ColombiaClass: proposal for a BIM Classification System for public buildings in Colombia

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Abstract –

The use of standardized BIM Classification Systems helps to improve the efficiency of the tendering, planning, and control of construction projects. The Colombian government has identified BIM as a key strategy to help increase the construction industry's productivity and improve value for money in public works projects. At the core of the strategy is the need to implement a standardized Classification System that allows the government to consistently verify project scope, compare bids, and easily control projects. Although numerous Classification Systems already exist, they do not include prevalent construction methods and linguistic variations specific to Colombia, which can lead to misrepresentation issues and lack of standardization across the industry. In this paper, a Colombian BIM Classification System is proposed, called ColombiaClass. ColombiaClass was developed based on the Chilean regulations for the standardization of construction items (NCh 1156), and adjusted to the Colombian context defining the order, classification, and name up to level 3 using current technical regulations, different databases for budgets of official entities and the collaboration with Colombian construction professionals. It was validated in 2 ways: checking ColombiaClass's ability to represent multiple official construction budgets corresponding to five Colombian regions (83% of the country) and using the Delphi Method, conducting two expert panels: one with field engineers and architects, and the other with BIM experts from the Colombian Ministry of Housing, BIM Forum Colombia, and the Colombian National Planning Department (DPN). As future research, the authors call to develop levels 4 and following, using the methodology described in this paper.

Keywords –

Building Information Modelling; BIM Classification Systems; Colombian BIM Classification System; Public works; National BIM strategy; ColombiaClass

1 Introduction

Unlike in other industries, productivity in the construction industry has not increased in the last 50 years [1]. In Colombia, 40% of pubic work projects during 2019 presented delays [2][3], and one of the main causes was attributed the uncertainty of project cost and non-compliance with project schedules [4]. Construction plays an essential role in the Colombian economy, representing 6.9% (average between 2015 and 2019) of the Gross Domestic Product (GDP) [5]. For this reason, the Colombian Government has launched a National BIM Strategy 2020-2026 seeking to increase productivity and improve project management practices, especially information management [4].

Public works in Colombia need to have transparent, auditable, non-fragmented processes that articulate the different actors [4]. Since 2019, several government decrees have been published called "standard tenders" that standardize public works bidding processes focusing on legal and professional experience requirements. However, to date requirements for budget structuring and project controls have not been addressed.

Currently, there is no norm that standardizes the construction items or the budget structure for public works in Colombia. Hence, each firm has its own ad-hoc Classification System. This makes it extremely difficult and time consuming for public entities to compare scopes and pricing between bids, and to carry out project controls throughout the project. Moreover, without a standardized BIM Classification System it is impossible to pursue initiatives towards the automatization and robotization of the tendering and control processes.

Since 2020, construction licenses in Colombia can be submitted to public authorities in a digital IFC format [6]. Having a standardized Classification System could enable stakeholders to leverage BIM through the entire building life cycle, taking advantage of IFC's data exchange formats that support interoperability between numerous BIM platforms[7].

Implementing an existing Classification System in Colombia has two main drawbacks. First, most Classification Systems are in English, making them unsuitable for public bids since Colombian contracting law requires that all documents must be in Spanish. On the other hand, Classification Systems that are in Spanish have been adapted to the specific linguistic and construction practices of their home countries (e.g., Chile NCh 1156 standard and Spain GuBIMClass Classification System). Implementing these existing Classification Systems in Colombia would not respect the linguistic diversity of the country and lead to misclassification problems. Moreover, there are several construction methods that are used in Colombia that are not typically used in other parts of the region. For example, Caissons are still a popular deep foundation method used in the country, partition walls are typically in clay masonry, and there are structures in special woods such as Guadua or bamboo.

In this paper, a BIM Classification System is proposed called the ColombiaClass. It is based on the Chilean NCh 1156 (designation of items) standard and was adapted to the Colombian context by comparing, analysing, and classifying the construction items of 33 existing public works budgets from several Colombian Public entities as well as different private databases. The proposed Classification System was validated by using the Delphi method, where two expert panels were held to determine adjustments considering the perspective of builders, designers, academics, and BIM professionals from construction companies and the Ministry of Housing, the National Planning Department (DNP) and the BIM FORUM Colombia. In the short term, ColombiaClass will help the Colombian government's goal to tender all public works projects using BIM methodology by 2026 and push towards standardized tenders.

