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idBIM4.0 – National Library of BIM Objects: The Railway

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Abstract

The Mobilizing Project "Digital Construction Revolution – REV@CONSTRUCTION" focuses on the Digital Transition, aiming to increase productivity, competitiveness, and sustainable growth of the Portuguese AEC sector through different R&D activities. One of these activities is creating and developing a national standardized library of BIM objects (idBIM4.0), aligned with the international normative documents. As such, this paper presents the approach to developing railway BIM objects and their respective Product Data Templates (PDTs).

Author Keywords. idBIM4.0, The Portuguese BIM Library, REV@CONSTRUCTION, DIGI4Construction, Product Data Template (PDT), Railway 4.0

1. Introduction

Since 2020, the Mobilizing Project "Digital Construction Revolution – REV@CONSTRUCTION" has focused on increasing the international competitiveness of the Portuguese AEC sector by developing and providing digital solutions to their stakeholders. Four main PPSs (Products, Processes or Services) were created to achieve this goal:

- PPS1 – DIGI4Construction
- PPS2 – Digital Twin for the AEC sector stakeholders
- PPS3 – Digital Twin for operation and maintenance
- PPS4 – Living Lab Paving and BIM Demonstrator for Civil Engineering Projects

This paper is related to PPS1, whose goal is, in summary, to create the basis for the digital transition in the sector. Among PPS1's activities is Activity 5: idBIM4.0 – National Library of BIM Objects. These objects must be capable of being linked with other BIM libraries, so they must be interoperable; therefore, they have to be aligned with the international normative documents (REV@CONSTRUCTION 2023).

Several BIM libraries exist worldwide, especially for building elements; however, for civil engineering structures with linear characteristics, such as bridges, tunnels, roads and railways, there is still a gap to be filled (Ciccone et al. 2022; Seo and Lee 2020).

Creating a free standardized Portuguese BIM online library that can be accessed and improved by different stakeholders has already been proposed in the literature (Nunes 2016). Considering the growth of the global railway market, there has been an increasing interest in applying BIM for these infrastructures (Neves, Sampaio, and Vilela 2019); thus, the Portuguese BIM library sought to include railway objects too, which has been suggested in other national research initiatives (Carmali et al. 2018; Pereira 2018).

2. Development of Railway PDTs and BIM Objects

The current IFC standard (IFC4 Add2 TC1) does not offer a suitable solution for horizontal infrastructures such as the railway (Ciccone et al. 2022); therefore, buildingSMART International developed IFC 4.3, whose goal is to extend the IFC benefits to this kind of assets (Kelly and buildingSMART International Ltd. 2022). Figure 1 shows the overview of the IFC expansion towards these infrastructures:

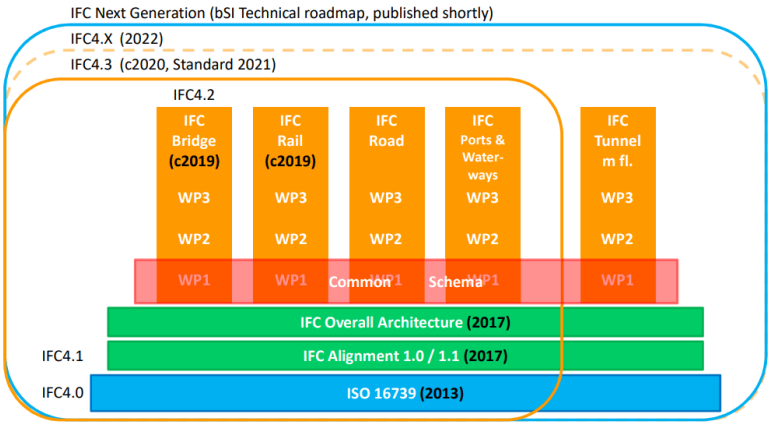

Figure 1 – IFC expansion for horizontal infrastructures (buildingSMART International Ltd. 2022)

As IFC 4.3 is due to be published in 2023, it was decided not to comply entirely with the Portuguese manual of BIM object modelling rules (El Sibaii et al. 2021) – as it still follows the current official IFC standard. Therefore, the Portuguese BIM library adopts the upcoming IFC 4.3 for railway assets.

