PERFORMANCE ASSESSMENT OF THE PORTUGUESE AECO SECTOR BASED ON BIG DATA MANAGEMENT

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CONTENTS

1. Introduction

- LNEC has been establishing a research priority to address performance assessment for the Portuguese AECO sector based on Big Data management
- Main research topics:

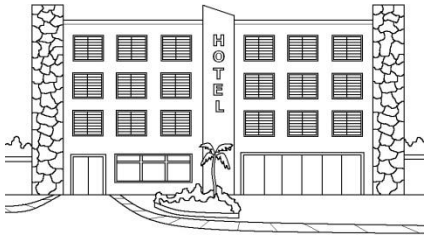
1. Investment decision support
2. Integrated management and building operation and maintenance
3. BIM and digital transformation
4. Life cycle cost assessment and circular economy

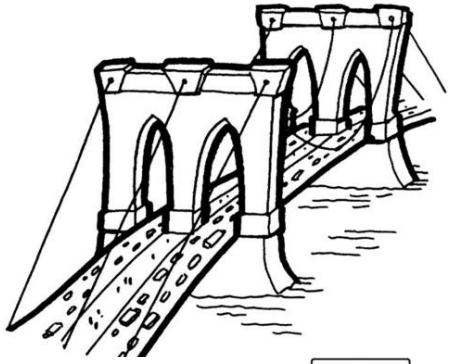
CONTENTS

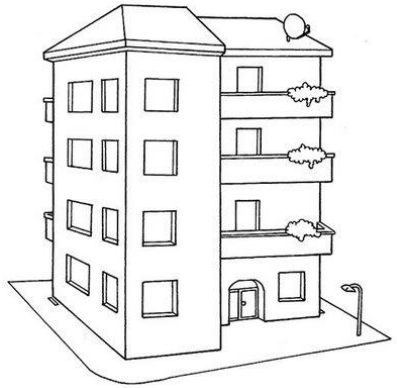
2. Investment Decision Support

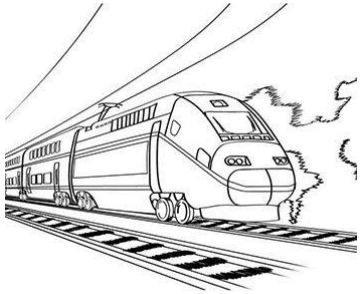
- European Union (EU) has been setting targets and policies to reduce AECO sector impacts;
- EU goals has led to a tendency to increase the useful life of the existing buildings by opting for rehabilitation and maintenance, rather than opting for new construction;
- In order to contribute to the alignment of the AECO sector with the millennium goals of sustainable development of UNESCO, namely with regard to sustainable cities and communities (Objective 11), the focus on the rehabilitation of the built heritage is urgent, based on feasibility studies covering several areas, namely: technical, financial, economic, environmental, social and cultural;
- CBA, MA and CEA methodologies can contribute to decision support on investment projects.

