

# Framework for Restoration of Heritage using Building Information Modelling

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**Dr. Noha Saleeb**

Associate Professor In Construction  
& Creative Technologies  
Programme Leader MSc BIM Management  
+ BSc Architectural Technology  
[n.saleeb@mdx.ac.uk](mailto:n.saleeb@mdx.ac.uk)

# Agenda

1

- **Why Classification ?**

2

- **Classification vs. Measurement**

3

- **What does Heritage need ?**

4

- **Difference between different systems**

5

- **Proposed Heritage Classification System**



# Why Classification ??

# What system does it belong to ?

**Complex ?**  
Rail / hospital...


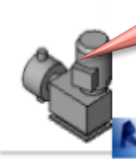

**Product**

**Entity ?**  
N. / S. wing...

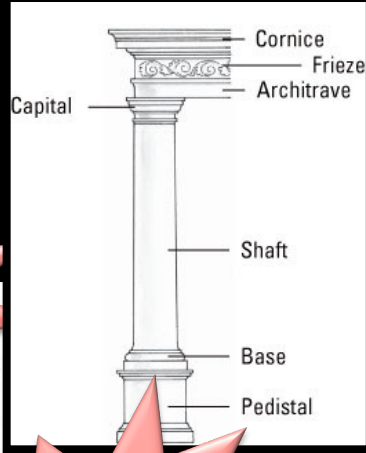
**Activity ?**  
Waste water treatment...

**Space ?**  
Control room...

**System ?**  
Hot water....

 Valve-Wastewater r-2-4 inch-THD.rfa	 Valve-2-6 inch-Changed Inlet.rfa	 Ball Valve-Metal Seated-6-30 inch-DI.rfa	 Butterfly Valve-MxMJ-CI-Buried Service.rfa	 Butterfly Valve-Wafer-CI-MDT Manual.rfa	 Check Valve-Swing-2.5-20 inch-DI.rfa	 Check Valve-Swing-Heavy Duty-3-24 inch-DI.rfa	 Control Valve-Booster Pump-60-31-4-16 inch.rfa
 Gate Valve-FLXFL-Resilient Wedge-Cast Iron-Hand Whe...	 Gate Valve-MxMJ-Resilient Wedge-Cast Iron...	 Plug Valve-Eccentric-0.5-2.5 inch-DI.rfa	 Plug Valve-Eccentric-3-24 inch-DI.rfa	 Pump-Cake-24bar.rfa	 Pump-Cavity-High Pressure.rfa	 Pump-De-Clogging-Self Priming.rfa	 Pump-Dewatering-Submersible.rfa
 Pump-Dosing-12 bar-Low Flow.rfa	 Pump-Dosing-Digital-4 gph.rfa	 Pump-Dosing-Digital-8 gph.rfa	 Pump-Dosing-Mechanical-166 gph.rfa	 Pump-Dosing-Mechanical-278 gph.rfa	 Pump-Drainage-Submersible-Cast Iron.rfa	 Pump-Submersible-Stainless Steel.rfa	 Pump-Effluent-Submersible-Stainless Steel.rfa
 Pump-Sewage Channel-Submersible-Cast Iron.rfa	 Pump-Sewage Vortex-Submersible-Cast Iron.rfa	 Pump-Sewage-Submersible-Cast Iron.rfa	 Pump-Solids-Vertical-High Efficiency.rfa	 Pump-Submersible-Dry Pit.rfa	 Pump-Transfer.rfa	 Pump-Wastewater-Submersible.rfa	 Pump-Wastewater-Vertical-Centrifugal.rfa
 Pump-Wastewater-Vertical-Inline.rfa	 Surge Relief Valve-2.5-8 inch-DI.rfa						

# What about..



# Heritage ?



Condition ?  
Complex ?

Entity ?  
Cultural value ?

Construction method ?

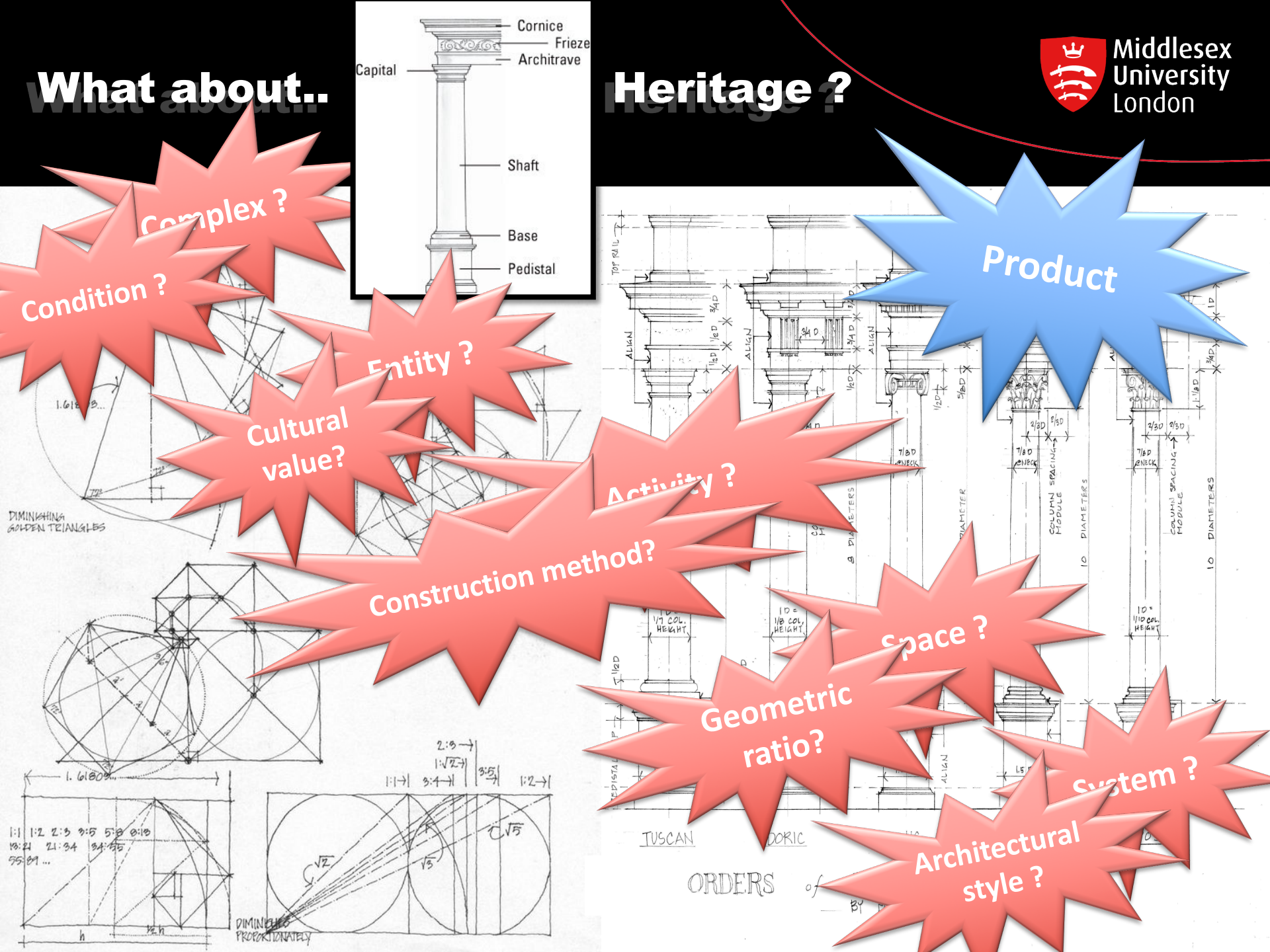
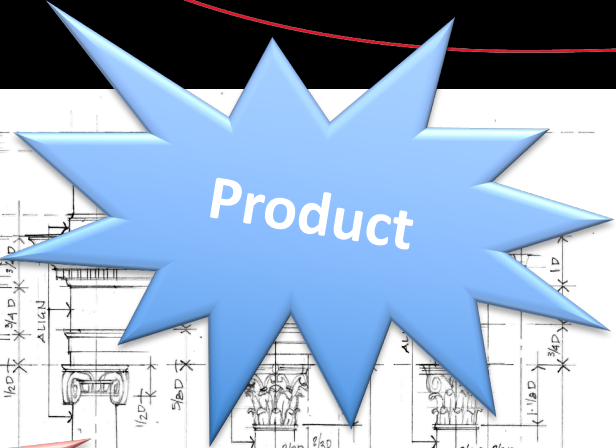
Activity ?