While ideally all BIM objects should abide by these rules in Portugal, the horizontal infrastructure elements lack information in IFC4 Add2 TC1. For instance, the current IFC standard states that a railway sleeper must be a member of the generic class IfcBuildingElementProxy (as USERDEFINED), while for IFC 4.3 this is changed to include track elements, being now part of the enumerations of IfcTrackElement (IfcTrackElementTypeEnum > SLEEPER).

2.1. Product Data Templates for the Railway Sector

A Product Data Template (PDT) defines the data structure of the characteristics of construction objects in a standardized way, anticipating the information required by their users. As standardization is a pillar of BIM implementation, these enable seamless information exchanges between the construction industry stakeholders (University of Minho 2021a).

To create a PDT, one must collect data from multiple data sources, with special attention to the IFC property sets for that specific object and its non-BIM harmonized standard.

In the case of the railway assets, no national BIM library was found to have either objects or PDTs. Therefore, with this lack of information, apart from the IFC 4.3 property sets and the non-BIM harmonized standards, it was decided to acquire information by using the IFC Rail Project data requirements (buildingSMART International Ltd. - Railway Room 2019) – prior to the creation of the IFC Rail domain and consequent property sets in IFC 4.3. Besides that, data from two European railway projects which were implementing BIM in their workflows was collected: Crossrail and Rail Baltica, respectively, from the United Kingdom and the Baltic countries – Finland, Estonia, Latvia, Lithuania, and Poland.

The creation of PDTs for the Portuguese BIM library does not require the inclusion of the IFC properties that are hierarchically superior to the class of the object that is being created. This is the case as there is already a Master Data Template in the Portuguese PDT platform (University of Minho 2021b), which is included in every object that is modelled for the BIM library.

Figures 2 and 3 show the creation of a PDT for a twin-block sleeper, including the properties gathering and normalization. This first part is done in Microsoft Excel, validated within the REV@CONSTRUCTION consortium, and then submitted to the industry to obtain feedback on a website created specifically for PDTs (pdts.pt) (Granja et al. 2023). At the time of writing, there are only a few PDTs on the website, none related to horizontal infrastructure assets (see Figure 4).