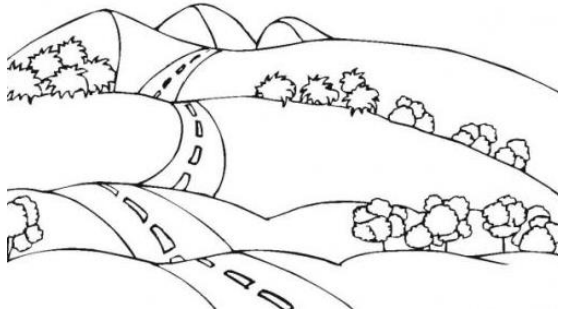
2. Investment Decision Support

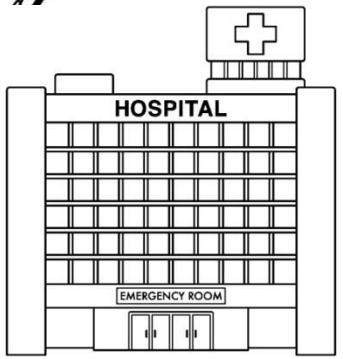


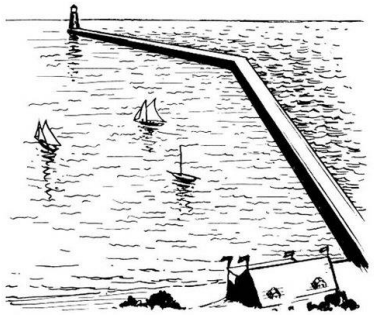


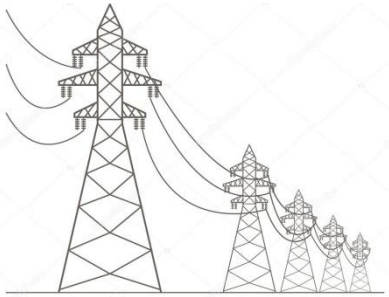


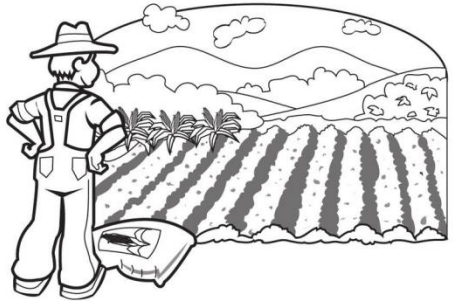






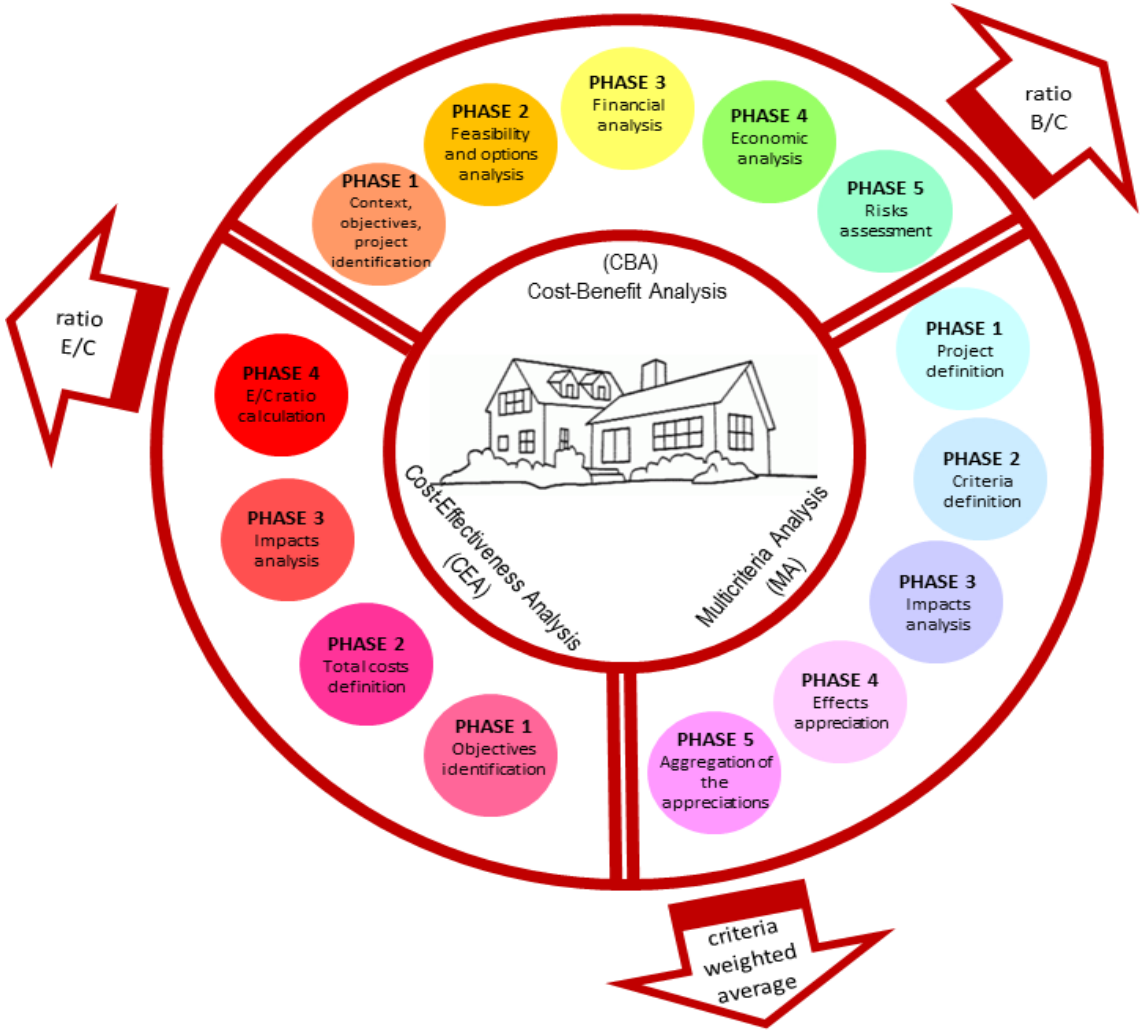






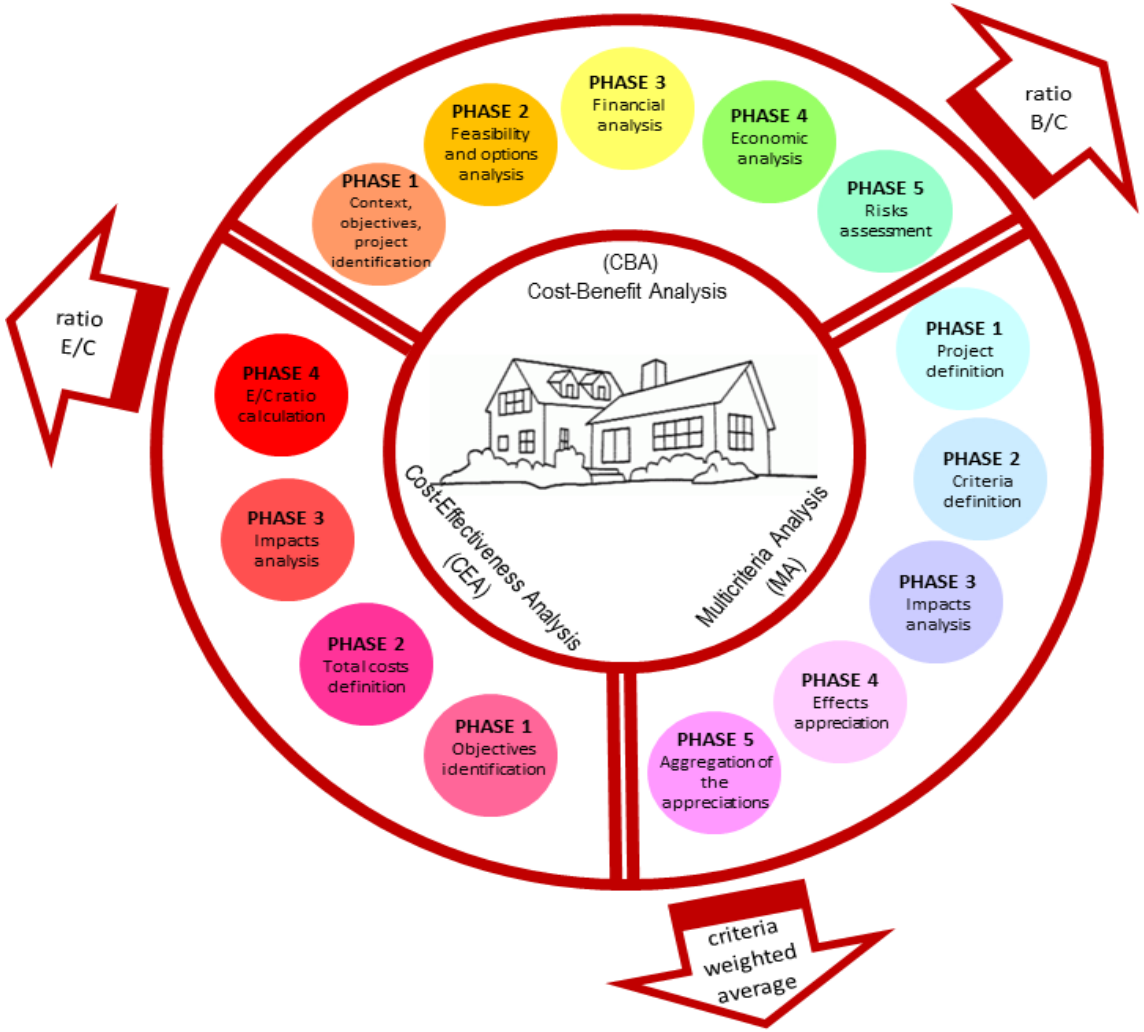
2. Investment Decision Support

- Cost-benefit analysis (CBA)
- Multicriteria analysis (MA)
- Cost-effectiveness analysis (CEA)



2. Investment Decision Support

- **Cost-benefit analysis (CBA)**
- Multicriteria analysis
- Cost-effectiveness analysis



2. Investment Decision Support

Cost-benefit analysis (CBA) is used by governments and other organizations, such as private sector companies, to assess the desirability of a policy or investment. It translates a comparative analysis between the expected benefits and costs, also considering the lost alternatives and the situation in which the status quo is maintained, ranking the studied alternatives in terms of cost-benefit ratio.

2. Investment Decision Support

- Cost-benefit analysis – New construction and rehabilitation interventions

Architectural heritage

School buildings

Waste water treatment plant

Health infrastructures

Habitational buildings

Industrial heritage

waste treatment facilities

2. Investment Decision Support

- Cost-benefit analysis – Economic indicators

Useful in the implementation of CBA for future projects, contributing to:

1 - Structuring of information;

2 - Improving the accuracy and quality of information;

3 - Reduction of uncertainties and errors;

4 - Streamlining access to information;

5 - Greater efficiency in supporting the stakeholder involved in the decision-making process.

2. Investment Decision Support

- Cost-benefit analysis – Economic indicators

Structures in three levels (depending on the project):

- General nature (GN)

  cost / m^2; cost / visitor (architectural heritage); cost / student and area / student (school buildings); cost / patient, cost / bed and area / patient (health infrastructures); cost / ton of waste treated (waste treatment) …

- Intermediate nature (IN)

  cost /m^2 of building and outdoor space rehabilitation; outdoor space area / visitor (architectural heritage); outdoor space area / student (school buildings); outdoor space area / patient (only for health infrastructures), …

- Specific nature (SN):

  costs of different design projects (Architecture, Structures, MEP…); costs of different technical solutions; technical characteristics of the different adopted solutions, …

2. Investment Decision Support

- Cost-benefit analysis – Economic indicators

	CBA Phase	Indicator Type			Contribution
		GN	IN	SN	
Project identification	1	x	x		Quantification of project social effects
Feasability	2			x	Implementation of design specialities
Financial analysis	3	x	x	x	Forecasting of project cash-flows
Economic analysis	4	x	x		Correction of externalities
Risks assessment	5	x	x	x	Optimization of performance indicators and analysis of alternatives

2. Investment Decision Support

- Cost-benefit analysis – Externalities (Positive)

Social benefits

- Possible creation of complementary activities to the existing one and more diversified job offer (if the intervention corresponds to a change of functionality)
- Increased job offer as well as individual and community productivity
- Improving the health and well-being of infrastructure users
- Increase of income in the tourism sector in the area of intervention, as well as the possible additional increase of income of other complementary activities in the area (commerce, restaurants, leisure activities, etc.)
- …

Environmental benefits

- Greater willingness to pay
- Long-term marginal costs (possible reduction of energy consumption after intervention)
- Shadow fees and salaries (benefits arising from changes in productivity)
- Frontier prices (marketable benefits notably carbon certificates, representative of improved air quality after intervention)
- …

2. Investment Decision Support

- Cost-benefit analysis – Externalities (Negative)

Social costs

- Loss to society as a result of the diversion of inputs (used raw materials and / or land where the project investment is incorporated) from better alternative uses
- Cost of social opportunity for staff employed in the structure under intervention may be performing their duties in the most economically advantageous occupations
- Possible loss of mobility and traffic congestion during the construction and/or rehabilitation phase
- …

Environmental costs

- Increased pollution of soil, water and air
- Recovery treatment of potentially contaminated areas
- Recycling of materials used in the intervention with the purpose of extending its life cycle
- Labor considered in the control and preservation activities of the surrounding environment
- Restoration of the areas where the structure under intervention is located and which are degraded;
- Maintenance of the characteristics of the territorial surroundings in which the structure to be constructed and/or rehabilitated is placed
- …

2. Investment Decision Support

- Cost-benefit analysis – CBA ratio (B/C)

Ratio between net present value of project benefits and net present value of project costs. The goal, for investment projects, is to take more than 1

$$B/C = \frac{\sum_{t=0}^{n} \rho_t B_t}{\sum_{t=0}^{n} \rho_t C_t}$$

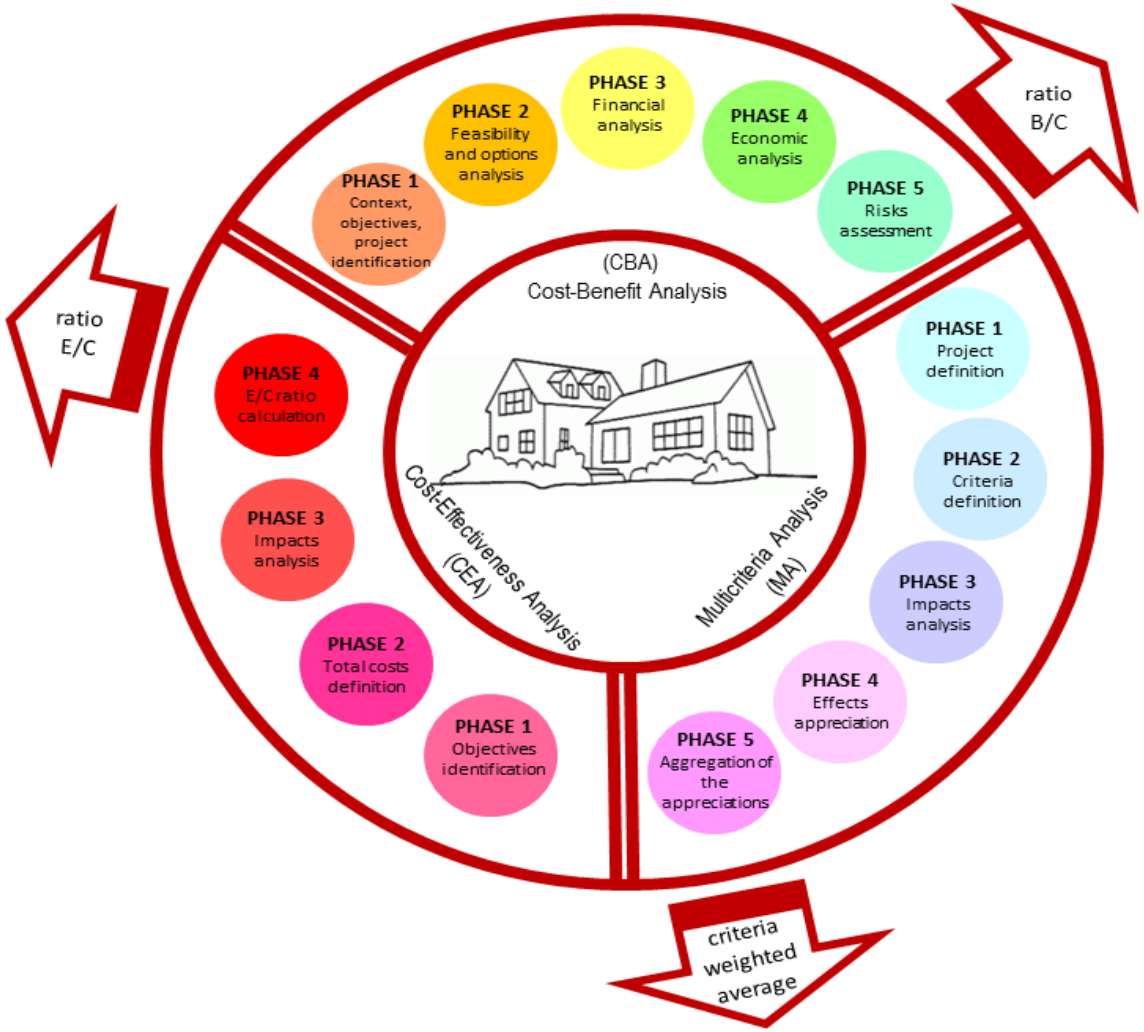
B is the total flow of benefits at time t, C is the total flow of social costs at time t, ρt is the social update factor chosen for the update at time t; r is the social refresh rate.

