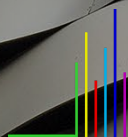




Linked Data for a construction big data platform

Daive Simeone
d.simeone@webuildgroup.com



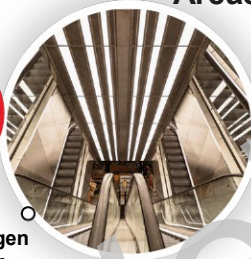
11th Linked Data in Architecture and Construction
Workshop (15 - 16 June 2023)

Webuild is a global player in the construction of large, complex infrastructure

1st Italian Contractor

Global Leader in Water sector⁽¹⁾

**Sustainable
Mobility**



**Copenhagen
Cityringen
Metro
Denmark**

**4 Business
Areas**

**Clean Hydro
Energy**



**Snowy 2.0
hydroelectric
Project
Australia**



**Clean
Water**

**Anacostia
River Tunnel
USA**



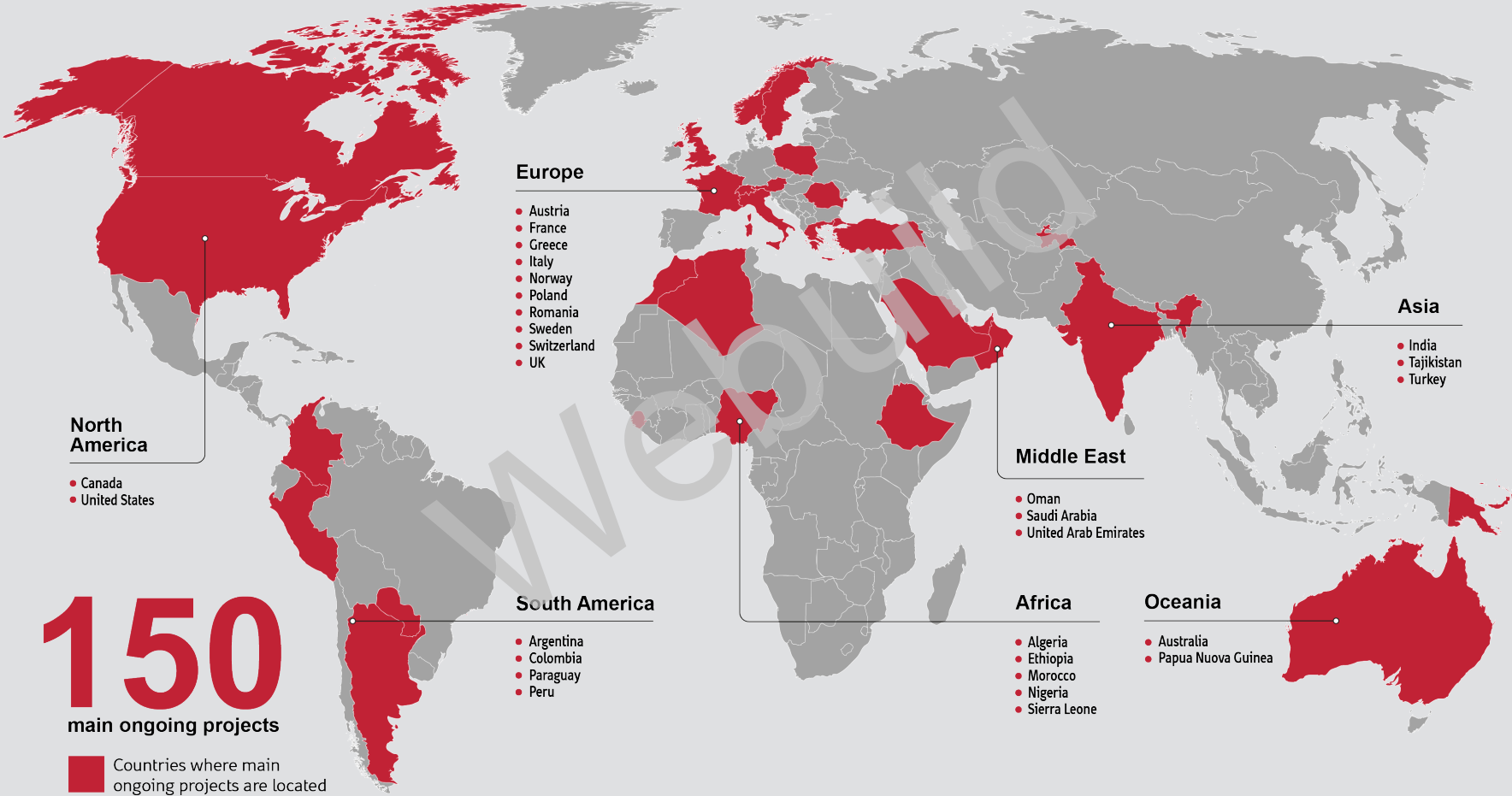
**Al Bayt
Stadium
Qatar**



**Green
Buildings**

- 117** Years
- 3,396km** Tunnels
- 50** Countries
- 82,509km** Motorways & Roads
- 150** Ongoing projects
- 14,118km** Railways and metros
- 60** Offices Worldwide
- 1,018km** Bridges and Viaducts
- 313** Dams and Hydro Plants
- 83,000** Direct & Third Party Workforce