space ?

Geometric ratio ?

System ?

Architectural style ?





Align with all stakeholder specifications and databases

Alignment with manufacturer products, details and Product data sheets

Organisation of maintainable asset data for FM and OM

Classifications / libraries / databases for heritage object replacement for renovation

Organised legacy data for comparison with other assets and reuse

# Classification vs. Measurement Systems vs. Thesaurus??

# Classification Systems

## CI/Sfb – Construction Index/Samarbetskommitten for Byggnadsfragor

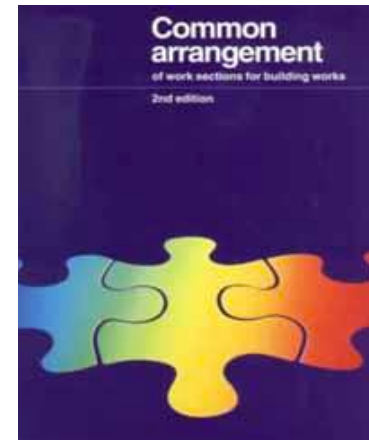
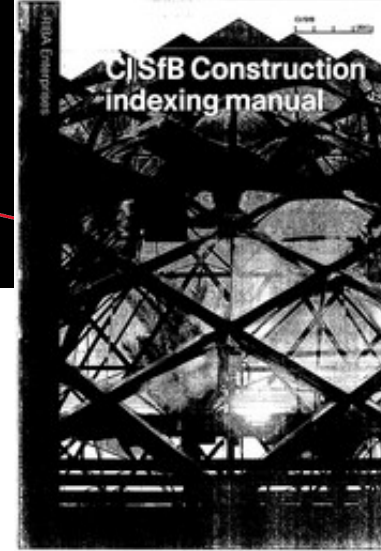
- 1959 - Swedish committee for building investigation
- Basis of BS1192-5:1998 Construction Drawing Practice
- Library classification – lacking on specs & pricing mechanical/electrical services

## CAWS – Common Arrangement of Work Sections (CPIC)

- 1987 – aligned with Uniclass (1997)
- > 300 sections
- Standardisation and coordination between bills of quantities & specifications
- Not ordered elementally - inappropriate for object naming in comp. models

## SFG20 – Standard Maintenance Specification (Service and Facilities Group)

- 1990 – BESA
- Library of maintenance specifications for building engineering services (online available)
- > 400 schedules covering 60 equipment types (task schedules)





# Classification Systems

## Omniclass

- 2001 – USA
- National BIM Standard (NBIMS) – initiative of BuildingSmart
- 15 tables based on ISO 12006 -2 (Organisation of Information about building ~Works – Framework for Classification)

### Problems: tables differ in

- SCOPE: not all deal with arch, civil & process
- LEVELS of depth 2-8
- OBJECTS: in some tables a level is for groups of objects & individual objects
- Some MISALIGNMENT

Figure 6. OmniClass Object Identification

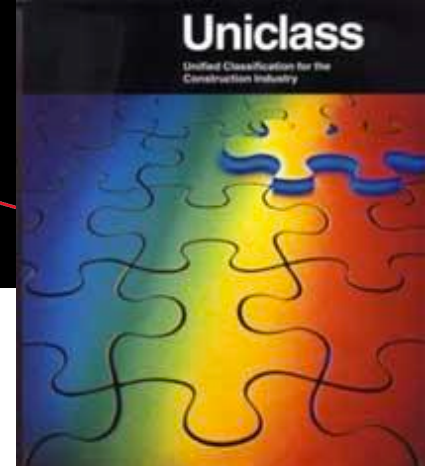


System	Condensate Return System	UniFormat, Table 21
Product	Ball Valve	Product, Table 23
Properties	Size Inch: 4	Properties, Table 49
Materials	Stainless Steel	Materials, Table 41

Condensed Return System | Ball Valve | VLV - 0001 - DC0000

Table code	OmniClass Table	Buildings & landscapes	Civil engineering	Process engineering
11	<i>Entities by Function</i>	***	**	**
12	<i>Entities by Form</i>	***	**	**
13	<i>Spaces by Function</i>	***		**
14	<i>Spaces by Form</i>	***		**
21	<i>Elements</i> (derived from UniFormat)	***		**
22	<i>Work Results</i> (derived from MasterFormat)	***	**	**
23	<i>Products</i>	***	**	**
31	<i>Phases</i>	***	***	***
32	<i>Services</i>	***	***	***
33	<i>Disciplines</i>	***	**	**
34	<i>Organizational Roles</i>	***	***	***
35	Tools	***		
36	Information	***	***	***
41	Materials	***	***	***
49	Properties	***	**	**
-	SectionFormat (outside)	***	***	***