2. Investment Decision Support

✓ Cost-benefit analysis

- **Multicriteria analysis (MA)**

- Cost-effectiveness analysis



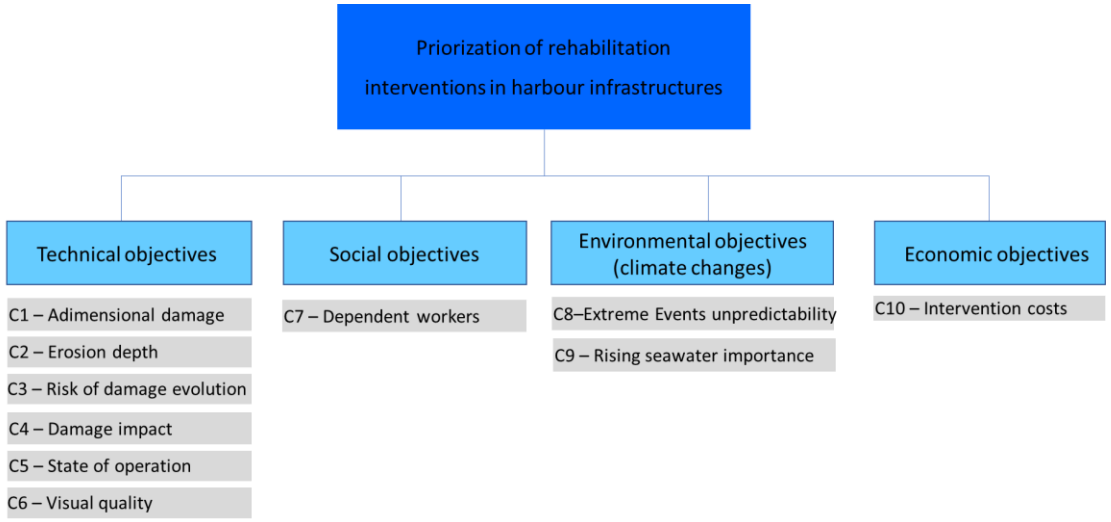
2. Investment Decision Support

Multicriteria analysis (MA) is applied in comparative analysis of alternative designs or heterogeneous measures in complex situations, considering several criteria simultaneously. It integrates different options in the actions to be taken by decision makers, reflecting the opinions or interests of the different actors involved. The results obtained are guiding operational decisions or recommendations for future activities.

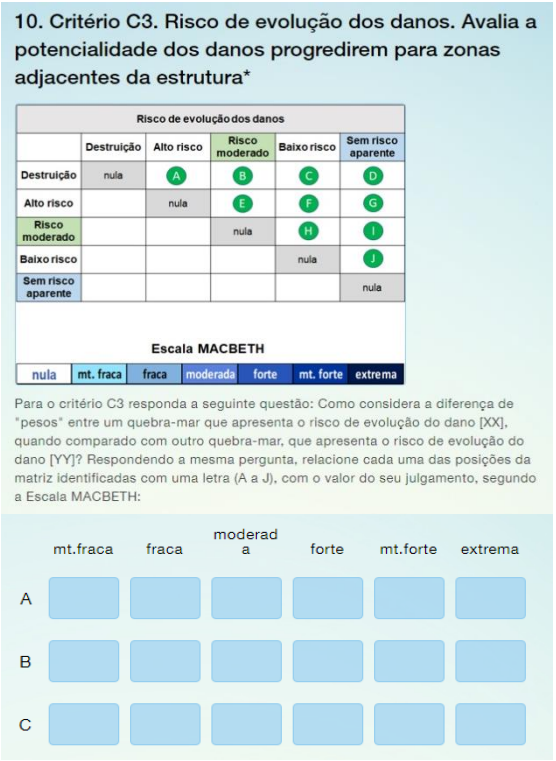
2. Investment Decision Support

- Multicriteria analysis – New construction and rehabilitation interventions

Harbour infrastructures



Value tree



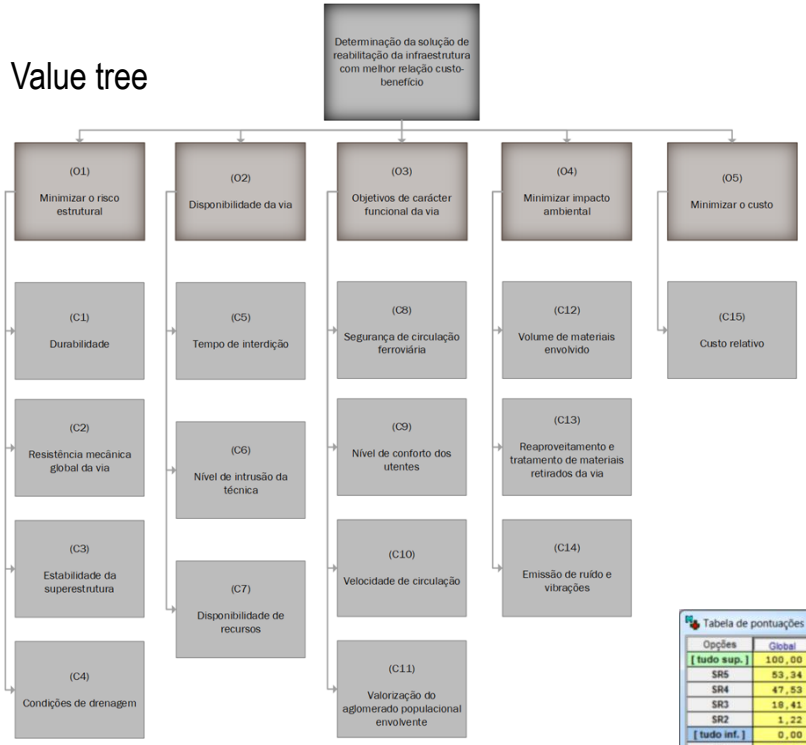
Performance level – Eletronic inquiry

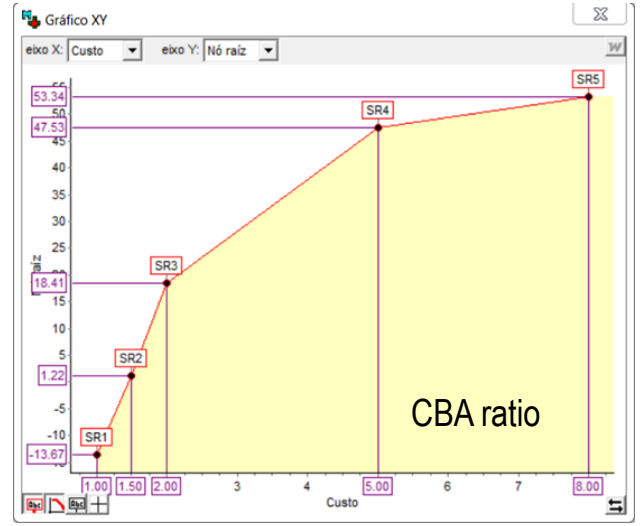
2. Investment Decision Support

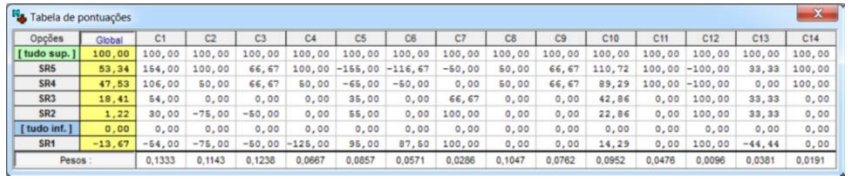
- Multicriteria analysis – New construction and rehabilitation interventions

