, Wood
       Door Frame, Rabbeted, Wood

JGEN  Door, Swinging  : Door Frame, Rabbeted
SPEC  Door, Swinging, Glass  : Door Frame,
       Rabbeted, Metal
       Door, Swinging, Wood  : Door Frame,
       Rabbeted, Wood
OBJ   Door, Swinging
       Door Frame, Rabbeted

OGEN  Door Assembly, Folding
PT    Door, Folding
       Door Frame, U-Shape

OGEN  Door Assembly, Sliding
PT    Door, Sliding
       Door Frame, U-Shape
OGEN   Door Assembly, Swinging
        Door Frame, Rabbeted
PT     Door, Swinging
        Door Assembly, Rabbeted

OGEN   Door Frame, U-Shape
WT     Door Assembly, Folding
        Door Assembly, Sliding

OGEN   Door Frame, Rabbeted
WT     Door Assembly, Swinging
JNT    Door, Swinging : Door Frame, Rabbeted

OSPEC  Door Frame, Rabbeted, Metal
GEN    Door Frame, Rabbeted
JNT    Door, Swinging, Glass : Door Frame, Rabbeted, Metal

OSPEC  Door Frame, Rabbeted, Wood
GEN    Door Frame, Rabbeted
JNT    Door, Swinging, Wood : Door Frame, Rabbeted, Wood
ATTACHMENT D: THESAURUS LISTINGS

Alphabetic Listing of Main Entries:

OT Bottom Rail
OT Center Rail
CT CI/SfB (1-) Substructure
CT CI/SfB (2-) Primary Elements
CT CI/SfB (3-) Secondary Elements
CT CI/SfB (30) Site Secondary Elements
CT CI/SfB (31) External Openings
CT CI/SfB (32) Internal Openings
CT CI/SfB (33) Floor Secondary Element
CT CI/SfB (34) Balustrades to Stairs
CT CI/SfB (35) Suspended Ceilings
CT CI/SfB (37) Rooflights
CT CI/SfB (4-) Finishes
CT CI/SfB (5-) Services
CT CI/SfB (6-) Installations
CT CI/SfB (7-) Fixtures
CT CI/SfB (8-) Loose Equipment
JAT Configuration
CT CSI DIV. 2 Sitework
CT CSI DIV. 3 Concrete
CT CSI DIV. 4 Masonry
CT CSI DIV. 5 Metal
CT CSI DIV. 6 Wood & Plastic
CT CSI DIV. 7 Thermal & Moisture Protection
CT CSI DIV. 8 Doors & Windows
CT CSI DIV. 9 Finishes
CT CSI DIV. 10 Specialties
CT CSI DIV. 11 Equipment
CT CSI DIV. 12 Furnishings
CT CSI DIV. 13 Special Construction
CT CSI DIV. 14 Conveying Systems
CT CSI DIV. 15 Mechanical
CT CSI DIV. 16 Electrical

OT Door
JT Door : Door Frame
OT Door Assembly
OT Door Core
CAT Door Form
OT Door Frame
OAT Door Frame Form
OT Door Frame Header
JT Door Frame Header : Top Rail
OT  Door Panel
**  Door Sash
**  Door Surround
OAT  Folding
OAT  Form
OAT  Glass
OT  Hinge Jamb
JT  Hinge Jamb : Hinge Stile
OT  Hinge Stile
JAT  Joining Method
OT  Lock Jamb
JT  Lock Jamb : Lock Stile
OT  Lock Stile
OAT  Material
OAT  Metal
OT  Opening
OAT  Rabbeted
OAT  Sliding
OAT  Swinging
OT  Top Rail
OAT  U-Shape
OT  Window
OT  Window Assembly
OT  Window Frame
OAT  Wood
Alpha-Hierarchical Listing of Main Entries:

CT CI/SfB (1-) Substructure
CT CI/SfB (2-) Primary Elements
CT CI/SfB (3-) Secondary Elements
CT CI/SfB (30) Site Secondary Elements
CT CI/SfB (31) External Openings
CT CI/SfB (32) Internal Openings
CT CI/SfB (33) Floor Secondary Element
CT CI/SfB (34) Balustrades to Stairs
CT CI/SfB (35) Suspended Ceilings
CT CI/SfB (37) Rooflights
CT CI/SfB (4-) Finishes
CT CI/SfB (5-) Services
CT CI/SfB (6-) Installations
CT CI/SfB (7-) Fixtures
CT CI/SfB (8-) Loose Equipment
JAT Configuration
CT CSI DIV. 2 Sitework
CT CSI DIV. 3 Concrete
CT CSI DIV. 4 Masonry
CT CSI DIV. 5 Metal
CT CSI DIV. 6 Wood & Plastic
CT CSI DIV. 7 Thermal & Moisture Protection
CT  CSI DIV. 8  Doors & Windows
CT  CSI DIV. 9  Finishes
CT  CSI DIV. 10  Specialties
CT  CSI DIV. 11  Equipment
CT  CSI DIV. 12  Furnishings
CT  CSI DIV. 13  Special Construction
CT  CSI DIV. 14  Conveying Systems
CT  CSI DIV. 15  Mechanical
CT  CSI DIV. 16  Electrical
JT  Door : Door Frame
JT  Door Frame Header : Top Rail
JT  Hinge Jamb : Hinge Stile
JT  Lock Jamb : Lock Stile
**  Door Sash
**  Door Surround
OAT  Form
OAT  Door Form
OAT  Folding
OAT  Sliding
OAT  Swinging
OAT  Door Frame Form
OAT  Rabbeted
OAT  U-Shape
JAT  Joining Method
OAT Material
OAT Glass
OAT Metal
OAT Wood
OT Opening
OT Door Assembly
OT Door
OT Bottom Rail
OT Center Rail
OT Door Core
OT Door Panel
OT Hinge Stile
OT Lock Stile
OT Top Rail
OT Door Frame
OT Door Frame Header
OT Hinge Jamb
OT Lock Jamb
OT Window Assembly
OT Window
OT Window Frame
Alpha-Relational Listing of Main Entries:

OT       Bottom Rail
          WT       Door

OT       Center Rail
          WT       Door

CT       CI/SfB (1-) Substructure

CT       CI/SfB (2-) Primary Elements

CT       CI/SfB (3-) Secondary Elements

NT       CI/SfB (30) Site Secondary Elements
          CI/SfB (31) External Openings
          CI/SfB (32) Internal Openings
          CI/SfB (33) Floor Secondary Element
          CI/SfB (34) Balustrades to Stairs
          CI/SfB (35) Suspended Ceilings
          CI/SfB (37) Rooflights

CT       CI/SfB (30) Site Secondary Elements

BT       CI/SfB (3-) Secondary Elements
CT  CI/SfB (31) External Openings
    BT  CI/SfB (3-) Secondary Elements
    OT  Opening

CT  CI/SfB (32) Internal Openings
    BT  CI/SfB (3-) Secondary Elements
    OT  Opening

CT  CI/SfB (33) Floor Secondary Element
    BT  CI/SfB (3-) Secondary Elements

CT  CI/SfB (34) Balustrades to Stairs
    BT  CI/SfB (3-) Secondary Elements

CT  CI/SfB (35) Suspended Ceilings
    BT  CI/SfB (3-) Secondary Elements

CT  CI/SfB (37) Rooflights
    BT  CI/SfB (3-) Secondary Elements

CT  CI/SfB (4-) Finishes

CT  CI/SfB (5-) Services

CT  CI/SfB (6-) Installations
CT CI/SfB (7-) Fixtures

CT CI/SfB (8-) Loose Equipment

JAT Configuration

JT Door : Door Frame
Door Frame Header : Top Rail
Hinge Jamb : Hinge Stile
Lock Jamb : Lock Stile

CT CSI DIV. 2 Sitework

CT CSI DIV. 3 Concrete

CT CSI DIV. 4 Masonry

CT CSI DIV. 5 Metal

OAT Metal

CT CSI DIV. 6 Wood & Plastic

OAT Wood

CT CSI DIV. 7 Thermal & Moisture Protection
CT CSI DIV. 8 Doors & Windows
OT Door Assembly
Window Assembly