# Classification Systems



Omniclass

Uniclass

- 1997 – by CPIC
- 16 tables based on CAWS, EPIC, CI/Sfb
- Aligned to ISO 12006-2

## Problems: tables differ in

- SCOPE: not all deal with arch, civil & process
- LEVELS of depth 2-7
- OBJECTS: in some tables a level is for groups of objects & individual objects
- NO ALIGNMENT: individually created.
- CODING: some numeric /alphanumeric

Uniclass Table		Table code	Architectural	Civil engineering	Process engineering
Form of information		A	•	•	•
Subject disciplines		B	••	•	
Management		C	•	•	•
Facilities		D	•	•	•
Construction entities		E	••	•	
Spaces		F	•		
Elements	Buildings	G	••	•	
	Civil engineering works	H	•	••	
Work sections	Buildings	J	••	•	
	Civil engineering works	K	•	••	
Construction products		L	••	•	
Construction aids		M	••	•	•
Properties and characteristics		N	•	•	•
Materials		P	•	•	•
Universal Decimal Classification		Q	•	•	•
Computer aided draughting		Z	•	•	•

# Classification Systems

Omniclass

Uniclass

Uniclass 2

- 2010-2015 – CPIc / NBS
- Complex – hospital →  
Entities - buildings, roads and landscape →  
Activity - surgical →  
Spaces – operations ward →  
Element - roof →  
Systems – HVAC →  
Products – ducts (oxygen..)
- Supports the creation of the built environment.

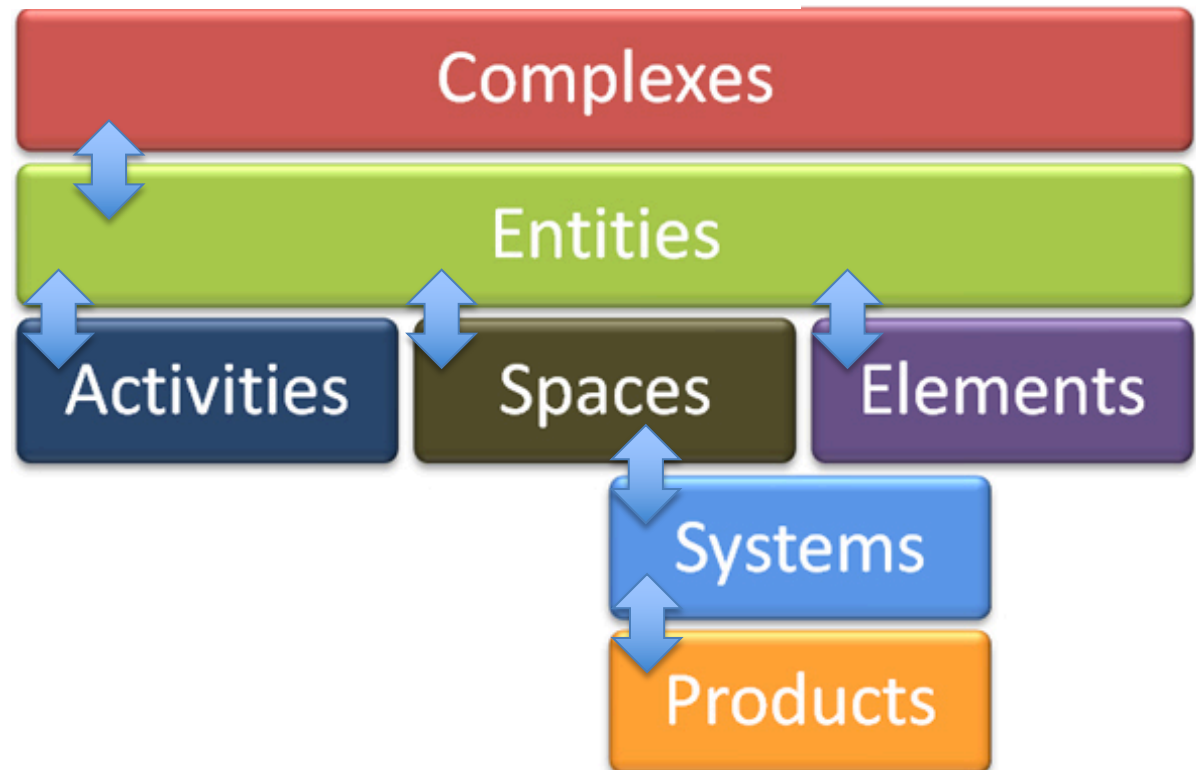
## Table Reference

Table Reference	Title
Co	Complexes
En	Entities
Ac	Activities
Sp	Spaces
Ee	Elements
Ss	Systems
Pr	Products
WR	Work results