Railway infrastructures

Value tree







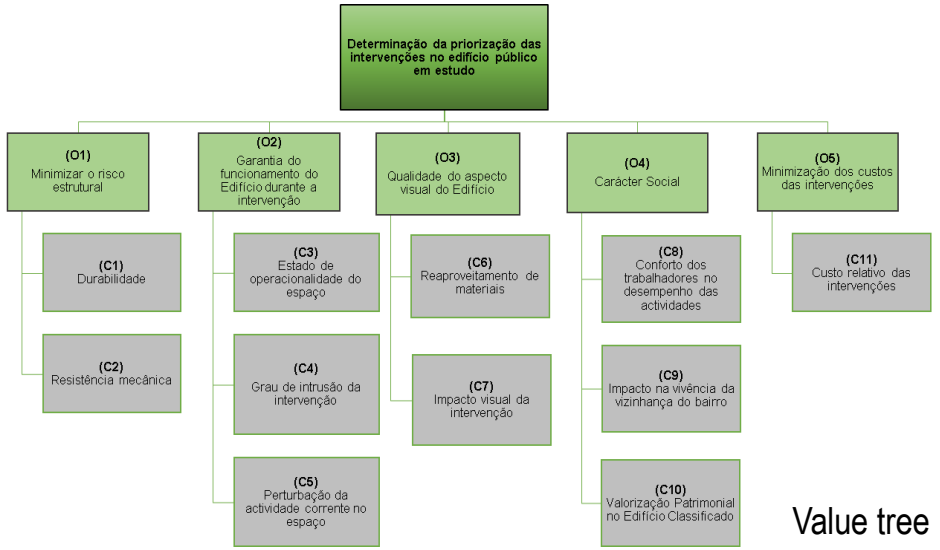
Opções	Global	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14
[tudo sup.]	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00
SR5	53,34	154,00	100,00	66,67	100,00	-155,00	-116,67	-50,00	50,00	66,67	110,72	100,00	-100,00	33,33	100,00
SR4	47,53	106,00	50,00	66,67	50,00	-65,00	-50,00	0,00	50,00	66,67	89,29	100,00	-100,00	0,00	100,00
SR3	18,41	54,00	0,00	0,00	0,00	35,00	0,00	66,67	0,00	0,00	42,86	0,00	100,00	33,33	0,00
SR2	1,22	30,00	-75,00	-50,00	0,00	55,00	0,00	100,00	0,00	0,00	22,86	0,00	100,00	33,33	0,00
[tudo inf.]	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
SR1	-13,67	-54,00	-75,00	-50,00	-125,00	95,00	87,50	100,00	0,00	0,00	14,29	0,00	100,00	-44,44	0,00
Pesos :		0,1333	0,1143	0,1238	0,0667	0,0857	0,0571	0,0286	0,1047	0,0762	0,0952	0,0476	0,0096	0,0381	0,0191

Global scores

2. Investment Decision Support

- Multicriteria analysis – New construction and rehabilitation interventions

Public buildings



Value tree

C1 - Durability (unid.: years)					
	Muito elevada	High	Medium	Low	Very low
Very high	**null**				
High	-	**null**			
Medium	-	-	**null**		
Low	-	-	-	**null**	
Very low	-	-	-	-	**null**

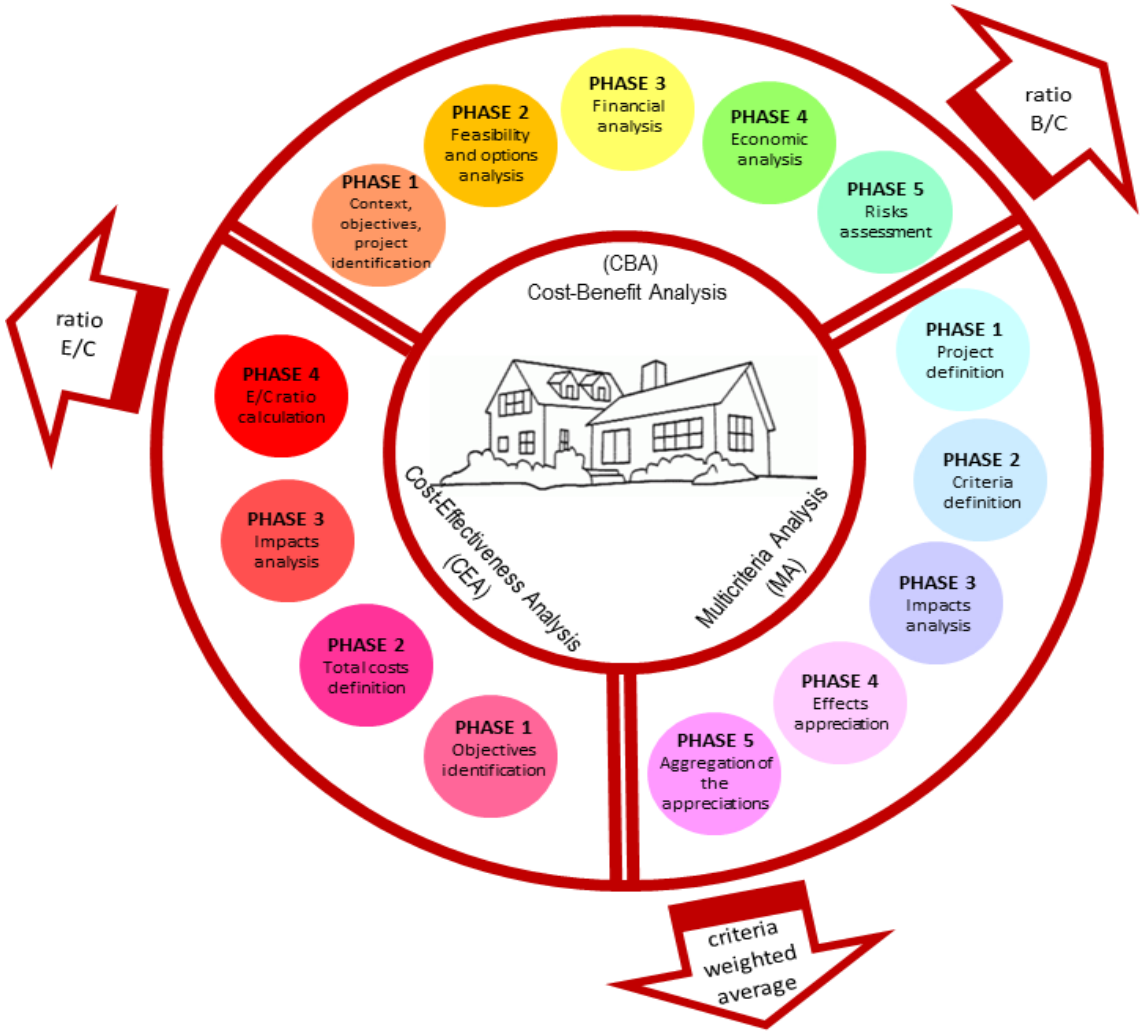
Performance level

2. Investment Decision Support

✓ Cost-benefit analysis

✓ Multicriteria analysis

- **Cost-effectiveness analysis (CEA)**



2. Investment Decision Support

Cost-effectiveness analysis (CEA) contributes to the efficient application of resources and investments in sectors where benefits are hard to quantify in monetary terms and can be quantified in terms of a physical accounting unit. The analysis tends to focus on direct results obtained in the short and medium term, usually ignoring the longer-term effects. CEA can only be applied to compare programs that are simple to implement and whose impact is similar.

CONTENTS

3. Integrated Management and Building Operation and Maintenance

- Constructed assets, over their life-cycle, demand for a considerable amount of resources and trigger transformations with important economic consequences
- The management of the built environment has to be primed by the needs of their stakeholders. Management activities are closely related and must integrate those that have been mapped by:
  - Asset management
  - Project management
  - Program and portfolio management
  - Facility management
  - Risk management
- All of them depend on accurate Big Data of the building lifecycle
- These activities require the support of Data Management solutions/approaches