IFC Rail (Official)		IFC Rail Project (2013)	DoP		CrossRail UK	Rail Baltica	Name Sources					Selected Property Name	Unit	Data Type	Description
Property	Property Set	Property	Property	Source	Property	Property	IFCOM	IFCPro	DoP	CrossR	RB				
InstalledCondition		Condition	-	-		-	X	X	-	-	-	InstalledCondition	Alphanumerical	Specification	Assessment of the condition of the element at point of installation.
SleeperType		Sleeper type	-	-	Sleeper Material, Sleeper Type	-	X	X	-	X	-	SleeperType	Alphanumerical	Specification	Indicates the sleeper type.
TechnicalStandard		Technical standard	Technical specification	EN 13230-1:2016	-	-	X	X	X	-	-	TechnicalStandard	Alphanumerical	Specification	The technical standard which the element should comply with.
FasteningType	Pset_TrackElementTypeSleeper	Type of fastening	-	-	-	-	X	X	-	-	-	FasteningType	Alphanumerical	Specification	Indicates the type of fastening used to generate traction between the foot of the rail and the sleeper. It depends on but is not uniquely identified by the type of sleeper. This property shall only be used when sleeper fastening is not modelled as an element.
IsElectricallyInsulated		Electrical insulation	Electrical insulation	EN 13230-1:2016	-	-	X	X	X	-	-	IsElectricallyInsulated	Boolean	Specification	Indicates whether the sleeper is electrically insulated due to its design or the running rails or not.
HollowSleeperUsage		-	-	-	-	-	X	-	-	-	-	HollowSleeperUsage	Alphanumerical	Specification	Indicates the purpose of using hollow sleeper. The possible value can be eg. cable trenching, protection of turnout mechanism, etc.
NumberOfTrackCenters		Number of axles	-	-	-	-	X	X	-	-	-	NumberOfTrackCenters	Numerical	Specification	Indicates the number of track centers running over the sleepers.
IsHollowSleeper		-	-	-	-	-	X	-	-	-	-	IsHollowSleeper	Boolean	Specification	Indicates whether the sleeper is hollowed or not.
HasSpecialEquipment		Equipment	-	-	-	-	X	X	-	-	-	HasSpecialEquipment	Boolean	Specification	Indicates whether the sleeper has any special equipment for fastening components (e.g. Ballox, signum magnet) or not.
SequenceInTrackPanel	Pset_TrackElementOccurenceSleeper	Track–Panel Sequence; Track–Panel Position	-	-	-	Sleeper Spacing	X	X	-	-	X	SequenceInTrackPanel	mm	Specification	Sequence of the sleeper within the track panel.
UnderSleeperPadStiffness		-	-	-	-	-	X	-	-	-	-	UnderSleeperPadStiffness	Alphanumerical	Specification	Indicates the stiffness of the under-sleeper pad as design reference for the sleeper.
IsContaminatedSleeper		Contamination	-	-	-	-	X	X	-	-	-	IsContaminatedSleeper	Boolean	Specification	Indicates whether the sleeper is contaminated and requires special disposal or not.
Length		Sleeper dimension	L	EN 13230-1:2016	Length	L	X	X	X	X	X	Lenght	mm	Geometric	The length of the object.
Width*	Qto_SleeperBaseQuantities	Sleeper dimension*	b1*	EN 13230-1:2016	-	b1	X	X	X	-	X	b1	mm	Geometric	Bottom width of the concrete element
Height		Sleeper dimension	b2*	EN 13230-1:2016	-	b2	X	X	X	-	X	b2	mm	Geometric	Top width of the concrete element
		Sleeper dimension	-	-	Depth	-	X	X	-	X	-	Height	mm	Geometric	Characteristic height.
		Panel	-	-	-	-	-	X	-	-	-	Panel	Alphanumerical	Specification	Referenced track panel or turnout panel or dilatation panel