Uniclass

Unified Classification for the Construction Industry

Figure 2 - Uniclass2 tables for construction information





# Classification Systems

Omniclass

Uniclass

Uniclass 2

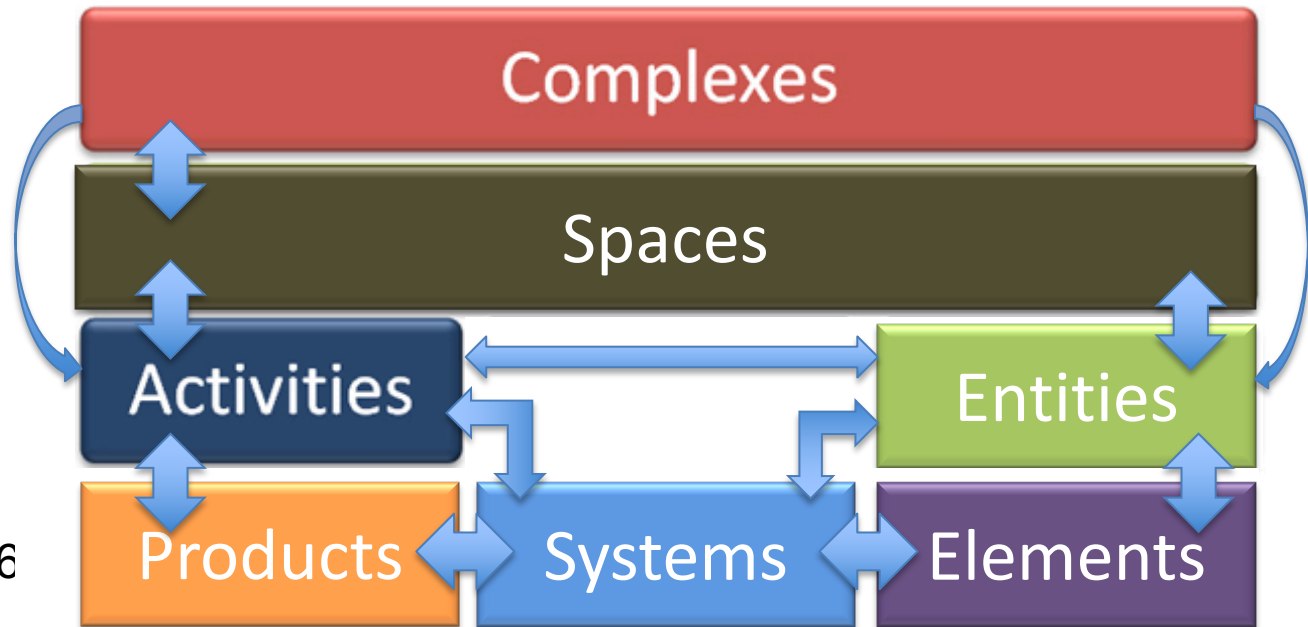
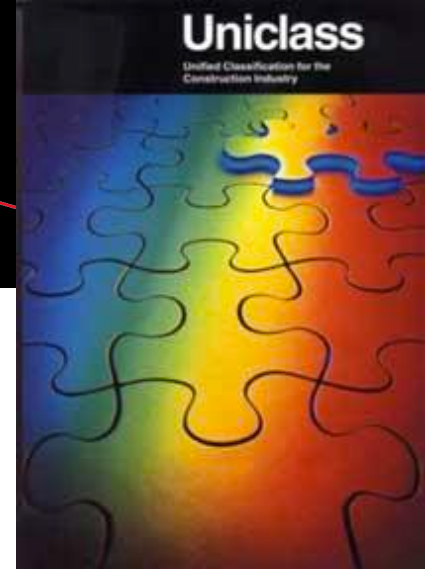
Uniclass 2015

- Includes: Buildings, engineering, landscape, infrastructure
- compliant with ISO 12006 2 - mapped to NRM1 (in PAS1192-4)

## Table Reference

Table Reference	Title
Co	Complexes
En	Entities
Ac	Activities
Sp	Spaces
Ee	Elements
Ss	Systems
Pr	Products
WR	Work results

TE - Tools & Equipment  
 Zz - CAD  
 ?? - PM - Project Management / FI - Form of Information



# How does it work?

## Ss - Systems

Ss_65	Ventilation and air conditioning systems	Level 1 class
Ss_65_40	Ventilation systems	Level 2 class
Ss_65_40_33	General space ventilation systems	Level 3 class
Ss_65_40_33_45	Kitchen extract ventilation systems	Level 4 class
Ss_65_40_33_48	Local extract ventilation systems	
Ss_65_40_33_50	Mechanical extract ventilation systems	
Ss_65_40_33_51	Mechanical supply ventilation systems	
Ss_65_40_33_52	Mechanical and whole building ventilation systems	
Ss_65_40_33_56	Natural ventilation systems	

23(!) different ventilation system categories

- ***Not strictly classification systems but MEASUREMENT systems***
- ***Map to classification systems e.g. Uniclass***

## **Contains**

- ***Classification tables (not aligned/related)***
- ***Measurement units***
- ***Measurement rules***





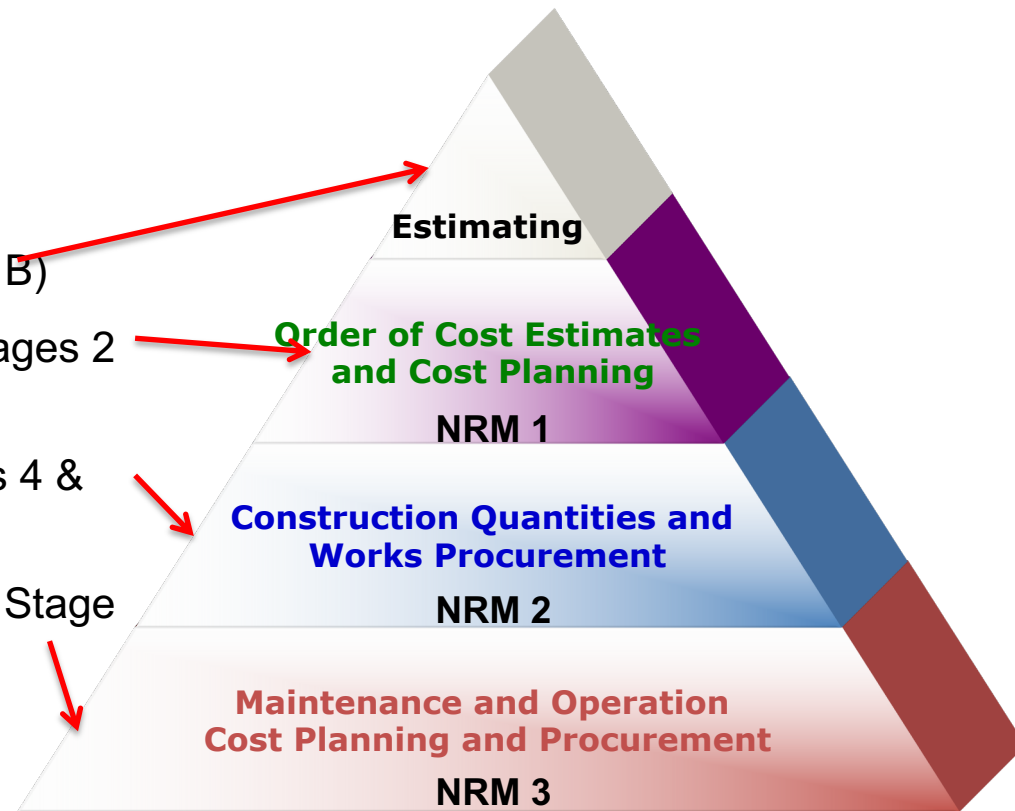
# Stages for NRM1, NRM2, NRM3

## Project overview

A suited set of rules for:

- **Estimating** - RIBA Work Stage 0 & 1 (A & B)
- **Cost planning** - Elements- RIBA Work Stages 2 & 3 (C – E)
- **Works Procurement** - RIBA Work Stages 4 & 5 (F – K)
- **Maintenance Procurement** - RIBA Work Stage 6 & 7 (L)

*All rules are developed in consultation with Clients and Practitioners.*



**What does Heritage need ?**

# Characteristics of a Classification System

- Online digital format
- Quick to use - allow rapid searching across all the tables simultaneously
- Free !!!
- Unified – tables not produced independently with associations
- One classification mode per table.
- Cross-sector - benefitting many disciplines in industry
- Full asset lifecycle (e.g. development, use, FM, demolition)
- Object hierarchy across all project phases and timeline
- Consider legacy classification systems
- Compliant with ISO 12006-2:2015
- Integration with barcoding developed by manufacturers for products.