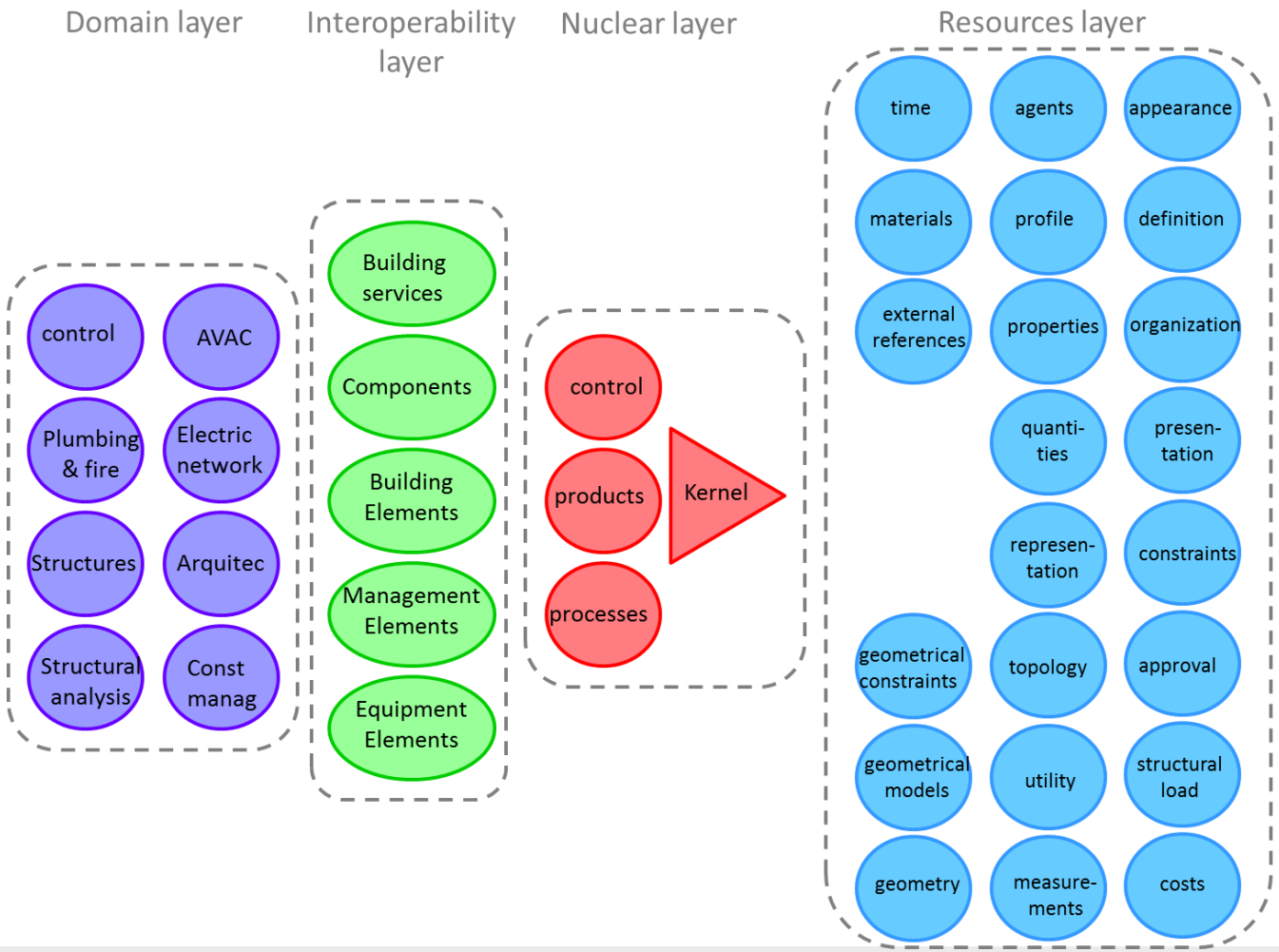
CONTENTS

4. BIM and Digital Transformation

- BIM has become more common throughout all phases of the building life cycle;
- Several problems have occurred
  (loss of data, communication problems, and poor work efficiency);
- Requirement to enrich BIM models with Big Data is a challenge
  (data interoperability and integration);
- The Industry Foundation Classes (IFC) includes the formal definitions of modeling entities – The modeling entities correspond to hierarchically organized types of Big Data characterized by attributes and constraints.

4. BIM and Digital Transformation

IFC model organization

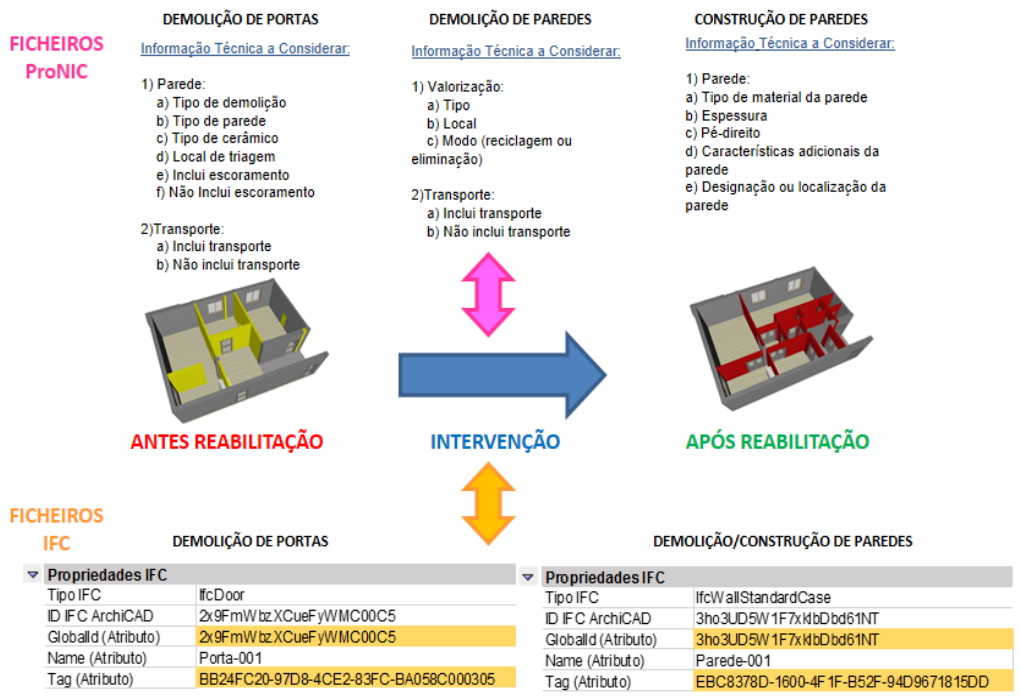


4. BIM and Digital Transformation

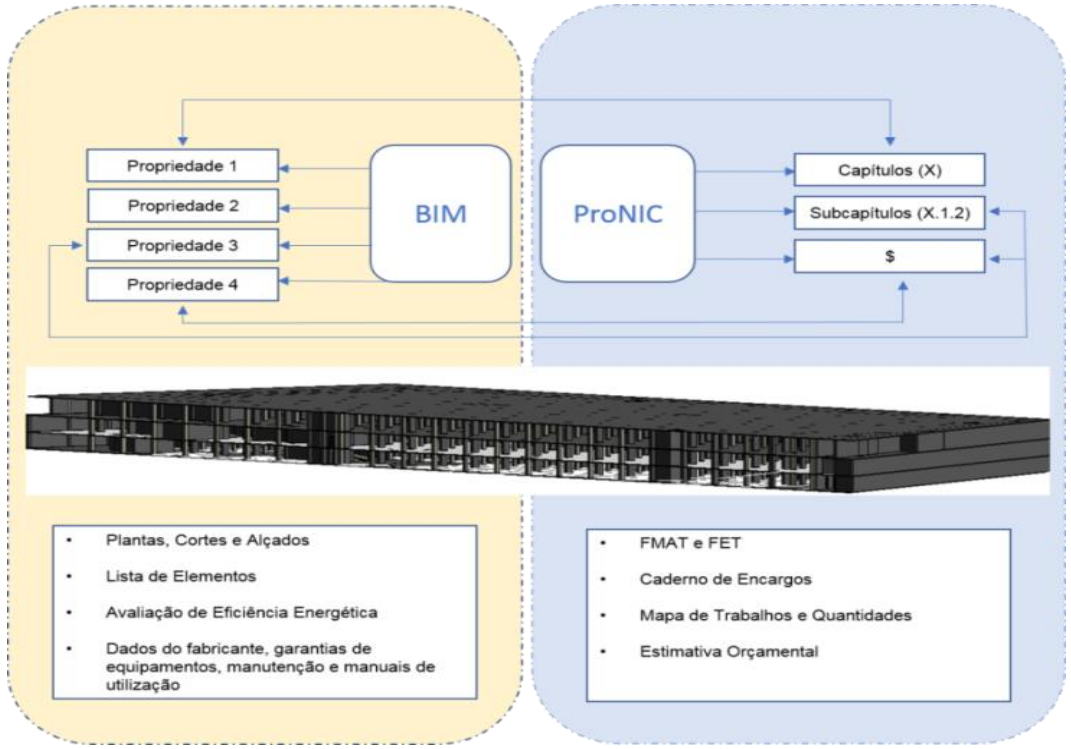
- Interoperability is simplified by the implementation and adoption of standards, such as the IFC data model;
- Scenarios where valuable Big Data is managed by external data sources (e.g. materials catalog) should be integrated to extend and enrich BIM models. Addressed by Extraction-Transformation-Loading (ETL) processes;
- This integration involves two main challenges:
  1. Syntactic interoperability, understanding all representation schemas and formats to ensure that multiple and heterogeneous data sources can be integrated;
  2. Semantic interoperability, providing the ability to identify the same concept (real entity) in distinct representations, making it possible map information that is represented in a specific data source to the corresponding Big Data that can extend this concept.