		Location of "variable spacing" start	-	-	-	-	-	X	-	-	-	StartVariableSpacing	km	Specification	Indication of kilometers on referenced track edge indicating the start of a section where the distance between the sleepers is not constant / [m]
		Location of "variable spacing" end	-	-	-	-	-	X	-	-	-	EndVariableSpacing	km	Specification	Indication of kilometers on referenced track edge indicating the end of a section where the distance between the sleepers is not constant / [m]
		Sleeper Model	-	-	-	-	-	X	-	-	-	SleeperModel	Alphanumerical	Specification	Sleeper Model
		Undersleeperpad	-	-	Attenuated Sleeper, Pad Type	-	-	X	-	X	-	UnderSleeperPad	Alphanumerical	Specification	Indication of whether the sleeper has an undersleeperpad and, if so, what type.
		Coating	-	-	-	-	-	X	-	-	-	Coating	Alphanumerical	Specification	Indication of whether and by what means the sleeper has been waterproofed (esp. wooden sleepers) to contamination, for special disposal
		Turnout-Panel Position	-	-	-	-	-	X	-	-	-	TurnoutPanelPosition	Alphanumerical	Specification	Reference of corresponding installation plan of the turnout
		Dilatation-Panel Position	-	-	-	-	-	X	-	-	-	DilatationPanelPosition	Alphanumerical	Specification	Reference of corresponding installation plan of the dilatation
		Manufacturer	Production plant	EN 13230-1:2016	-	-	-	X	X	-	-	Manufacturer	Alphanumerical	Manufacturer	Who or which company is the manufactor of the sleeper?
		Work company	-	-	-	-	-	X	-	-	-	WorkCompany	Alphanumerical	Manufacturer	Who put the sleeper in place?
		Installation date	-	-	-	-	-	X	-	-	-	InstallationDate	Date	Specification	Date on which the sleeper was (or will be) installed.
		Disassembly date	-	-	-	-	-	X	-	-	-	DisassemblyDate	Date	Specification	Date on which the sleeper was (or will be) removed.
		Manufacturing date	Year of manufacture	EN 13230-1:2016	-	-	-	X	-	-	-	ManufacturingDate	Date	Specification	Date on which the sleeper was (or will be) manufactured.
		Putting into operation date	-	-	-	-	-	X	-	-	-	PuttingIntoOperationDate	Date	Specification	Date on which the sleeper was (or will be) put into operation.
			L1	EN 13230-1:2016; EN 13230-3:2016	-	-	-	-	X	-	-	L1	mm	Geometric	Distance between the rail fastening gauge points
			L2	EN 13230-1:2016	-	-	-	-	X	-	-	L2	mm	Geometric	Position of the rail fastening gauge point with regard to the end of the sleeper
NOTE(*): Exceptionally, preference for the official IFC (or IFC Project) will not be followed for this PDT, as it is important to define both the bottom (b1) and upper (b2) width of the sleeper.			L3	EN 13230-1:2016	-	-	-	-	X	-	-	L3	mm	Geometric	Total length of **reinforced** concrete block (**twin-block only**)
			hp	EN 13230-1:2016	-	-	-	-	X	-	-	hp	mm	Geometric	Depth at any position along the total length of the **prestressed** concrete element measured in accordance with the quality plan (**monoblock only**). In this case it was selected to be used at the sleeper's middle section
			hr	EN 13230-1:2016	-	-	-	-	X	-	-	hr	mm	Geometric	Depth at any position along the total length of the **reinforced** concrete element measured in accordance with the quality plan (**twin-block only**). In this case it was selected to be used at the sleeper's middle section