2 Methodology

Chile is a pioneer in the region in BIM implementation for public works, with a 10-year National BIM Strategy from 2016 to 2025. As a result, by 2020, 53% of the projects of the Ministry of Public Works have been tendered under the BIM methodology described in its PlanBIM [8]. Hence, the Chilean standard NCh 1156 of 2018: construction - technical specifications - management and designation of items [9] was used as a basis for the ColombiaClass. The NCh 1156 was analysed and fully understood by reviewing documents, databases and consulting with a Chilean engineer who has been working in field for more than 10 years.

Using the NCh 1156 as a base, the ColmbiaClass scope and construction item names was reviewed by following three steps: 1) reviewing applicable Colombian technical regulations 2) analysing publicly available budgets for different types of buildings 3) checking the scopes of other Classification Systems. During this process the construction items in the proposed Classification System were named, hierarchized, and designated.

2.1 Review of technical regulations

An exhaustive review was made for the main technical regulations related to public works in Colombia checking the naming and completeness against the NCh 1156:

- RAS2000 [10] is the technical regulation for hydraulic infrastructure networks and NTC1500 [11] is the Colombian Pipework code. Based on these two documents, the correct names for networks, accessories and structures were extracted according to whether the systems were for buildings or infrastructure.
- RETIE [12] and Retilap, [13] both contain the technical specifications for electrical and lighting networks. From these, construction items were extracted related to electrical networks, telecommunication, public lighting, normal and emergency lighting.
- IDU Sidewalks Booklet 2018 [14], Bogotá Planning Office. This technical specification was used to extract the names of the pavement layers and the complementary elements of the sidewalks.
- The book Architects' Data (in Spanish "El arte de proyectar en Arquitectura) [15], was used to understand, classify and name the different architectural elements. In general, Colombian architectural projects use the nomenclature that is used in this book.
- INVIAS technical documents for roads [16]. The authors used the technical specifications published by INVIAS to extract names, components and elements that make up the roads and their complements.
- Health infrastructure regulations of the Ministry of Health[17]. This ministry has published several decrees establishing the guidelines and requirements for health centres. From these documents, the authors extracted mainly line items related to the management of clinical gases and extraction of contaminated water and clinical waste.

2.2 Analysis of official budgets

A Classification System for BIM is not limited to coding the construction elements (3D), it is also used for scheduling (4D) and cost estimating (5D) [1]. Therefore, it is necessary that the construction items in the ColombiaClass allow field managers to link BIM elements with budget elements. In this step, the authors adjusted the construction items that were identified in the previous step according to the results obtained when analysing the 33 official budgets described in Table 1.

The choice of budgets was developed using an information-oriented selection with maximum variation cases strategy [18]. The selection criteria were the type of public building, the contracting entity, and the geographical location of the project. Additional budgets were added to the analysis if they provided added information along a certain dimension. The analysis was closed once no new budgets could be found that added information dimensions to the case studies that had already been analysed. The selected budgets correspond to 25 state entities and different types of public buildings that have been tendered in recent years.

Table 1 Official budgets analysed.

Entity	Qty	Building type
Aerocivil	4	Airport
Ministry of Culture	2	Library
Mayor's Office of Espinal	1	Cafeteria
USPEC	1	Jail
Mayor's Office of Remedios	1	Social centre
Gov. of Cundinamarca and N.S	2	Clinic
Mayor's Office of…	3	School
UAESP	1	School
Pascual Bravo Tech institute	1	School
Gov. of...	2	School
Mayor's Office of...	3	Sports centre
IMDRI	1	Sports centre
Mayor's Office of Cucuta	1	Office
Findeter	2	Park
IDRD	1	Park
IDU	1	Skating rink
College of Cauca	1	University
IDU	2	Transport Station
Metrocali	2	Transport Station
Mayor's Office of San Juan	1	Houses

The analysed budgets correspond to projects located in five of the six regions of the country as shown in Figure 2. Only the island region of San Andres and Providencia is missing.

Figure 1. Budgets analysed by region (adapted from ICA Map)[20]

One of the objectives of the project was to cover the entire range of public building types tendered in Colombia. The authors found and analysed budgets for 14 types of public buildings, which to the author's knowledge, covers the entirety of tendered public buildings in Colombia published in SECOP. ColombiaClass was able to represent the scopes of all the different types of building projects. On the other hand, the variety of budgets selected by location and contracting entity made it possible to compare and adjust the linguistic diversity, construction processes, elements and materials used in different regions.