4. BIM and Digital Transformation

- Interoperability in BIM



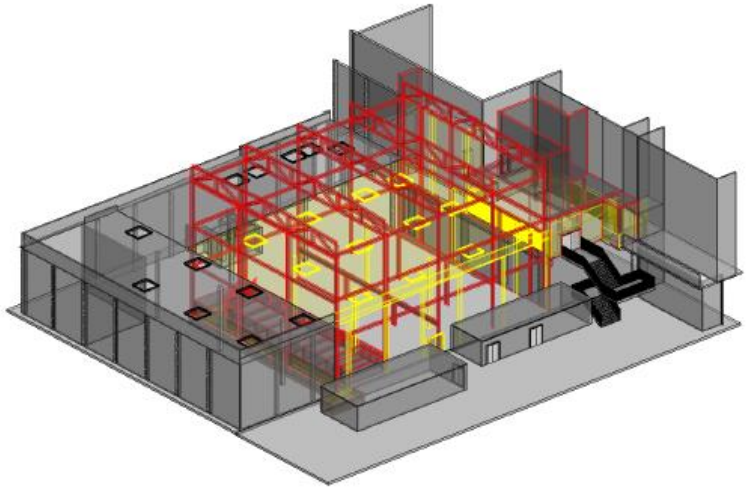
Architecture design specifications

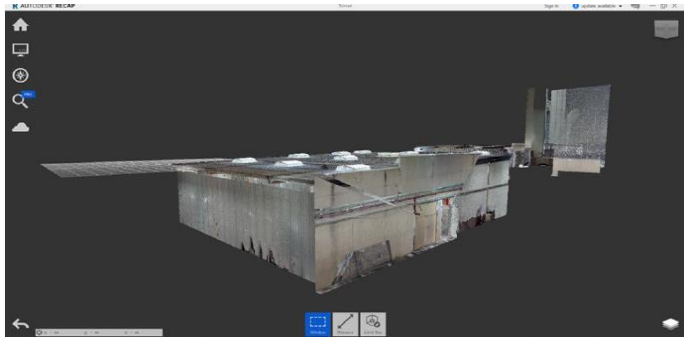


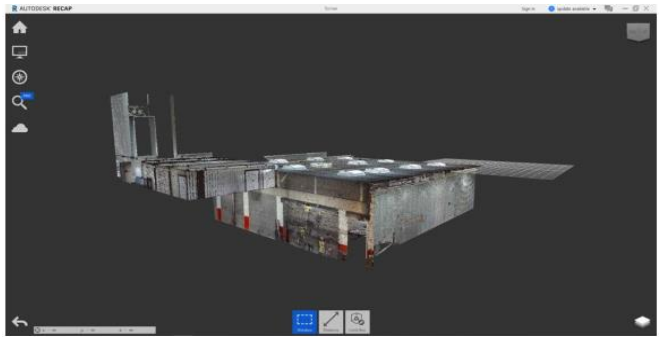
Fire network design specifications

4. BIM and Digital Transformation

- BIM and Laser scaning

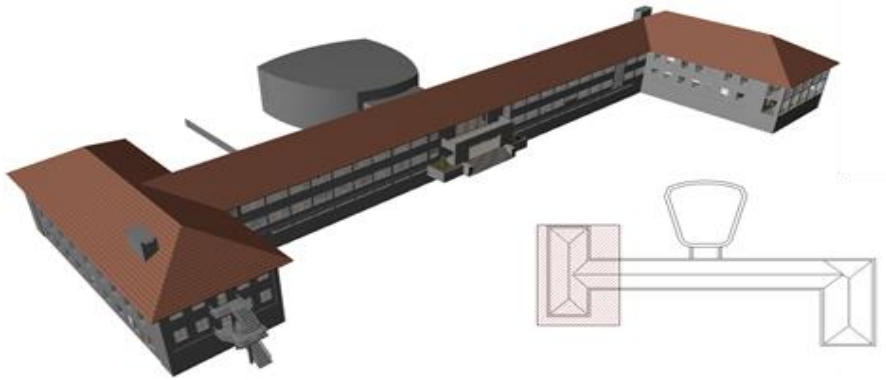


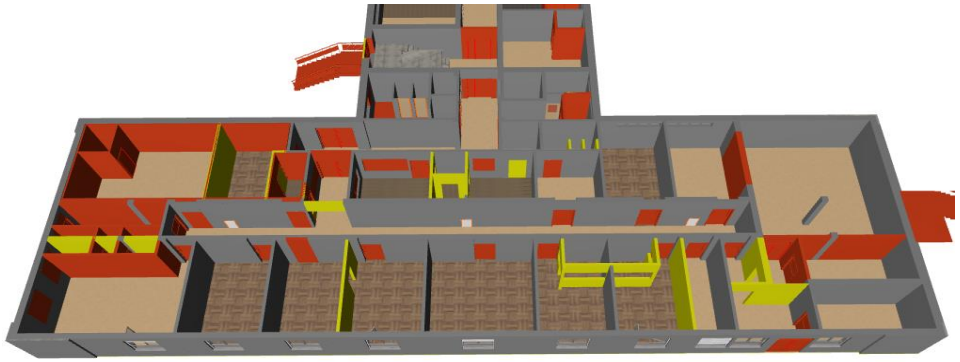




4. BIM and Digital Transformation

- BIM in rehabilitation (Architecture)



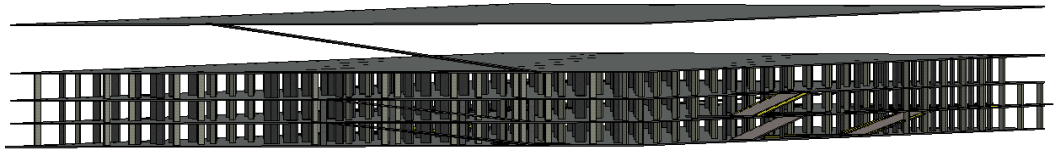


Before

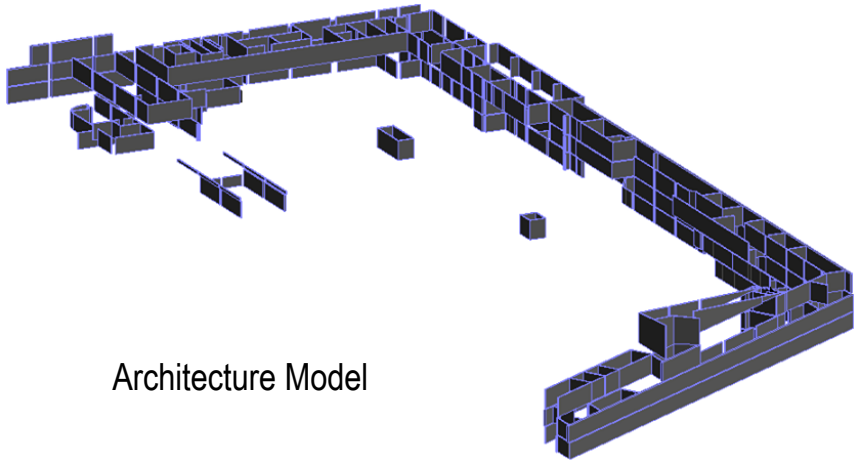
After

4. BIM and Digital Transformation

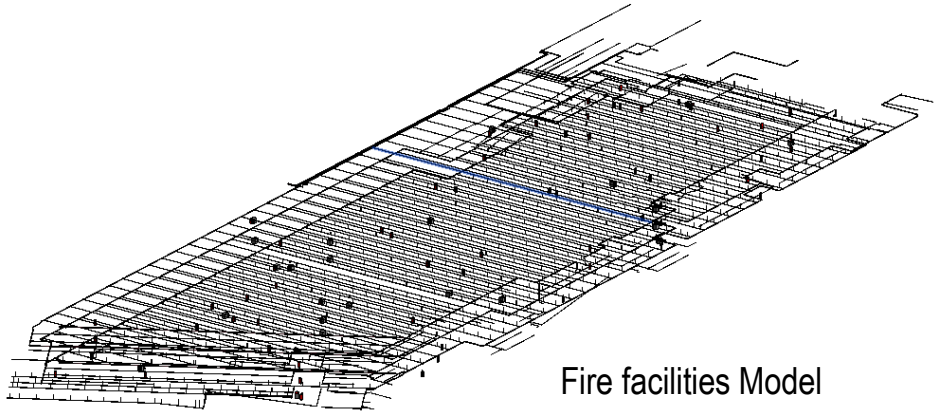
- BIM in rehabilitation (MEP - Fire)