(1) ENR Report, The TOP 250, 22/29 August 2022



150

main ongoing projects

Countries where main ongoing projects are located

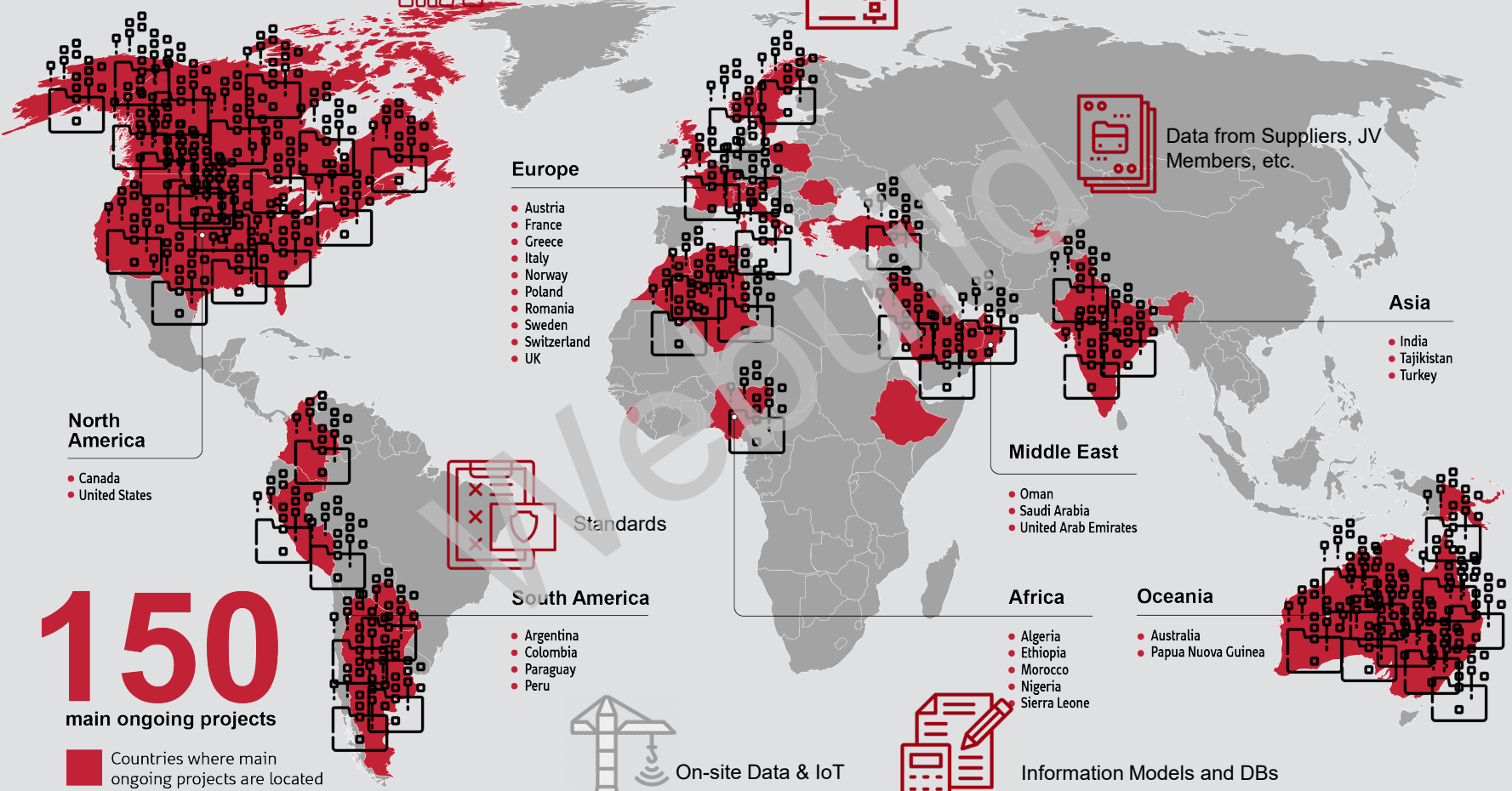
FOOTPRINT



Documents, Norms & regulations, Contracts



Design and Engineering



Europe

- Austria
- France
- Greece
- Italy
- Norway
- Poland
- Romania
- Sweden
- Switzerland
- UK

Data from Suppliers, JV Members, etc.

Asia

- India
- Tajikistan
- Turkey

North America

- Canada
- United States

Middle East

- Oman
- Saudi Arabia
- United Arab Emirates

Standards



South America

- Argentina
- Colombia
- Paraguay
- Peru

Africa

- Algeria
- Ethiopia
- Morocco
- Nigeria
- Sierra Leone

Oceania

- Australia
- Papua Nuova Guinea

150

main ongoing projects

■ Countries where main ongoing projects are located



On-site Data & IoT

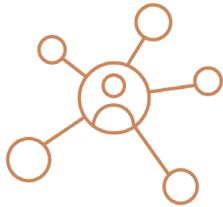


Information Models and DBs

Research context and motivations



- Multiple Disciplines, multiple projects, large amount of data elaborated in each project
- On-demand information sharing model
- Technical knowledge and data are dispersed and dishomogenously represented



- Accessibility and reuse of Historic Data from projects and tenders
- Centralization of the knowledge base and automation of knowledge exchange
- Provision of interpretative context of data
- Generate value from knowledge produced in projects (control and predict)
- Progressive in the adoption and implementation

R&D funded project: “An innovative integrated platform for advanced production processes in the construction sector” funded by the Italian Minister for Economic Development and Regione Lombardia

Research objectives

Construction Data Platform

Reference Data model

- Standardized
- Modular and scalable
- Clear and disambiguous
- Adherent to requirements of each discipline
 - Context-aware
- Interoperability with platforms models



Linked Data

Handling of large amount of data

- Different environments (construction sites and tenders)
- Cleaning, refinement, homogenization of data
 - Different sources: Platforms, IoT
 - Different granularity and aggregation
 - Accessibility levels and security