2.3 Analysis of existing Classification Systems

After adjusting the ColombiaClass line items with the technical regulations and official budgets, a review and comparison was made between the scopes of the Uniformat 1998 [21], UniClass [22], and GuBIMClass [23] classification against the ColombiaClass.

The Uniformat was analysed because it is an American Classification System and most of Colombian design standards have been based on American standards. Additionally, the Uniformat has the same hierarchical criteria as ColombiaClass. The EF table of UniClass was also analysed because it is an extremely complete Classification System that is also structured using a hierarchical organization. Finally, the GuBIMClass was analysed because it is one of the few Classification Systems that were created specifically to be used in conjunction with the BIM methodology [24]. Also, it has an important focus on the design and construction phases, that are the phases in which public projects are tendered in Colombia. Overall, one of the most significant adjustments that were made to the ColombiaClass was

incorporating the health and safety section of GuBIMClass, which is a critical element to ensure project success especially during the past few years due to COVID-19 epidemic.

2.4 Validation using the Delphi Method

The Colombia Class was validated by using the Delphi method, which is a common research method employed in numerous scientific disciplines. Only in 2008, 105 of 15,000 articles published by 4,000 publishers in Scopus employed the Delphi Method [25]. This method consists of a panel of several experts, preferably between five and ten, who are presented with a complex topic or problem and after discussion agree on a solution [26]. The value of the Delphi method lies in the ideas that come out of the expert panel, since the communication in this activity is effective, allowing the consensus of the participants [26].

For this paper, the topic to be addressed by the panel of experts was the ColombiaClass up to level 2: chapters and subchapters through a top-down approach. Two expert panels were held, the first one focused on the validation of the names of the first two levels of the ColombiaClass. The experts were composed of engineers and architects BIM coordinators, designers of hydraulic, gas, and electrical networks, contractors with more than 25 years of experience in public works, project engineers, and a member of the Department of Public Works. It should be noted that these panellists are from different regions of the country, to achieve a correct validity of the terminology.

The second panel focused on the validation of the scope, hierarchy, and order of the ColombiaClass. The experts were composed of engineers and architects with extensive BIM knowledge and experience in BIM implementation in Colombia. These panellists work with the Ministry of Housing, the BIM Forum Colombia, and advising public and private companies in BIM implementation and the creation of Classification Systems for private construction companies.

The Delphi Method provided useful feedback that enriched the research and completing the final adjustments to the ColombiaClass. Some of the most significant changes were a) scope of wet and dry networks, b) inclusion of industrial wastewater according to applicable regulations, c) more intuitive and user-friendly nomenclature.

3 Proposed classification system for BIM: ColombiaClass.

The ColombiaClass has the following coding:

$$AAA.\#\#.\#\#.\#\#$$

Where the first 3 letters correspond to the chapter, the first 2 digits that follow correspond to the subchapters, the next 2 digits to the section, and the last 2 digits to the elements. In addition, the numbers increase by 10, giving the user the flexibility to enter information that was not classified while preserving a logical hierarchical representation. It is worth mentioning that the last 2 digits of the coding corresponding to the elements were not developed since they are not part of the scope of this research.

ColombiaClass level one is composed of 21 chapters show in table 2. The letters that name each of these chapters correspond to an abbreviation of the chapter name in Spanish.

Table 2 Chapter letters and Names

Chapter letters	Chapter Name
TRA	Procedures and preliminary studies
CAL	Quality control
PRO	Provisionals
PRE	Preliminaries
MOV	Earthworks and soil stabilization
CIM	Containment and foundations
EST	Structure
MAM	Masonry and partition walls
CUB	Roof
MET	Metal, aluminium, and glass carpentry
MAD	Carpentry wood and other materials
PIN	Painting and waterproofing
ACA	Finishes
HID	Hydraulic and gas networks and installations
CLI	HVAC
COM	Telecommunication networks and installations
ELE	Electrical and lighting networks and installations
ESP	Special networks and installations
MEC	Mechanical conveying systems
URB	Urban planning and exterior works
CIV	Civil works

Table 3 contains the subchapters (level 2) of each one chapter described in table 2.