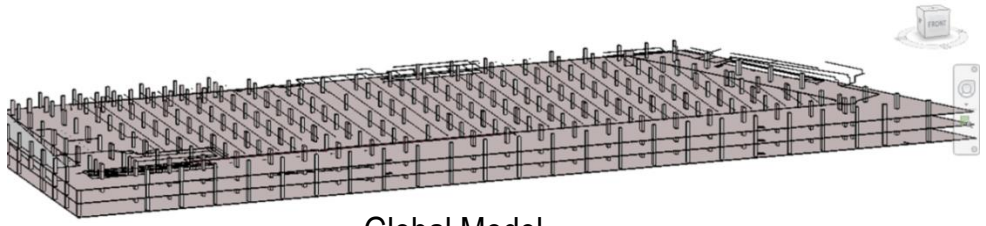
Structural Model



Architecture Model



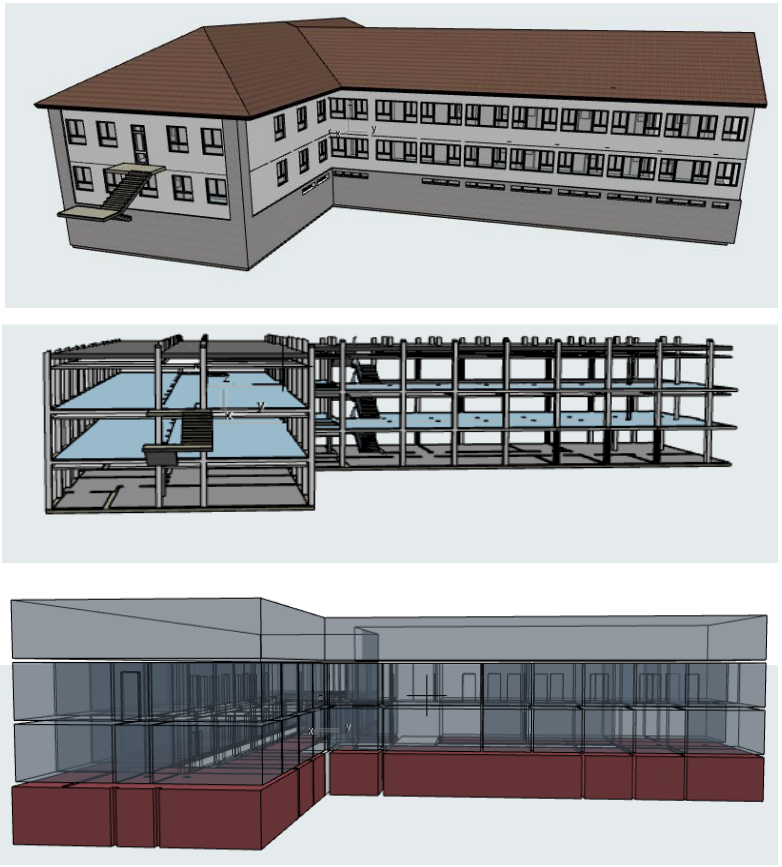
Fire facilities Model

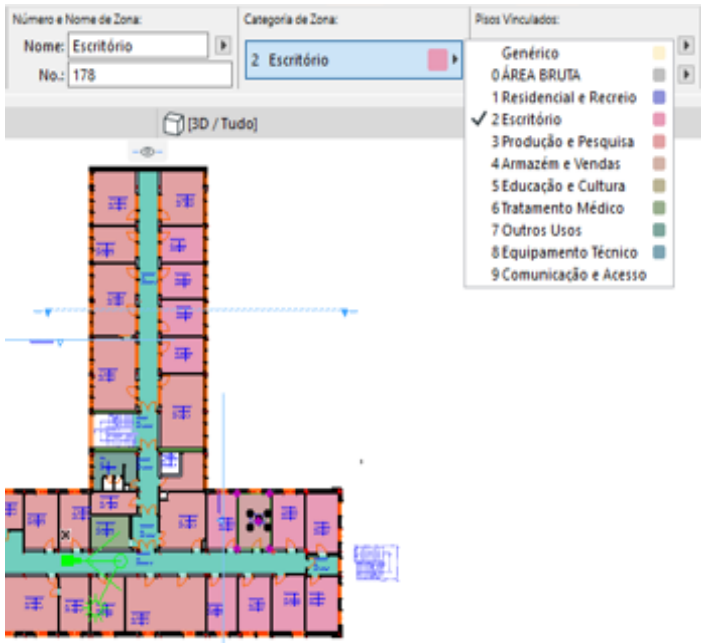


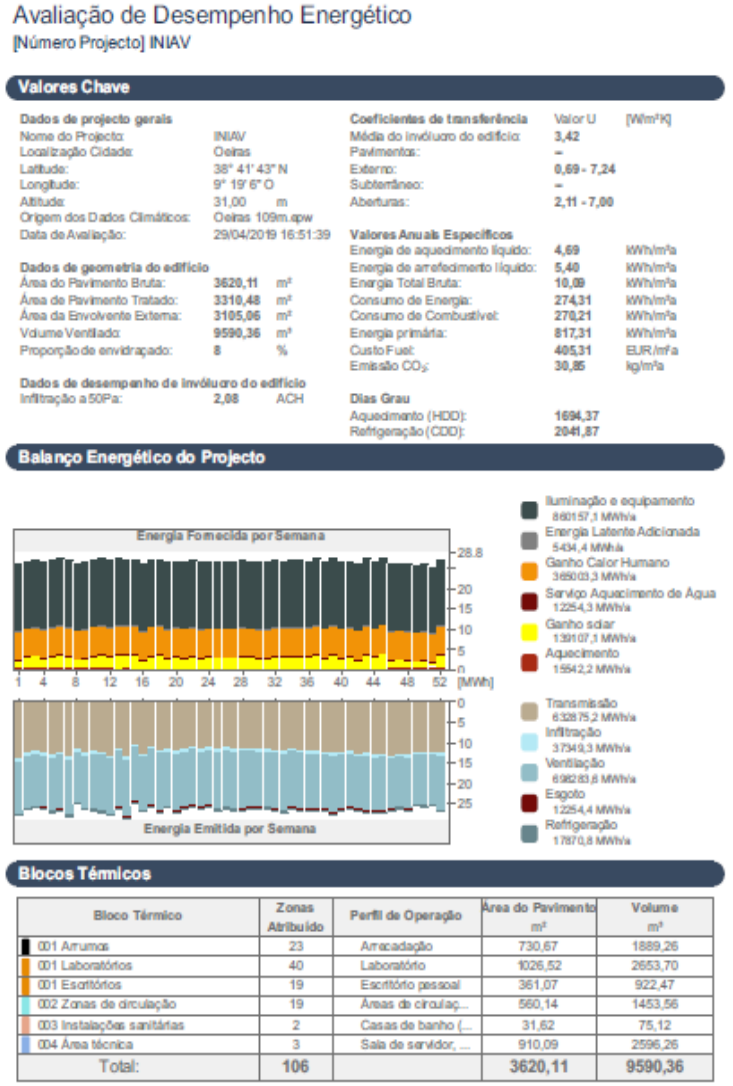
Global Model

4. BIM and Digital Transformation

- BIM in rehabilitation (Energy efficiency)

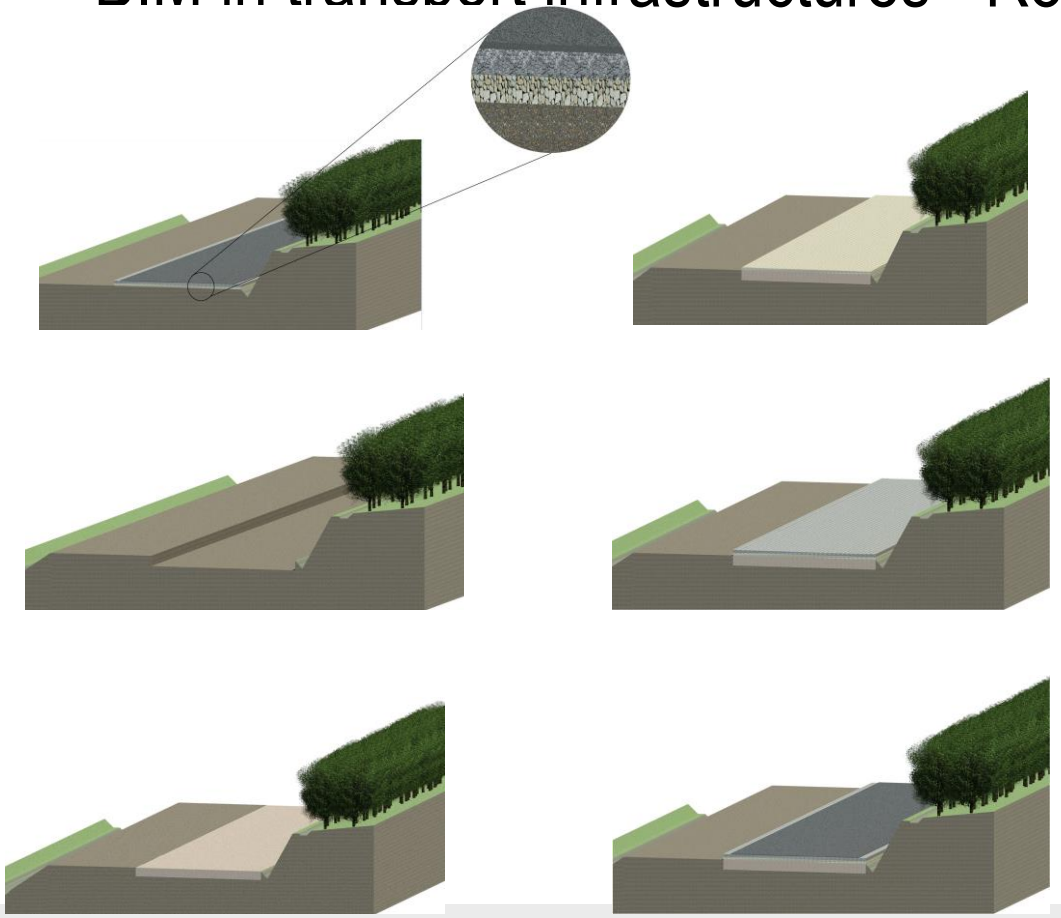


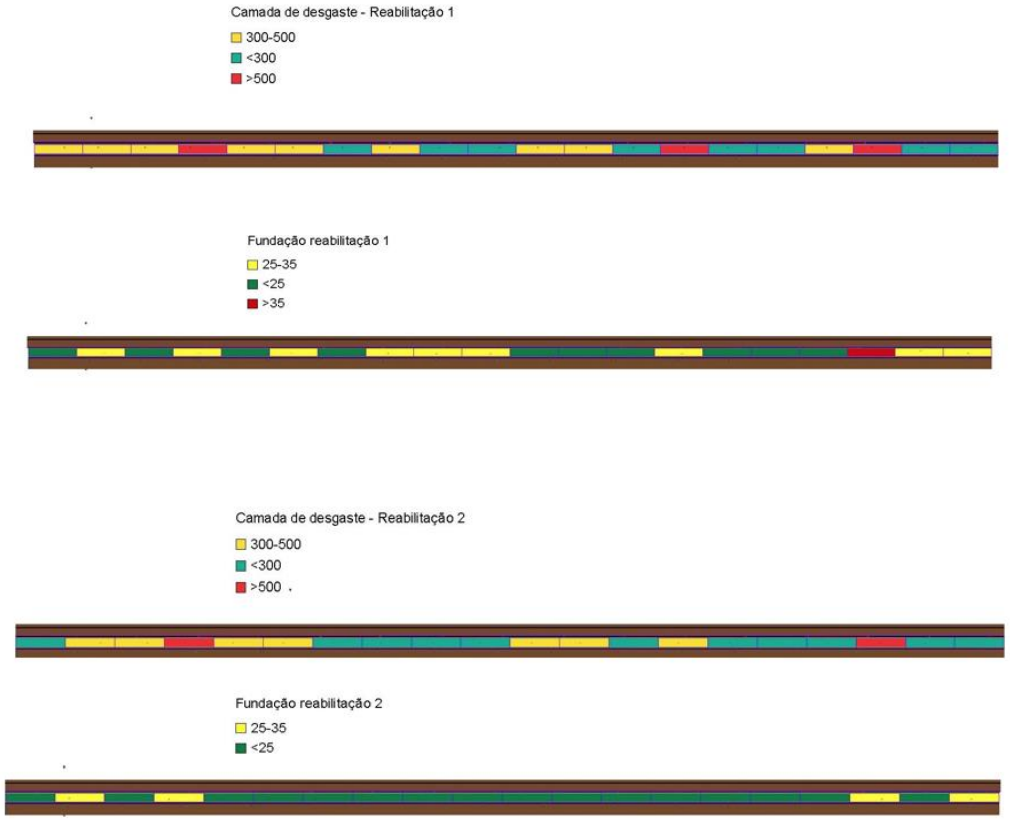




4. BIM and Digital Transformation

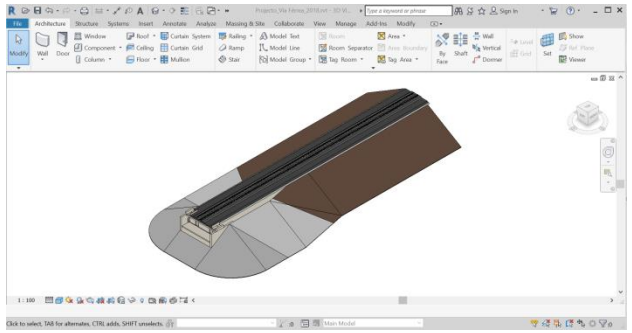
- BIM in transport infrastructures - Roads