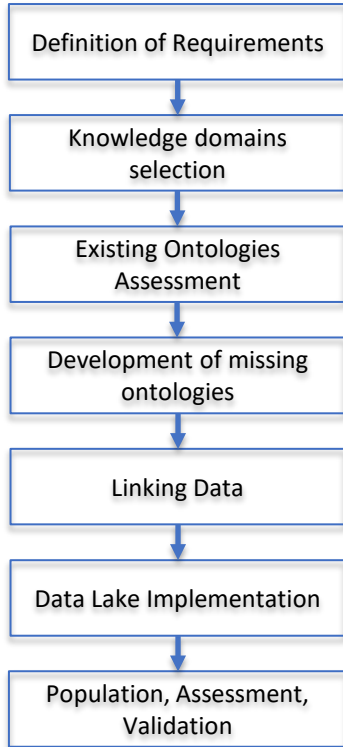


Construction Big Data Platform



Construction knowledge domains and the adopted reference data models

DEVELOPMENT METHODOLOGY



Discipline	Code	Requirement (summarized)
QTO	QTO-01	Distinguish BOQItem, price item and measures
QTO	QTO-02	Versioning of BoQs, Price Lists, measures
QTO	QTO-03	Measurement units based on international standards
QTO	QTO-04	Distinguish materials and quantity typologies
QTO	QTO-05	Measurements/estimations from different information carriers
BIM	BIM-01	Interoperability with IFC
BIM	BIM-02	Identification of quantified elements and attributes
Estimating	EST-01	Include classification systems (CESMM4, NRM2)
Estimating	EST-02	Methods of measurement and/or calculation
Estimating	EST-03	Adopted construction methods
Planning	PLA-01	Relationships with WBS for activities duration
Planning	PLA-02	Possibility to relate quantities and locations
Technical coordination	TEC-01	Quantities aggregation at high-level representation
Technical coordination	TEC-02	Actor providing the quantity value (client, consultant, QTO specialist, etc.)
Procurement	PRO-01	Quantities extracted as per BOQItem specifications

Domain	Reference Data Model	Note
Product (building or infrastructure)	IfcOWL	Other ontologies adopted: BOT, DiCon
Project Framework	Contractor existing model	Revised and aligned with E-Cognos, DiCon
Quantity Take-Off	QTOnt ontology	Developed from scratch, aligned with DiCon
Construction Planning	ConPla ontology	Re-use/alignment with Dicon, Construction Scheduling Ontology
Cost Modeling	Contractor existing model	Detailed model interoperable with QTOnt and ConPla ontologies

DISCIPLINES



INTEROPERABILITY



Quantity Take-Off ontology

The screenshot displays the Protege ontology editor interface. The left pane shows a class hierarchy starting with `owl:Thing` and including various classes like `DiconConcept`, `MaterialEntity`, `IfcConcept`, and `QuantifiableObject`. The right pane shows the details for the `QuantifiableObject` class, including its annotations and description.

Class hierarchy: QuantifiableObject

- owl:Thing
 - DiconConcept
 - DiconInformationConcept
 - Dataset
 - BreakdownStructure
 - MaterialEntity
 - Material
 - Quantification Reference Material
 - IfcConcept
 - IfcIdentifier
 - IfcLabel
 - IfcMaterialDefinition
 - IfcMaterial
 - IfcMaterialConstituent
 - IfcMaterialConstituentSet
 - IfcMaterialDefinitionRepresentation
 - IfcMaterialLayer
 - IfcMaterialLayerSet
 - IfcMaterialProfile
 - IfcMaterialProfileSet
 - IfcMaterialRelationship
 - IfcText
 - IfcPhysicalQuantity
 - IfcProduct
 - IfcQuantitySet
 - IfcElementQuantity
 - QTONConcept
 - Bill of Quantities
 - BoQItem
 - ConstructionQuantity
 - IfcElement
 - PriceList
 - PriceListItem
 - QuantifiableObject
 - Quantification Reference Material
 - QuantificationMethod
 - QuantificationUnit
 - Unit
 - QUDTConcept
 - QuantificationUnit

Annotations: QuantifiableObject

Annotations: `rdfs:comment` [type: `rdfs:Literal`]

A component or a part of a design that can be quantified, as a whole or for some of its parts/aspects.

Description: QuantifiableObject

Equivalent To: `IfcElement`

SubClass Of: `QTONConcept`

General class axioms:

SubClass Of (Anonymous Ancestor):

- `tag_ifcElement max 1 IfcIdentifier`
- `tag_ifcElement only IfcIdentifier`
- `QuantifiableObject`

Instances: +

To use the reasoner click Reasoner > Start reasoner Show Inferences ⓘ

Construction Planning ontology

ConstructionPlanning (http://www.semanticweb.org/webuild/ontologies/2022/ConstructionPlanning)

Active ontology x Entities x Object properties x Data properties x Individuals by class x OntoGraf x

Class hierarchy: Activity

owl:Thing

- ConPlanConcept
 - Activity
 - ActivityLibraryItem
 - Calendar
 - CalendarFestivity
 - CalendarShift
 - Constraint
 - CostConstraint
 - EnvironmentConstraint
 - SafetyConstraint
 - TimeConstraint
 - ConstructionMethod
 - CriticalPath
 - Float
 - Lag
 - Milestone
 - PlanningRelationship
 - FinishToFinishRelationship
 - FinishToStartRelationship
 - StartToFinishRelationship
 - StartToStartRelationship
 - Resource
 - Equipment
 - LabourCrew
 - PlanningReferenceMaterial
 - Team
- DiConConcept
 - dicaConcept
 - LabourCrew
 - Team
 - diceConcept
 - diciConcept
 - dicmConcept
 - dicpConcept
- QTONConcept
 - BoQItem
 - PriceListItem