# More Hierarchical Attributes

## *What's missing...*

- *Architectural style / age*
- *Geometric information*
- *Construction restrictions*
- *Condition (deterioration, material durability etc.)*
- *Maintenance constraints*
- *Cultural / Heritage value*
- *Reflectance attributes.....*



**Difference between**  
**Thesaurus – Classification – Taxonomy -**  
**Ontology**

# Classification vs. Thesaurus

## *Definition*

- **Classification** is a process of categorisation, where ideas & objects are recognised, differentiated and understood.
- **Classification systems** are systems with a distribution of classes created according to common relations or affinities

## Definition

- **Thesaurus** is a reference work that lists words grouped together according to similarity of meaning (synonyms and antonyms) - in contrast to a dictionary, which provides definitions for words
- FISH: “A Thesaurus is a structured wordlist used to standardise terminology. It is used to assist in indexing and retrieving information within databases that make use of the same terminology.”

# Classification vs. Thesaurus

## Classification System

Using symbols: numbers, letters or combination

Established relations between concepts – hierarchical representation of objects

Taxonomic: list one concept in one place only in the classification structure

Levels of classification e.g. object → activity → function

Terms inside each hierarchical level are listed alphabetically

## Thesaurus

Using natural language terms or words

Alphabetical listing and a systematic or classified display

Object can be listed more than once depending on synonyms

Can have semantic levels. Any related relationships between terms are shown

Navigation from non-preferred to preferred terms through synonyms



## *Examples of Thesauri*

- **Historic England:** *Heritage Data – Linked Data Vocabularies for Cultural Heritage*  
<http://www.heritagedata.org/blog/vocabularies-provided/>
- *SMR Forum Scotland* <http://smrforum-scotland.org.uk/shed/data-standards/thesauri/>
- *FISH (Forum on Information Standards in Heritage)* <http://heritage-standards.org.uk/fish-vocabularies/>



# Classification vs. Thesaurus

## Vocabularies

We have used the [STELLAR](#) tools to convert the data to [SKOS](#) format, and each vocabulary has then undergone validation using the [PoolParty SKOS validator](#) service. There are direct links to the [Linked Data vocabularies](#) below, and the SKOS RDF files are also available for individual download. We have used the [SKOS Play](#) service to create additional downloadable alphabetical and hierarchical listings for each vocabulary.

## Historic England

SCHEME	EXAMPLES	DOWNLOADS
<a href="#">FISH Archaeological Sciences Thesaurus</a> Terminology used for recording the techniques, recovery methods and materials associated with archaeological sciences. Maintained by Historic England on behalf of the FISH Terminology Working Group.	<a href="#">MINERALOGY</a> <a href="#">PEAT HUMIDIFICATION</a> <a href="#">DENDROCHRONOLOGY</a>	<a href="#">SKOS (RDF)</a> <a href="#">Alphabetical (PDF)</a> <a href="#">Hierarchical (PDF)</a>
<a href="#">FISH Building Materials Thesaurus</a> Terminology used for recording the main construction materials of monuments, buildings and structures relating to the built and buried heritage of the British Isles. Maintained by Historic England on behalf of the FISH Terminology Working Group.	<a href="#">DOLOMITE</a> <a href="#">FELT</a> <a href="#">LEATHER</a>	<a href="#">SKOS (RDF)</a> <a href="#">Alphabetical (PDF)</a> <a href="#">Hierarchical (PDF)</a>
<a href="#">COMPONENTS (EH)</a> Terminology covering divisions and structural elements of a building or monument	<a href="#">SPIRAL FLUTING</a> <a href="#">STAIRCASE</a> <a href="#">TRUSS</a>	<a href="#">SKOS (RDF)</a> <a href="#">Alphabetical (PDF)</a> <a href="#">Hierarchical (PDF)</a>
<a href="#">FISH Event Types Thesaurus</a> Terminology used for recording	<a href="#">CORE SAMPLING</a> <a href="#">DENDROCHRONOLOGICAL SURVEY</a> <a href="#">BOX TRENCHING</a>	<a href="#">SKOS (RDF)</a> <a href="#">Alphabetical (PDF)</a> <a href="#">Hierarchical (PDF)</a>

## AGED MENS WARD

BT : **STEAM ENGINE**

SN : A simple, single cylinder vertical steam engine with its cylinder mounted directly on a baseplate, driving an overhead crankshaft which is supported by two A-shaped frames

## AGIASTERIUM

BT : **BUILDING COMPONENT**

SN : Series of rooms within a workhouse where elderly men were housed.

## AGRAFE

BT : **INTERNAL AREA OR SPACE**

SN : The area of the Basilica, especially in the early church, in which the altar resides.

## AGRAFE

UF : *Agraffe*

BT : **KEYSTONE**

SN : A keystone decorated with a relief sculpture, usually a cartouche

## Agraffe

USE : **AGRAFE**

## AILERON

BT : **GABLE**

BT : **PEDIMENT**

SN : A half gable or half pediment concealing the lean-to roof of an aisle.

## Airing Yard

USE : **EXERCISE YARD**

## AIR PUMP

BT : **PUMP**

SN : A pump for removing condensed steam from the condenser of a steam raising plant.

## Air Shaft

USE : **VENTILATION SHAFT**

## AISE

BT : **STRUCTURAL COMPONENT**

BT : **PASSAGE**

NT : **AMBULATORY (INTERIOR)**

NT : **CARREL (AISLE)**

NT : **PASSAGE AISLE**

SN : The side compartment of a building, usually a church, hall or barn, separated from the main body of the building by an arcade; or a passage allowing access to rows of seats in an auditorium or church.