Table 3 Subchapters of chapter CAL

Coding to level 2	Subchapter Name
TRA (Procedures and preliminary studies**)**	

TRA.10	Procedures
TRA.20	Study of biological agent
TRA.30	Environmental, hydraulic, and hydrological study
TRA.40	Archaeological survey and paleontological study
TRA.50	Vulnerability study
CAL (Quality control)	
CAL.10	Testing of internal networks and installations
CAL.20	Soil testing
CAL.30	Provisionals
CAL.40	Civil works testing
PRO (Provisional works)	
PRO.10	Provisional construction
PRO.20	Provisional networks
PRO.30	Temporary signs
PRE(Preliminaries)	
PRE.10	Demolition clean-up
PRE.20	Topography
PRE.30	Canalization of water courses
PRE.40	River defence and water table
MOV(Earthworks and soil stabilization)	
MOV.10	Earthworks
MOV.20	Slope stabilization
CIM(Containment and foundations)	
CIM.10	Retaining wall
CIM.20	Shallow foundation
CIM.30	Deep foundation
EST(Structure)	
EST.10	Vertical elements
EST.20	Horizontal elements
EST.30	Reinforcement of existing building
EST.40	Seismic response control system
EST.50	Roof structure
EST.60	Reinforcement of roof
EST.70	Stair
MAM(Masonry and partition walls)	
MAM.10	Masonry wall
MAM.20	Lightweight walls
MAM.30	Concrete wall
MAM.40	Mud wall
CUB(Roof)	
CUB.10	Support and structure
CUB.20	Cover roof
CUB.30	Eaves
CUB.40	Skylight
CUB.50	Pediment
CUB.60	Complementary and water protection elements
CUB.70	Bargeboard
CUB.80	Special details
CUB.90	Green roof
MET(Metal, aluminium and glass carpentry)	
MET.10	Exterior door
MET.20	Gate
MET.30	Interior door
MET.40	Closet door
MET.50	Window
MET.60	Locksmith and railing
MAD(Carpentry wood and other materials)	
MAD.10	Exterior door
MAD.20	Gate
MAD.30	Interior door
MAD.40	Closet door
MAD.50	Window
PIN(Painting and waterproofing)	
PIN.10	Painting
PIN.20	Varnish and sealant
PIN.30	Waterproofing, sealing and water repellent.
ACA(Finishes)	
ACA.10	Ceiling
ACA.20	Façade and exterior wall
ACA.30	Interior wall
ACA.40	Floor
ACA.50	Thermal and acoustic insulation
ACA.60	Safety and security
ACA.70	Overlapping mouldings
ACA.80	Finishing stair
ACA.90	Ventilation grids
ACA.100	Fireplaces
ACA.110	Fixed furniture and accessories
ACA.120	Mobile furniture
ACA.130	Signage
HID(Hydraulic and gas networks and installations)	
HID.10	Plumbing fixture
HID.20	Water system
HID.30	Irrigation system
HID.40	Rainwater system
HID.50	Sanitary system
HID.60	Industrial water
HID.70	Water treatment system
HID.80	Fire protection system
HID.90	Gas system
CLI(HVAC)	
CLI.10	Air-conditioning system
CLI.20	Heating system
CLI.30	Ventilation system
COM(Telecommunication networks and installations)	
COM.10	Radio and TV
COM.20	Access control
COM.30	Voice and data
ELE(Electrical and lighting networks and installations)	
ELE.10	Lighting system
ELE.20	Electrical system
ELE.30	Audio & projection system

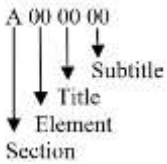
ESP(Special networks and installations)	
ELE.10	Waste extraction
ELE.20	Fuel and specialty gases
ELE.30	Scenotechnics
ELE.40	Facade cleaning system
ELE.50	Security
MEC(Mechanical conveying systems)	
MEC.10	Elevator
MEC.20	Stretcher elevator
MEC.30	Forklift
MEC.40	Car lift
MEC.50	Overhead crane
MEC.60	Escalator
MEC.70	Conveyor belt
MEC.80	Funicular
URB(Urban planning and exterior works)	
URB.10	Enclosures
URB.20	External roads and sidewalks
URB.30	Bicycle lane
URB.40	Landscaping
URB.50	Parks, squares and kiosks
URB.60	Swimming pool
URB.70	Sport and urban furniture
URB.80	Parking
CIV(Civil works)	
CIV.10	Water system
CIV.20	Sanity system
CIV.30	High and very high voltage electricity system
CIV.40	High pressure natural gas system
CIV.50	Earthwork
CIV.60	Pavement structure
CIV.70	Highways complement
CIV.80	Signalling and road safety elements
CIV.90	Green areas

As an example, up to level 3 (section), the shotcrete coding is MOV.20.40, where:

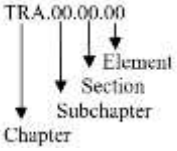
- The chapter (level 1) is MOV which corresponds to the Earthworks and soil stabilization.
- The subchapter (level 2) is .20 corresponding to the Slope stabilization
- The Section (level 3) es .40 which corresponds to the Shotcrete.