Annotations: Activity

Annotations +

- rdfs:label
- Activity
- rdfs:comment
- A process in a project that has to be planned in terms of time and resources.
- This class inherits the characterizations defined for the "Activity" object defined in DiCon (<https://digitalconstruction.github.io/Processes/M0.5/#Activity>); it is actually declared as a subclass of that concept and is in fact equivalent to an Activity that is planned in at least one "Plan" (see the "<https://w3id.org/digitalconstruction/0.5/Information#isPlannedActivityOf>" property).

Description: Activity

Equivalent To +

- Activity
- and (isPlannedActivityOf min 1 Plan)

SubClass Of +

- Activity
- ConPlanConcept

General class axioms +

SubClass Of (Anonymous Ancestor)

Instances +

Target for Key +

Data integration and reuse

The screenshot displays a software interface for estimating and BIM management. The main window is titled 'Estimating' and shows a list of items with columns for 'Progr.', 'Type', 'Entry...', 'Item', 'Short', 'UM code', 'UM descr.', 'Quantity', 'Lump.', and 'Lumpsum UM...'. The item 'Béton pour paroi moulée y compris joi...' is highlighted in blue.

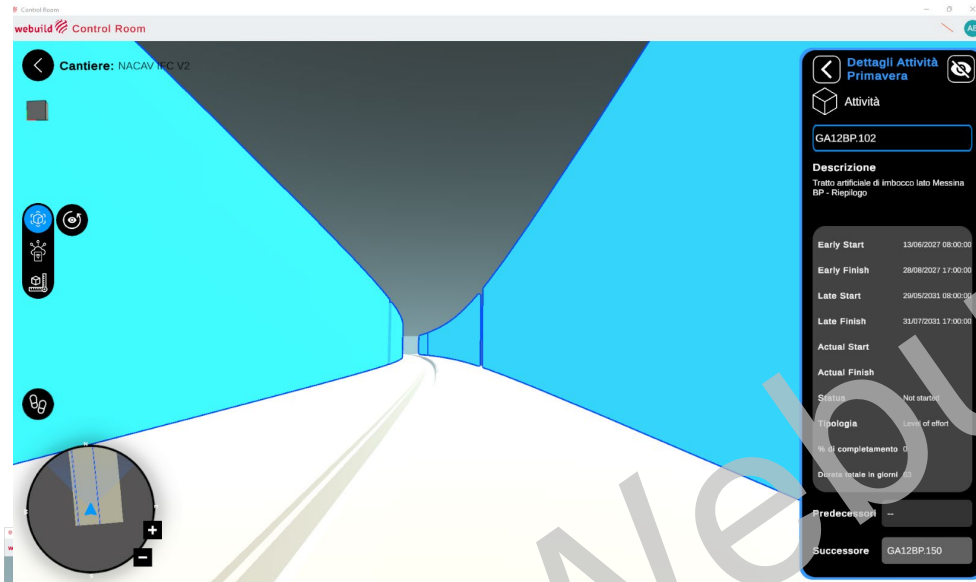
Progr.	Type	Entry...	Item	Short	UM code	UM descr.	Quantity	Lump.	Lumpsum UM...
20	Misura	Fattori	TRC.GC.TR...	Amenée et remplissage du matériel de ...	ens		0,00		
30	Misura	Fattori	TRC.GC.TR...	Amenée et remplissage station de boue	ens		0,00		
40	Misura	Fattori	TRC.GC.TR...	Réalisation des doubles murettes gui...	ml de pa...		129,76		
50	Misura	Fattori	TRC.GC.TR...	Forage pour parois moulées	M2	m²	0,00		
60	Misura	Fattori	TRC.GC.TR...	Evacuation et mise en dépôt des debli...	M3	m³	0,00		