## AISLE PLATE

BT : **WALL PLATE**

SN : A horizontal member along the length of an aisle wall to receive the ends of rafters.

## AISLE TRUSS

BT : **TRUSS**

SN : A roof truss supported by arcade posts in an aisled building.

[http://purl.org/heritagedata/schemes/eh\\_com](http://purl.org/heritagedata/schemes/eh_com)

## AREAS AND SPACES

### CHAPEL

[APSE CHAPEL](#)  
[CHANTRY CHAPEL](#)  
[GALILEE](#)  
[LADY CHAPEL](#)  
[RADIATING CHAPEL](#)

### DANCE FLOOR

### ENTRANCE

[ADIT](#)  
[CARRIAGE ENTRANCE](#)  
[CREEP](#)  
[CROSS ENTRY](#)  
[DOORWAY](#)  
[ENTRANCE HALL](#)  
[GATEWAY](#)

### EXTERNAL AREA OR SPACE

[AMBITUS](#)  
[AMBULATORY \(EXTERNAL\)](#)  
[CLOISTER](#)  
[ANTEPORTICO](#)  
[ATRIUM \(ECCLESIASTICAL\)](#)  
[BAILEY](#)

[INNER BAILEY](#)  
[OUTER BAILEY](#)

### BOATING POOL

[COURTYARD](#)  
[ANTECOURT](#)  
[BASE COURT](#)  
[CLOISTER GARTH](#)  
[FORECOURT](#)

### COVERED WAY

[EXERCISE YARD](#)  
[PADDLING POOL](#)  
[PARADISE](#)

### PARVIS

### PERGOLA

### INTERNAL AREA OR SPACE

[AGIASTERIUM](#)  
[AMBITUS](#)  
[ANTECHAPEL](#)  
[ANTECHOIR](#)  
[APOTHESIS](#)  
[ARENA](#)  
[ATRIUM \(SECULAR\)](#)  
[AUCTION ROOM](#)  
[BAPTISTERY](#)  
[CHANCEL](#)

### CHEVET

### CHOIR

### CLOSET

### CONFESSIONAL

### CORRIDOR

### CROSSING

### FERETORY

### HAYLOFT

### LOGGIA

# Classification vs. Taxonomy

## Differences

### Classification System

**Definition:** systematic arrangement in groups or categories according to established criteria

Criteria for hierarchy based on any external factors e.g. discipline, energy usage, structure, function, dimensions

Classification is not concerned with providing exhaustive lists

classification simply groups the items--beneficial for defining a clear specification and codification of asset components

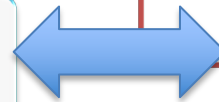
### Taxonomy

**Definition:** giving names to objects or groups of objects according to their positions in a hierarchy

Hierarchical relationships usually rely on internal characteristics inherent within the items themselves

Taxonomies are more concerned with providing exhaustive lists

Taxonomies describe relationships between items



# Ontology vs. Taxonomy

## Ontology

Highlights metadata of associative relationships between objects and intricacies between them

Inference – e.g. connecting a type of window to a façade can have differing relationships based on architectural period, location and cultural aspects (e.g. privacy considerations of that era). Hence a relationship could be conditional, temporary or seasonal

Relationships and associations are not absolute – dynamic (live history and context of a Heritage building that affects how its components are refurbished and maintained, as opposed to a new build)

## Taxonomy

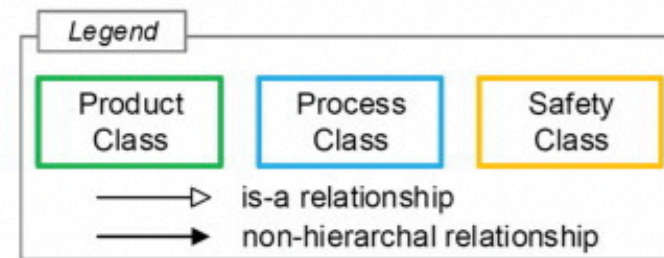
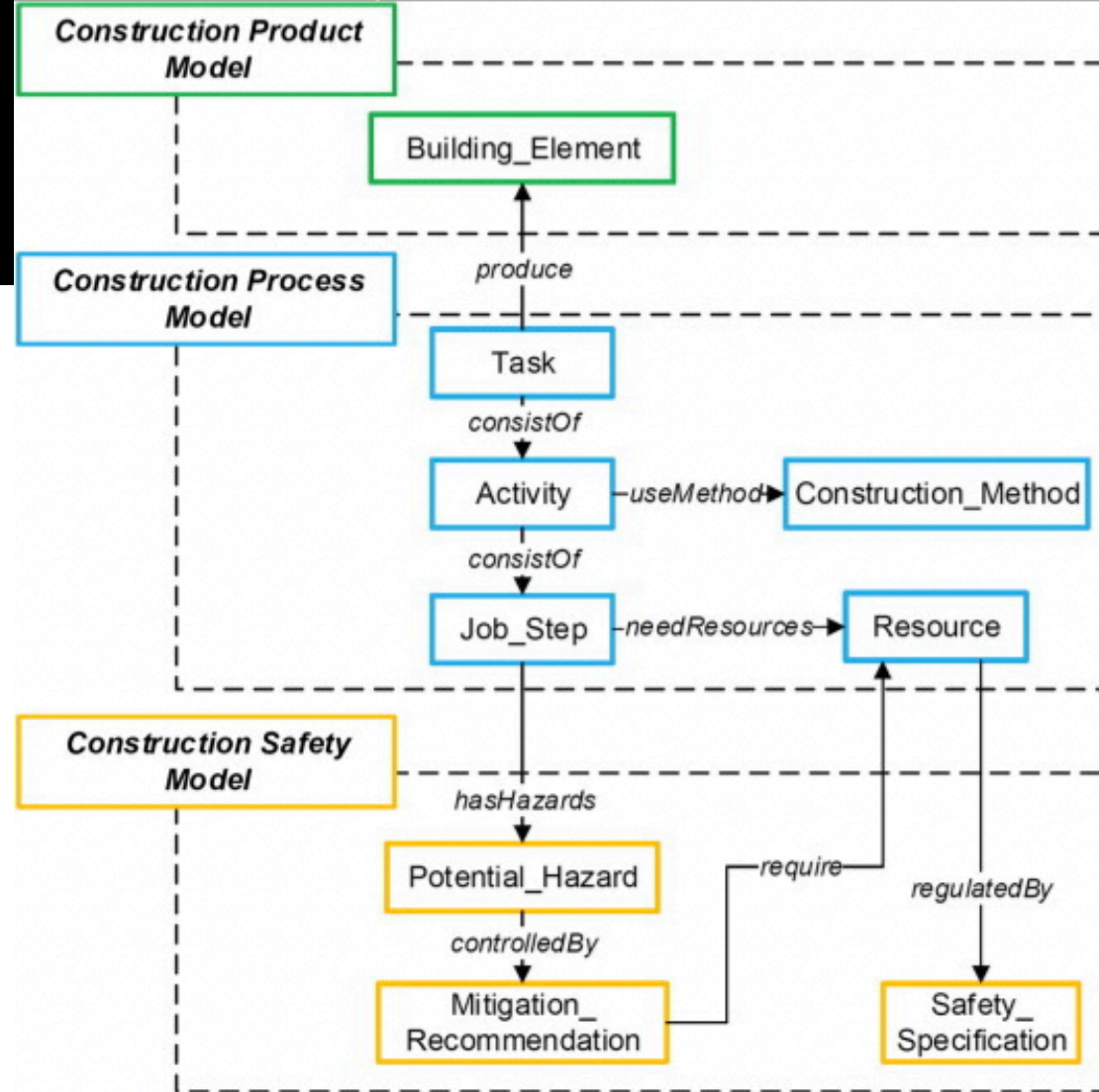
identifies relationships between items and categories, but lacks displaying the metadata of those items that can change the associations between them