Figure 2 – PDT data collection and normalization

OmniClass Number: Pr_20_85_72_22

Twin-Block Sleeper Data Template

Categoria	PropertyNameEn	NomeDaPropriedadePt	Unidade	Enumerators	Enumeradores	Description	Descrição
Geométrica	Lenght	Comprimento	mm	-	-	The length of the object.	O comprimento do objeto
	b1	b1	mm	-	-	Bottom width of the concrete element	Largura da base da travessa
	b2	b2	mm	-	-	Top width of the concrete element	Largura do topo da travessa
	Height	Altura	mm	-	-	Characteristic height.	Altura caraterística
	L1	L1	mm	-	-	Distance between the rail fastening gauge points	Distância entre pontos de fixações de carris
	L2	L2	mm	-	-	Position of the rail fastening gauge point with regard to the end of the sleeper	Posição entre o ponto de fixação de um carril e o término da travessa
	L3	L3	mm	-	-	Total length of **reinforced** concrete block	Comprimento total do bloco de betão armado (travessa bi-bloco)
	hr	hr	mm	-	-	Depth at any position along the total length of the **reinforced** concrete element measured in accordance with the quality plan (**twin-block only**). In this case it was selected to be used at the sleeper's middle section	Profundidade em qualquer posição do comprimento total do elemento de betão armado, medido de acordo com o plano de qualidade (**apenas bi-bloco**). Neste caso foi escolhida a posição da zona central da travessa
	i	i	°	-	-	Inclination of the rail seat	Inclinação da mesa de assentamento do carril na travessa
	DepthRailSeat	ProfundidadeMesaAssentamento	mm	-	-	Indicates the depth at the rail seat	Indica a profundidade na mesa de assentamento do carril na travessa
	Lcb	Lcb	mm	Lcb > L1 (EN 13230-3 Clause 6.1)	Lcb > L1 (EN 13230-3 Cláusula 6.1)	Connecting bar length	Indica o comprimento do perfil metálico (cantoneira) que liga os blocos de betão armado
	he	he	mm	min 40 mm (EN 13230-3 Clause 6.3)	min 40 mm (EN 13230-3 Cláusula 6.3)	Distance between bottom surface of the sleeper to steel connecting bar	Indica a distância entre a base da travessa e o perfil metálico (cantoneira) que liga os blocos de betão armado
	a	a	mm	-	(Utilizada função size_lookup no Revit)	Indicates the cross-section vertical leg length	Indica o valor da perna vertical da secção do perfil metálico (cantoneira) que liga os blocos de betão armado
	b	b	mm	-	(Utilizada função size_lookup no Revit)	Indicates the cross-section horizontal leg length	Indica o valor da perna horizontal da secção do perfil metálico (cantoneira) que liga os blocos de betão armado
	t	t	mm	-	(Utilizada função size_lookup no Revit)	Indicates the thickness of the steel connecting bar cross-section	Indica o valor da espessura da secção do perfil metálico (cantoneira) que liga os blocos de betão armado
	rroot	Raio	mm	-	(Utilizada função size_lookup no Revit)	Indicates the radius between the vertical (a) and the horizontal (b) legs of the steel connecting bar cross-section	Indica o raio entre a parte vertical (a) e horizontal (b) da secção do perfil metálico (cantoneira) que liga os blocos de betão armado
	DepthEmbedded	ProfundidadeEmbutida	mm	-	-	Depth of sleeper that is below the level of the slab	Profundidade da travessa que se encontra abaixo do nível da laje/superfície
	LongitudinalExteriorAngle	AnguloExteriorSeccaoLongitudinal	°	-	-	Indicates the longitudinal section exterior extremity angle of the sleeper	Indica o ângulo da extremidade exterior da travessa
	LongitudinalInteriorAngle	AnguloInteriorSeccaoLongitudinal	°	-	-	Indicates the longitudinal section interior extremity angle of the sleeper	Indica o ângulo da extremidade interior da travessa (**apenas bi-bloco**)
	CrossSectionAngle	AnguloSeccaoTransversal	°	-	-	Indicates the cross section extremity angle of the sleeper	Indica o ângulo da extremidade da secção transversal da travessa
Fabricante	Manufacturer	Fabricante	Alfanumérica	-	-	Who or which company is the manufactor of the sleeper?	Quem fabricou a travessa
	WorkCompany	PrestadorServicos	Alfanumérica	-	-	Who put the sleeper in place?	Quem colocou a travessa no local
	InstalledCondition	CondicaoInstalacao	Alfanumérica	new, regenerated, reused, other, notknown, unset	novo, regenerado, reutilizado, outro, desconhecido, não definido	Assessment of the condition of the element at point of installation.	Avaliação da condição do elemento aquando da instalação
	SleeperType	TipoTravessa	Alfanumérica	compositesleeper, concretesleeper, insulatedsteelsleeper, monoblockconcretesleeper, notinsulatedsteelsleeper, twoblockconcretesleeper, woodensleeper, other, notknown, unset	compósito, betão, isolado, **monobloco de betão**, não isolado, **bi-bloco de betão**, **madeira**, outro, desconhecido, não definido	Indicates the sleeper type.	Indica o tipo de travessa
	TechnicalStandard	StandardTecnico	Alfanumérica	-	-	The technical standard which the element should comply with.	O standard técnico ao qual o elemento deve satisfazer
	IsElectricallyInsulated	ÉEletricamenteIsolada	Boolean	Yes/No	Sim/Não	Indicates whether the sleeper is electrically insulated due to its design or the running rails or not.	Indica se a travessa é eletricamente isolada ou não devido ao seu design ou dos carris da travessa
	HollowSleeperUsage	UtilizacaoTravessaOca	Alfanumérica	-	-	Indicates the purpose of using hollow sleeper. The possible value can be eg. cable trenching, protection of turnout mechanism, etc.	Indica o propósito de se utilizar uma travessa oca. Podem ser, por exemplo, para: valas para cabos, proteção do mecanismo de mudança de via, etc.
	NumberOfTrackCenters	NumeroCentrosDeVias	Numérica	-	-	Indicates the number of track centers running over the sleepers.	Indica o número de centros de vias que passam sobre a travessa
	IsHollowSleeper	ÉTravessaOca	Boolean	Yes/No	Sim/Não	Indicates whether the sleeper is hollowed or not.	Indica se a travessa é oca ou não