70	Misura	Fattori	TRC.GC.TR...	Béton pour paroi moulée y compris joi...	M3	m³	9,354,04		
80	Misura	Fattori	TRC.GC.TR...	Armature en cage pour parois moulées...	KG	kg	0,00		
90	Misura	Fattori	TRC.GC.TR...	Recépage des parois moulées	ml		74,46		
100	Misura	Fattori	TRC.GC.TR...	Démolition des doubles murettes guid...	ml de pa...		129,76		
110	Misura	Fattori	TRC.GC.TR...	Rabotage de parois moulées par frai...	M2	m²	0,00		
120	Misura	Fattori	TRC.GC.TR...	Poutre de couronnement en tête de ...	ml		0,00		
130	Misura	Fattori	TRC.GC.TR...	Sujétions pour traversée tunnelier au...	U		0,00		
140	Misura	Fattori	TRC.GC.TR...	Démolition des parois moulées provis...	M3	m³	737,08		
150	Misura	Fattori	TRC.GC.TR...	Mise en station (après implantation)	U		0,00		
160	Misura	Fattori	TRC.GC.TR...	Forage	M2	m²	0,00		
170	Misura	Fattori	TRC.GC.TR...	Béton armé pour préfondés (y compris...	M3	m³	1.400,16		
180	Misura	Fattori	TRC.GC.TR...	Remplissage provisoire en grave	M3	m³	379,28		
190	Misura	Fattori	TRC.GC.TR...	Profils métalliques (y compris sujétio...	KG	kg	59.149,12		
200	Misura	Fattori	TRC.GC.TR...	Démolition des préfondés provisoires	ens		0,00		
210	Misura	Fattori	TRC.GC.TR...	Terrassement en tranchée	M3	m³	60.000,00		
220	Misura	Fattori	TRC.GC.TR...	Plus-value pour terrassement en tran...	M3	m³	0,00		
230	Misura	Fattori	TRC.GC.TR...	Plus valeur pour terrassement de 20 à...	M3	m³	0,00		
240	Misura	Fattori	TRC.GC.TR...	Plus valeur pour terrassement au-delà...	M3	m³	0,00		
250	Misura	Fattori	TRC.GC.TR...	Epousillage des fouilles (c. taxes de r...	M3	m³	0,00		
260	Misura	Fattori	TRC.GC.TR...	Béton de propreté	M2	m²	2.000,00		
270	Misura	Fattori	TRC.GC.TR...	Béton de remplissage	M3	m³	1.586,86		