CT CSI DIV. 9 Finishes

CT CSI DIV. 10 Specialties

CT CSI DIV. 11 Equipment

CT CSI DIV. 12 Furnishings

CT CSI DIV. 13 Special Construction

CT CSI DIV. 14 Conveying Systems

CT CSI DIV. 15 Mechanical

CT CSI DIV. 16 Electrical
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<td>WT</td>
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<tr>
<td>PT</td>
<td>Bottom Rail</td>
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<tr>
<td></td>
<td>Center Rail</td>
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<td>Door Core</td>
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<td>Hinge Stile</td>
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<td>Lock Stile</td>
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<td>Material</td>
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</tr>
<tr>
<td>JT</td>
<td>Door : Door Frame</td>
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<tr>
<td>UF</td>
<td>Door Sash</td>
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<tr>
<td>JT</td>
<td>Door : Door Frame</td>
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<td>OT</td>
<td>Door</td>
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<td>JAT</td>
<td>Configuration</td>
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<td></td>
<td>Joining Method</td>
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</table>
OT  Door Assembly
    PT  Door
        Door Frame
    OAT  Door Form
    CT  CSI DIV. 8 Doors & Windows

OT  Door Core
    WT  Door

OAT  Door Form
    OT  Door

OT  Door Frame
    WT  Door Assembly
    PT  Door Frame Header
        Hinge Jamb
        Lock Jamb
    OAT  Door Frame Form
        Material
    JT  Door : Door Frame
    UF  Door Surround

OAT  Door Frame Form
    OT  Door Frame
OT  Door Frame Header
    WT  Door Frame
    JT  Door Frame Header : Top Rail

JT  Door Frame Header : Top Rail
    OT  Door Frame Header
        Top Rail
    JAT  Configuration
        Joining Method

OT  Door Panel
    WT  Door

**  Door Sash
    USE  Door

**  Door Surround
    USE  Door Frame

OAT  Folding
    BT  Door Form

OAT  Form
    NT  Door Form
    NT  Door Frame Form
OAT  Glass
BT   Material

OT   Hinge Jamb
WT   Door Frame
JT   Hinge Jamb : Hinge Stile

JT   Hinge Jamb : Hinge Stile
OT   Hinge Jamb
     Hinge Stile
JAT  Configuration
     Joining Method

OT   Hinge Stile
WT   Door
JT   Hinge Jamb : Hinge Stile

JAT  Joining Method
JT   Door : Door Frame
     Door Frame Header : Top Rail
     Hinge Jamb : Hinge Stile
     Lock Jamb : Lock Stile
OT  Lock Jamb
    WT  Door Frame
    JT  Lock Jamb : Lock Stile

JT  Lock Jamb : Lock Stile
OT  Lock Jamb
    Lock Stile
JAT  Configuration
     Joining Method

OT  Lock Stile
    WT  Door Frame
    JT  Lock Jamb : Lock Stile

OAT  Material
    NT  Glass
        Metal
        Wood

OAT  Metal
    BT  Material
    CT  CSI DIV. 5  Metal
OT  Opening
    NT  Door Assembly
        Window Assembly
    CT  CI/SfB (31)  External Openings
        CI/SfB (32)  Internal Openings

OAT  Rabbeted
    BT  Door Frame Form

OAT  Sliding
    BT  Door Form

OAT  Swinging
    BT  Door Form

OT  Top Rail
    WT  Door
    JT  Door Frame Header : Top Rail

OAT  U-Shape
    BT  Door Frame Form

OT  Window
    WT  Window Assembly
OT  Window Assembly
PT  Window
     Window Frame
CT  CSI DIV. 8  Doors & Windows

OT  Window Frame
WT  Window Assembly

OAT  Wood
BT  Material
CT  CSI DIV. 6  Wood & Plastic
ATTACHMENT E: INDEXING SAMPLES

Sample Index: **Generic Type Object Index**

1. Enter Object Identifier: [ Door ]
2. Select Door Form
   
   **Door Form:**
   
   Folding
   Sliding
   Swinging

3. Enter Dimensions
4. Form 'Generic Type' Descriptor
   
   Check if Descriptor exists in Typology
5. If Descriptor exists, display Error Message
6. If Descriptor does not exist, store Object and add Object Descriptor to Typology
Sample Index: **Specific Type Object Index**

1. Enter Object Identifier: [Door]
2. Select Door Form
   - Door Form:
     - Folding
     - Sliding
     - Swinging
3. Enter Dimensions
4. Form 'Generic Type' Descriptor
   Check if Descriptor exists in Typology
5. If Descriptor exists, go to Step 7
6. If Descriptor does not exist,
   add Descriptor to Typology
7. Select Door Material
   - Material:
     - Glass
     - Metal
     - Wood
8. Form 'Specific Type' Descriptor
   Check if Descriptor exists in Typology
9. If Descriptor exists, display Error Message
10. If Descriptor does not exist, store Object
    and add Object Descriptor to Typology
Sample Search: Using CSI Classification Scheme