Figure 3 – An excerpt of the twin-block sleeper data template

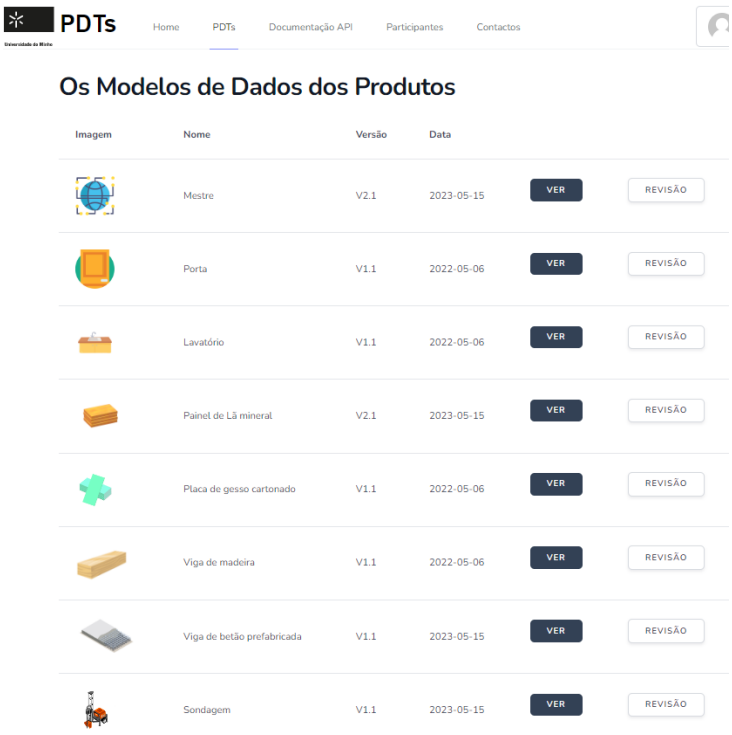

Figure 4 – The current state of the Portuguese PDT website (University of Minho 2021c)

2.2. BIM Objects for the Railway Sector

The standardized drawings of the objects' non-BIM harmonized standards collected during the PDT phase were used to create railway families for the Portuguese BIM Object Library. This way, the 3D BIM models seek to reflect the real geometry of the assets as close to reality as possible.

The modelling process was conducted using Autodesk Revit, which has already been deployed in other BIM prototype libraries for the railway (Seo and Lee 2020). Except for using IFC 4.3 data, this BIM modelling phase also aimed to comply with the Portuguese manual of BIM object modelling rules (El Sibaii et al. 2021).

According to this guidebook, BIM objects can be parametric or non-parametric, depending on the situation. Figures 5 and 6 illustrate both types of objects:

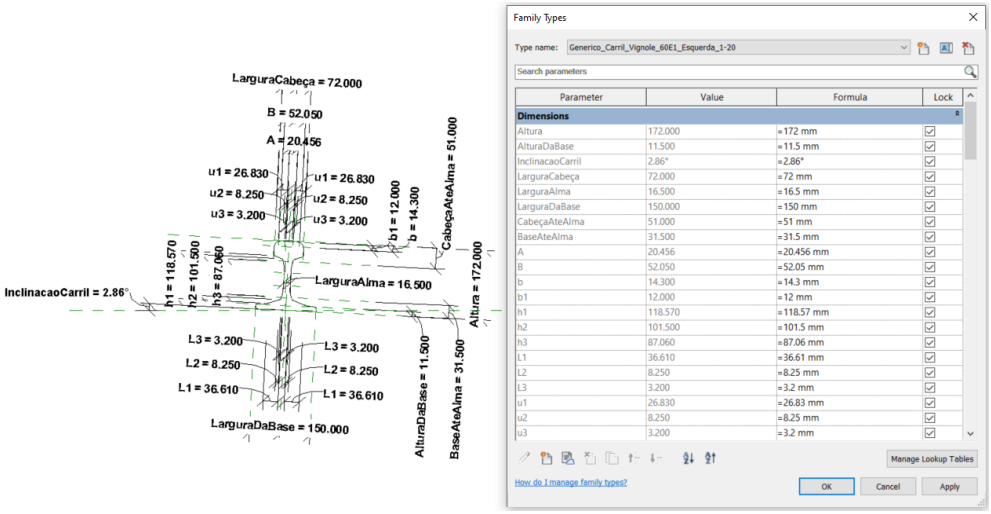

Figure 5 – A geometrically non-parametric 60E1 Vignole rail (according to EN 13674-1:2011+A1:2017)