Inference Non existent

Taxonomy is a defined, static entity. taxonomy tries to simplify a complex collection of seemingly unrelated items into a linear, organization



# Construction Related Ontology



**In conclusion**

**Ontological Classification System**



Non-exhaustive - allowing addition of new elements -  
*Attribute of Classification systems as opposed to Taxonomy*

Non-semantic specific – focus is not on meaning of words and which terms are synonymous with each other, but on hierarchy

Also word mentioned once

*Attribute of Classification not Thesaurus*

Doesn't need associative relationships between child objects – the objective is clearly classifying the individual components of a building without complex parent & many to many relationships – *Attribute of Classification not Thesaurus*

Concepts for hierarchical categorization preferred to be according to general criteria and external characteristics not based on internal inherent characteristics –

*Attribute of Classification not Taxonomy*

Inclusion of metadata, as per ontologies hence  
Merge between classification and ontology schemes.

*Ontological Classification System for Heritage*



# Heritage Ontological Classification Classes & Subclasses

## Assembly Category

Structural components / Attached Architectural Components  
Independent Components / Cladding



## Orientation

Horizontal Support / Vertical Support / Inclined Support



## System

e.g. Columns / Load bearing walls. / Sanitary Fittings



## Type

e.g. Doric Architrave / Ionic Frieze / Retaining Walls / Sink



## Composition

e.g. Concrete. / Stone / Brick / Timber / Steel

# Example

Class 1 Assembly Category	Sub-Class2 Orientation	Sub-Class3 System	Sub-Class4 Type	Sub-Class5 Composition
<b>Structural components</b>	<b>Vertical Support</b>	<b>Columns</b>	Egyptian	
			Doric	
			Ionic	
			Corinthian	
			Tuscan	
			Islamic	
		<b>Embedded Columns</b>	Concrete	
			Stone	
			Brick	
			Timber	
			Steel	
	<b>Load bearing walls</b>	Interior wall		
		Exterior wall		
		Retaining wall		
	<b>Interior Stairs</b>	Flying stairs		
		Honorary stairs		
		Spiral stairs		
	<b>Exterior Stairs</b>	Flying stairs		
		Honorary stairs		
		Spiral stairs		
<b>Horizontal Support</b>	<b>Beams</b>	Simple support beam		
		Fixed beam		
		Cantilever beam		
		Continuous beam		
	<b>Joists</b>	Single Joists		
		Double Joists		
		Struss Joists		
	<b>Lintels</b>	Flat		
		Arch		
	<b>Roofs</b>	Flat roof		
		Gable roof		
		Hip roof		
Shed Roof				
Butterfly				
Mansard				
Gambrel				
Perforated				
Balcony				



**1. Add *Data Properties*** - which describe the common attributes for instances of a class i.e. the relationship between instances and their data values. In this case of sub-class level 5 giving the opportunity to document all the different components with their different characteristics that are actually available onsite.

**2. Add *Object Properties*** - which describe the relationship between the instances of the different classes / sub classes and each other at sub-class 3 level. These change the relationship and relevance between different components from one heritage asset to another hence affect the way these components are maintained

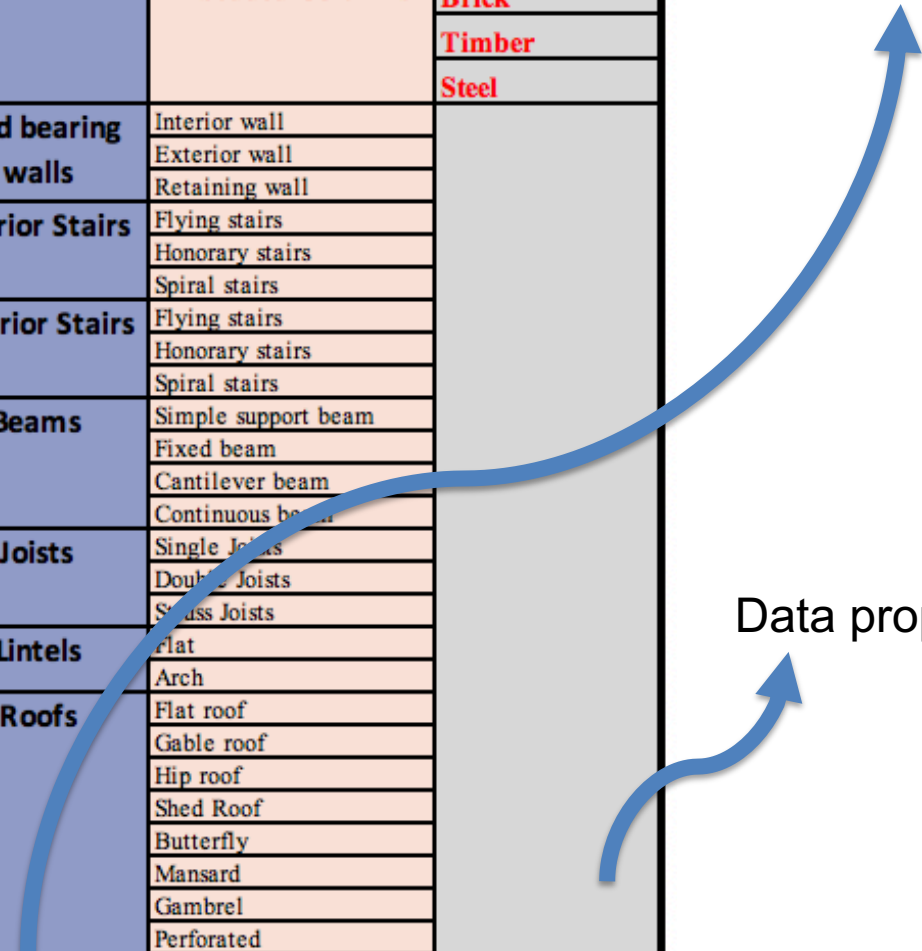
# Data Properties to add to Sub-class 5 "Composition"