Below the table, there are summary statistics: Page size 26 - 6/244, Amount: 0,00 | Cost Amount: 0,00 | Bid Amount: 0,00. A 'Measures' tab is active, showing a table with columns: Comment, Similar, Length, Width, Height, Total.

Comment	Similar	Length	Width	Height	Total
→ 1 Muro di base:IGC_Mur_ep150cm_béton_Paroi...		6,693,36			6.693,36
2 Muro di base:IGC_Mur_ep150cm_béton_Paroi...		434,51			434,51
3 Muro di base:IGC_Mur_ep150cm_béton_Paroi...		443,08			443,08
4 parois moulées SUD:parois moulées SUD:4245174		206,85			206,85
5 Muro di base:IGC_Mur_ep150cm_béton_Paroi...		279,60			279,60
6 Muro di base:IGC_Mur_ep150cm_béton_Paroi...		286,91			286,91

On the right, a 'BIMViewer' window shows a 3D model of a cylindrical structure with internal reinforcement. A 'Tools' panel is visible with a list of items: Code, Description, IFF_00, PN1206-1_4, IFF_01, PN1206-1_4, IFF_02, PN1206-1_4, IFF_03, PN1206-1_4, IFF_04, PN1206-1_4, IFF_05, PN1206-1_4.

Data fruition in VR



Conclusions and future developments



- LD implementation in a general contractor is difficult but a modular approach is a key for success
- Value is not only in the resulting knowledge base but also in the process of creation
- LD can overcome difficulties of top-down standardization
- LD is perceived as critical for the ongoing automation processes in the construction industry (project monitoring, reporting, and execution of tasks)



- Extension of the knowledge base to sustainability and materials handling
- Integration with Digital Twin ontologies
- Development of platforms integrations with the Enterprise Datalake

Thank you

Webuild

webuild 