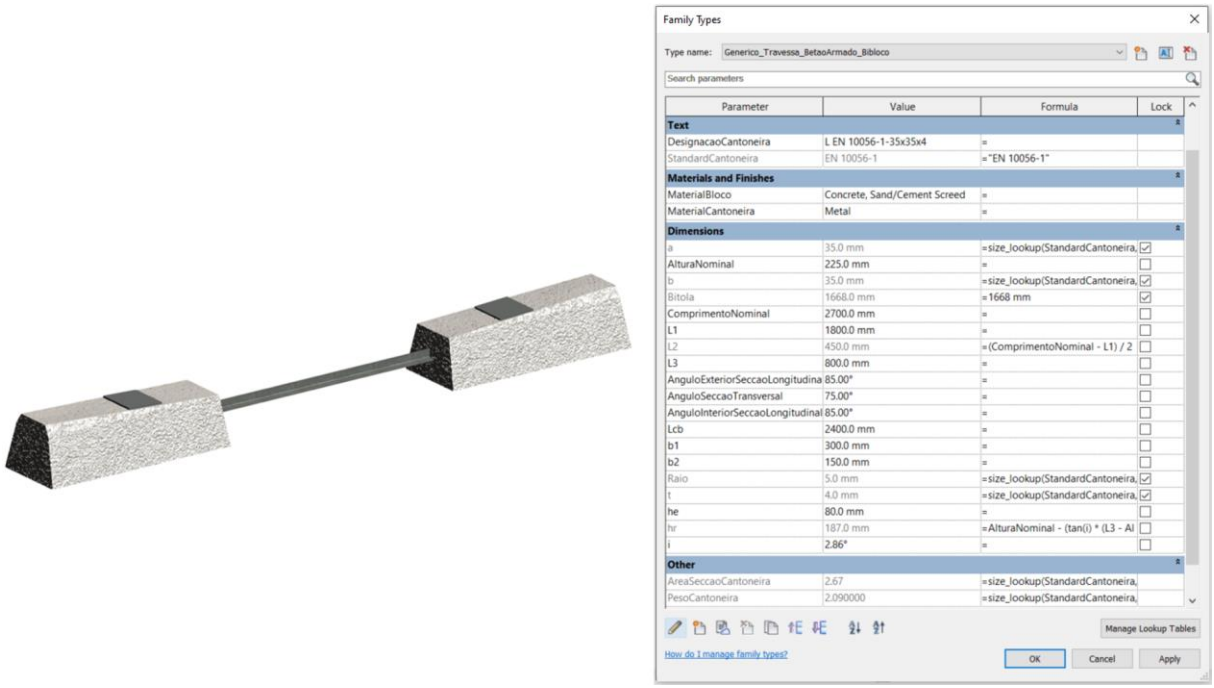

Figure 6 – A fully parametric twin-block concrete sleeper and its steel connecting bar

One of the missions of the REV@CONSTRUCTION project is the interoperability between BIM platforms and the Portuguese AEC sector stakeholders. Hence, the idBIM4.0 platform connects the BIM objects and their respective PDT so that no information is lost along the way. At the time of writing, the platform is not yet publicly available; however, Figure 7 shows the two interfaces it will have: a website (on the left) and a plugin (on the right) developed by BUILT CoLAB:

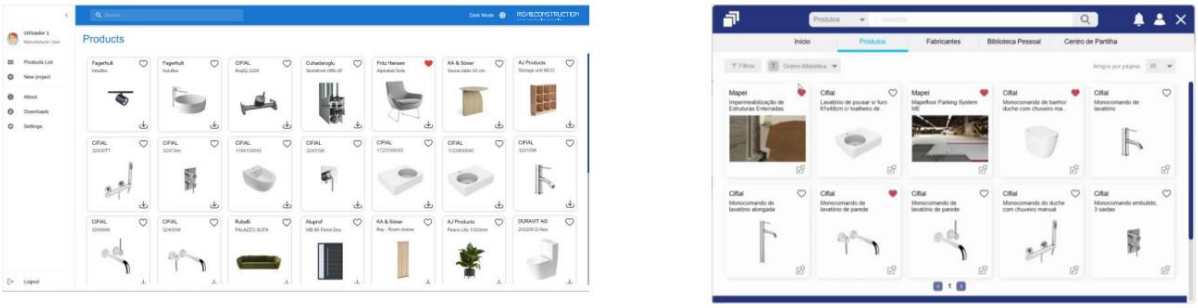

Figure 7 – idBIM4.0: The National BIM Object Library. On the left, as a website, and on the right, as a plugin (in this case for Autodesk Revit) (Martins, Amândio, and Sanhudo 2023)

3. Conclusions

The creation of a standardized national BIM object library has been long-awaited in Portugal. Academic and AEC industry stakeholders are expected to use this platform to increase the sector's productivity and continuously share objects and their PDTs.

Horizontal infrastructures, including the railway, have been neglected by the openBIM entities over the years; however, existing initiatives target these infrastructures, enabling the adoption of BIM in new fields. With the arrival of IFC 4.3, horizontal infrastructures can now be modelled in openBIM formats.

The idBIM4.0 platform has already started with the railway (Figure 8 shows a few more examples), albeit with few interventions from the main railway sector value-chain masters. With the growing use and maturity of this tool, it is expected that the Portuguese railway sector stakeholders will cooperate and adhere to this digital solution, developing the concept of Railway 4.0 in the country.

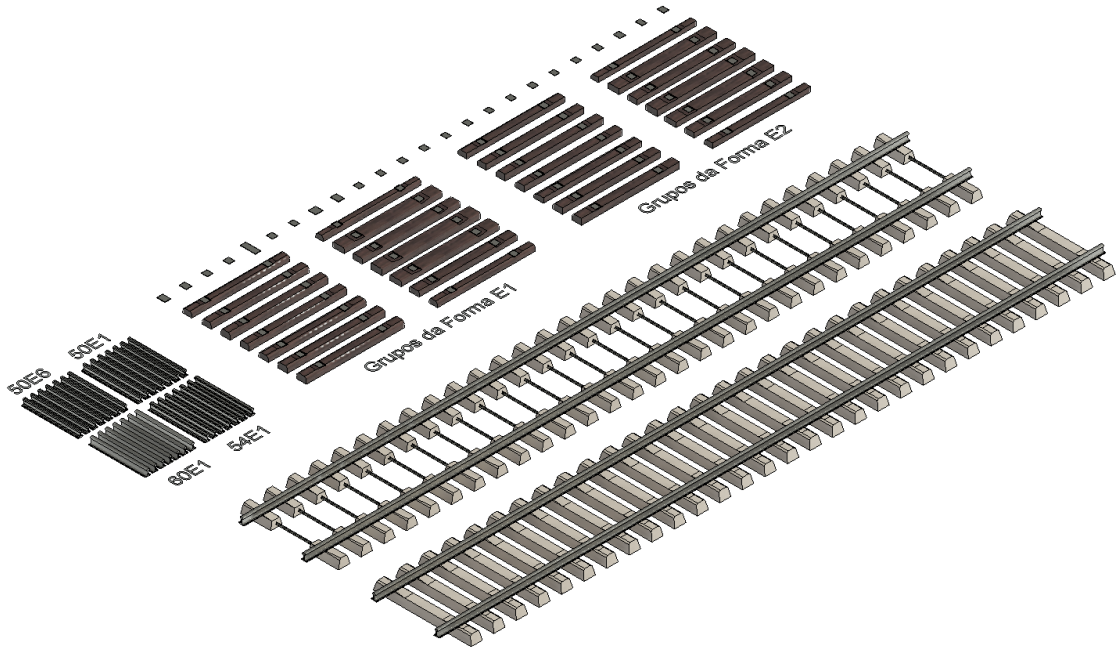

Figure 8 – Railway BIM families for the idBIM4.0 platform

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