1. Code ID
2. Architectural style
3. Age
4. Geometric ratio
5. Origin
6. Material name
7. Allowed stresses / load bearing
8. Construction method
9. Condition (deterioration)
10. Life expectancy
11. Maintenance constraints
12. Cultural Heritage value
13. Reflectance
14. Space function

Class 1 Assembly Category	Sub-Class2 Orientation	Sub-Class3 System	Sub-Class4 Type	Sub-Class5 Composition
Structural components	Vertical Support	Columns	Egyptian	
			Doric	
			Ionic	
			Corinthian	
			Tuscan	
			Islamic	
			Embedded Columns	
		Concrete		
		Stone		
		Brick		
		Timber		
		Steel		
		Load bearing walls	Interior wall	
			Exterior wall	
	Retaining wall			
	Interior Stairs	Flying stairs		
		Honorary stairs		
		Spiral stairs		
	Exterior Stairs	Flying stairs		
		Honorary stairs		
		Spiral stairs		
	Horizontal Support	Beams	Simple support beam	
			Fixed beam	
			Cantilever beam	
			Continuous beam	
	Joists	Single Joists		
		Double Joists		
		Stress Joists		
Lintels	Flat			
	Arch			
Roofs	Flat roof			
	Gable roof			
	Hip roof			
	Shed Roof			
	Butterfly			
	Mansard			
	Gambrel			
	Perforated			
	Balcony			

Object properties

Data properties





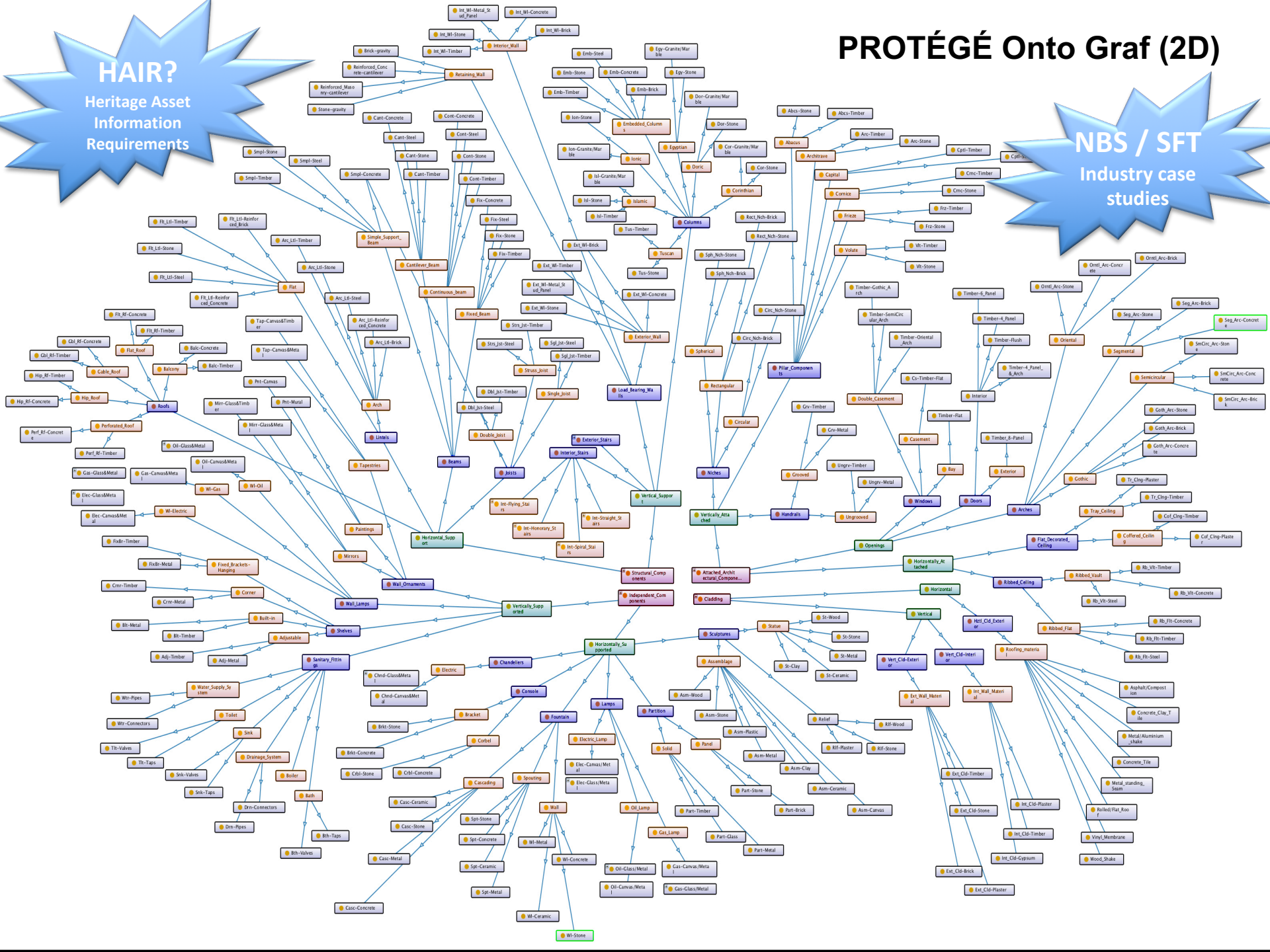


HAIR?

Heritage Asset  
Information  
Requirements

# PROTÉGÉ Onto Graf (2D)

NBS / SFT  
Industry case  
studies



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# Questions



Dr. Noha Saleeb    [n.saleeb@mdx.ac.uk](mailto:n.saleeb@mdx.ac.uk)