4 Analysis.

NCh 1156 of 2018 [9] was the main input to create the ColombiaClass, however, as the research progressed, much of the structure of NCh 1156 was transformed. The coding used by NCh 1156 is shown below.



The section is represented with a letter ranging from A to I, the elements, titles, and subtitles have a number that increases 1 by 1. In addition, the number 80 is used in the section, element, title, and subtitle to include everything that has not been standardized and the letter G to describe generalities. These last two representations were removed in the ColombiaClass and the coding is as follows:



NCh 1156 in its level 3 (title) has 980 items, 653 of which were modified to get the ColombiaClass, this means that more than 66% of the level was modified. Also, level 1, went from 9 sections (NCh1556) to 21 chapters (ColombiaClass), changing all the names and scopes of each item of this level, except for mechanical conveying systems.

Not only does the ColombiaClass have numerous differences from Nch 1156, but it also differs from GuBIMClass, Uniclass and Uniformat. Some examples of scope gaps that were resolved using ColombiaClass are shown below:

1. Clinical gases:

- ColombiaClass: ESP.20.10
- UniClass: No classification for specific gases, the nearest is EF_55_05 corresponding to Gas Extraction and Treatment [22]
- Uniformat: No classification for gases, all types of gases are implicitly included in D2090 corresponding to Other Plumbing Systems [21]
- GuBIMClass: No classification

2. Escalator:

- ColombiaClass: MEC.60.10
- UniClass: No classification for specific type of stair, the nearest is EF_35_10_30 and EF_35_10_40, corresponding to Internal Stairs and External Stairs respectively. [22]
- Uniformat: No classification for specific type of stair, the most similar is C2010 corresponding to Stair Construction [21]
- GuBIMClass: 60.30.10.30 [23]

3. Green Roof:

- ColombiaClass: green roof is the section CUB.100 and the elements that make it up are CUB.100.10 to CUB.100.90 where they include the growth medium, drainage layer, etc.
- UniClass: No classification
- Uniformat: No classification
- GuBIMClass: No classification

4. Measuring and protection equipment- biosafety and health:

- ColombiaClass: ACA.10.40
- UniClass: No classification
- Uniformat: No classification
- GuBIMClass: 80.40.20.10 corresponding to Health and safety measurement and detection equipment [23] .

ColombiaClass was created with the goal of going beyond 3D BIM modelling, helping field managers to use it for scheduling (4D), cost estimation (5D), and beyond. For this reason, the Procedures chapter was created, which includes codes that cannot be assigned to a BIM element of the 3D model but can be assigned to cost estimation and scheduling.

Table 4 reproduces the comparison between Classification Systems published by Eastman [18], adding the ColombiaClass for comparison.

Table 4. Comparison between existing Classification Systems (adapted from Eastman [18])

Classif. system/ criteria	Scope	Principle Categori-zation	Taxonomy
OmniClass	Organization and sorting of product information for all elements in the project life cycle	Faceted	15 tables
UniFormat	Organization of physical elements of a construction. Used for cost estimation	Hierarchical	1 table with 5 levels
Uniclass	All aspects of the design and construction process.	Faceted	11 tables
Colombia Class	All elements (physical and non-physical) of design and construction process	Hierarchical	1 Table

5 Conclusions and future work

ColombiaClass is a BIM Classification System designed for building projects and in turn, serves as a standard for the definition and hierarchization of building construction items for public buildings in Colombia. This system was conceived for the public sector and is aimed at standardizing the bidding documents that have been developed in recent years, thus allowing bidding processes and works to be more transparent, efficient, and with better information management.

In the discussions generated in the expert panels, it was corroborated that Colombia needs to create a Classification System for BIM that fits the Colombian construction context.

To ensure that the ColombiaClass articulates correctly with BIM models and supports interoperability, data exchange, and cost and time analysis, future research should be done carrying out case studies using a bottom-up approach. This research should be done once the level 4 of the ColombiaClass is completed.

Additionally, as future research, the authors propose that the ColombiaClass be reviewed with ISO 12006 and adjusted if necessary. Also, the ColombiaClass should be expanded to cover the asset management phase and infrastructure projects. We invite readers to contact the corresponding authors to access the ColombiaClass and to collaborate in developing it further.

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