1. Select CSI Division [CSI DIV. 8]

CSI Divisions:
CSI DIV. 2 Sitework
CSI DIV. 3 Concrete
CSI DIV. 4 Masonry
CSI DIV. 5 Metal
CSI DIV. 6 Wood & Plastic
CSI DIV. 7 Thermal & Moisture Protection
CSI DIV. 8 Doors & Windows
CSI DIV. 9 Finishes
CSI DIV. 10 Specialties
CSI DIV. 11 Equipment
CSI DIV. 12 Furnishings
CSI DIV. 13 Special Construction
CSI DIV. 14 Conveying Systems
CSI DIV. 15 Mechanical
CSI DIV. 16 Electrical
2. Select Object Identifier [ Door Assembly ]

CSI DIV. & Doors & Windows:
Door Assembly
Window Assembly

3. Select Generic Type Object
Door Assembly:
Door Assembly, Folding
Door Assembly, Sliding
Door Assembly, Swinging

4. Obtain Object File
Sample Search: Using CI/SfB Classification System

1. Select CI/SfB Category [ CI/SfB (31) ]

   CI/SfB Categories:
   CI/SfB (1-) Substructure
   CI/SfB (2-) Primary Elements
   CI/SfB (3-) Secondary Elements
       CI/SfB (30) Site Secondary Elements
       CI/SfB (31) External Openings
       CI/SfB (32) Internal Openings
       CI/SfB (33) Floor Secondary Element
       CI/SfB (34) Balustrades to Stairs
       CI/SfB (35) Suspended Ceilings
       CI/SfB (37) Rooflights
   CI/SfB (4-) Finishes
   CI/SfB (5-) Services
   CI/SfB (6-) Installations
   CI/SfB (7-) Fixtures
   CI/SfB (8-) Loose Equipment

2. Use Object Identifier [ Opening ]

   CI/SfB (31) External Openings:

   USE Opening
3. Select Object Identifier  [Door Assembly]

   **Opening:**
   Door Assembly
   Window Assembly

4. Select Generic or Specific Type Object

   **Door Assembly:**
   Door Assembly, Folding
   Door Assembly, Sliding
   Door Assembly, Swinging

5. Obtain Object File
Sample Search: **Direct Search (1)**

1. Enter Object Identifier [ Door ]
2. Select Generic or Specific Type Object and Obtain Object File
   
   **Door:**
   
   Door, Folding
   Door, Folding, Wood
   
   Door, Sliding
   Door, Sliding, Glass
   Door, Sliding, Wood
   
   Door, Swinging
   Door, Swinging, Glass
   Door, Swinging, Wood
Sample Search: Direct Search (2)

1. Enter Object Identifier [ Door Sash ]
2. Use Preferred Term [ Door ]
   **Door Sash:**
   USE Door
3. Select Generic or Specific Type Object and Obtain Object File
   **Door:**
   Door, Folding
     Door, Folding, Wood
   Door, Sliding
     Door, Sliding, Glass
     Door, Sliding, Wood
   Door, Swinging
     Door, Swinging, Glass
     Door, Swinging, Wood
Sample Search: Direct Search (3)

1. Enter Object Identifier [ Door ]
2. Select Generic Type Object [ Door, Swinging ]
   
   Door:
   Door, Folding
   Door, Sliding
   Door, Swinging

3. Select Specific Type Object and Obtain Object File
   
   Door, Swinging:
   Door, Swinging, Glass
   Door, Swinging, Wood
V I T A

Bettina G. de Dios

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Quezon City, Philippines

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December 12, 1959

EDUCATION

1990 Master of Architecture
    Virginia Polytechnic Inst. and State University

1984 Basic Computer Science
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1983 Construction Project Management
    Ateneo de Manila, Philippines

1982 Bachelor of Science in Architecture
    University of the Philippines
WORK EXPERIENCE

1983-1984 Project Manager. Balanga Housing Project, Bataan, Philippines
1980-1984 Assistant Building Administrator and In-House Architect. Gutierrez David-Roque Building, Quezon City, Philippines

LICENSE AND AFFILIATIONS

1984 National Architectural Board Examination, Philippines - Ranked Fourth
1984 Member, United Architects of the Philippines
1984 Member, United Architects of the Philippines, Diliman Chapter