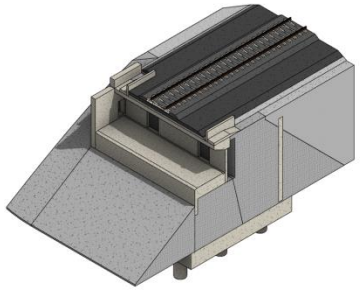


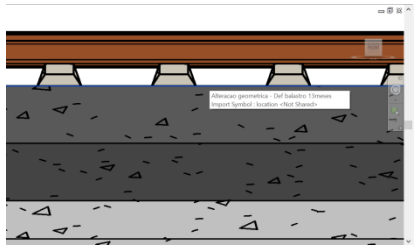


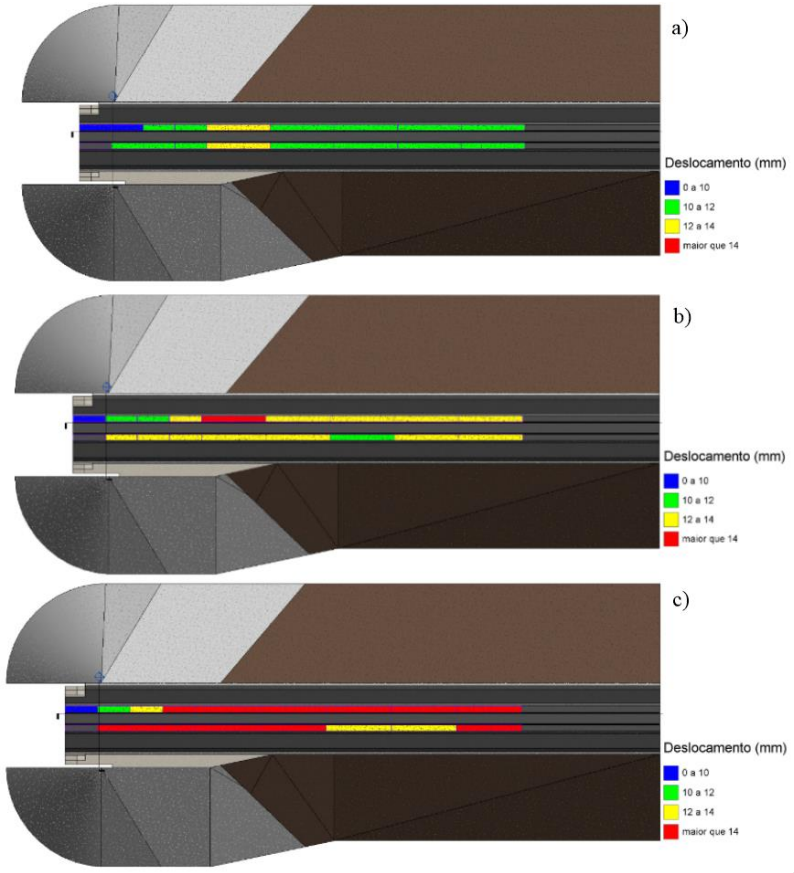
4. BIM and Digital Transformation

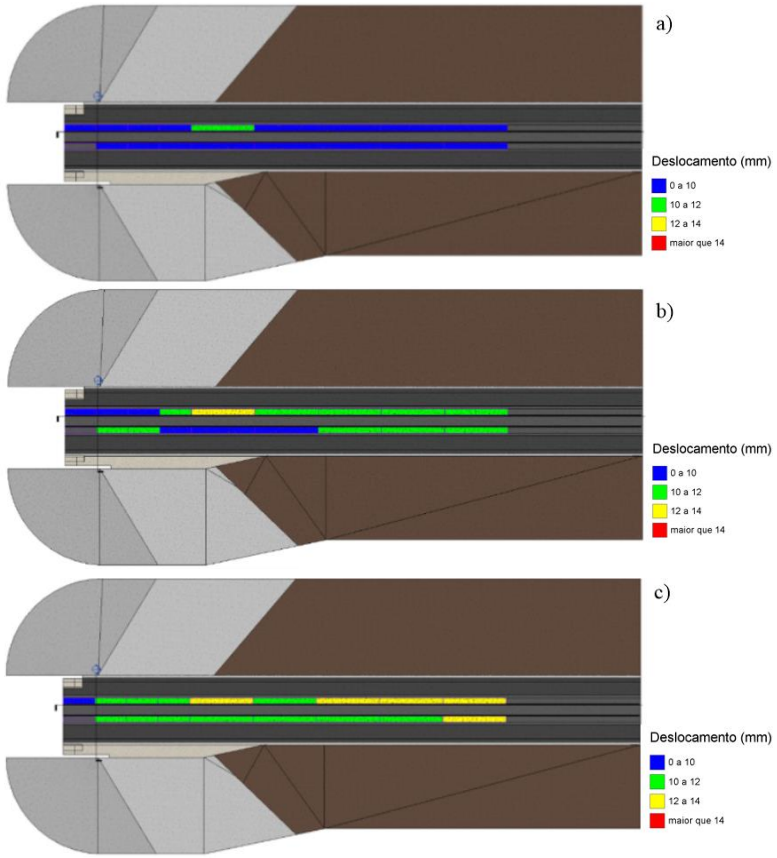
- BIM in transport infrastructures - Railways





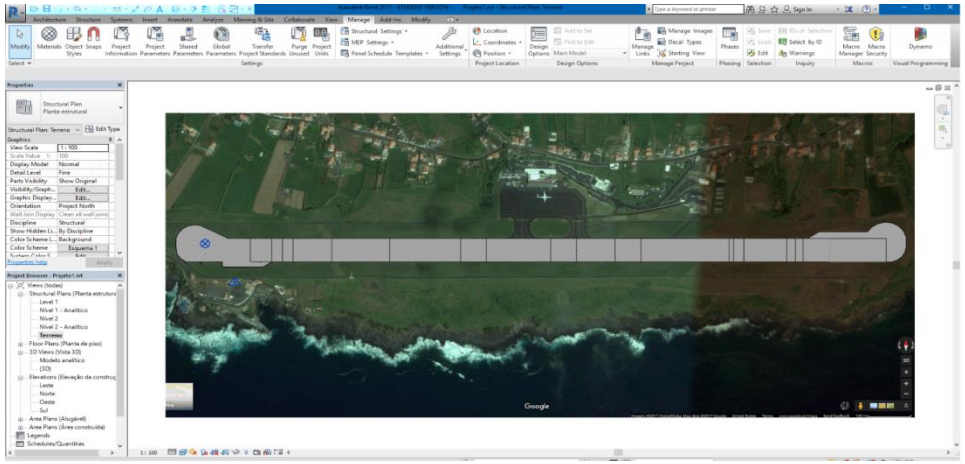


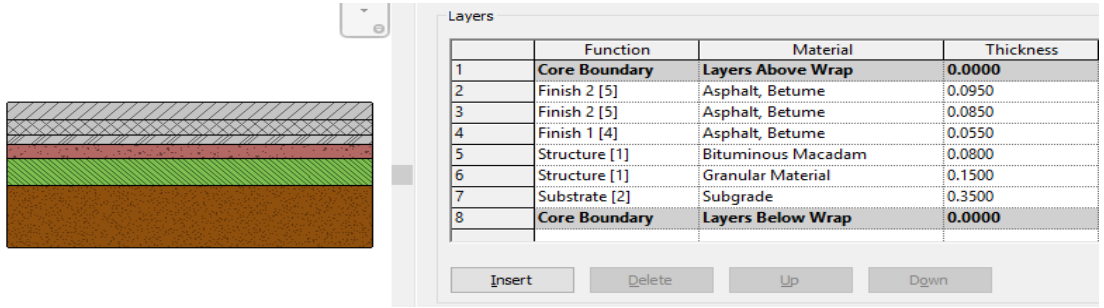


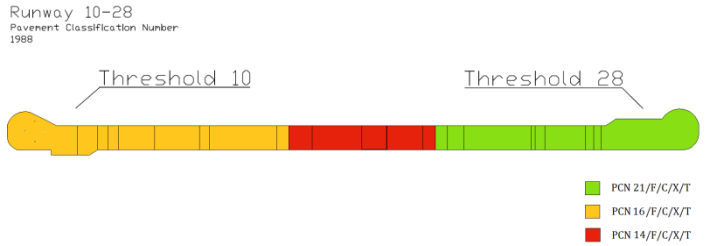


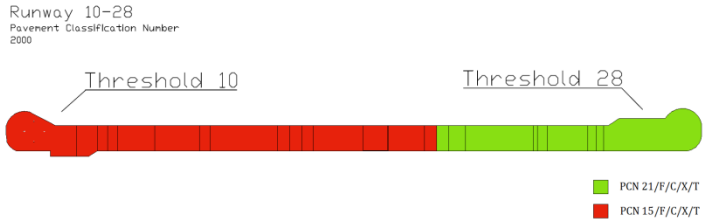
4. BIM and Digital Transformation

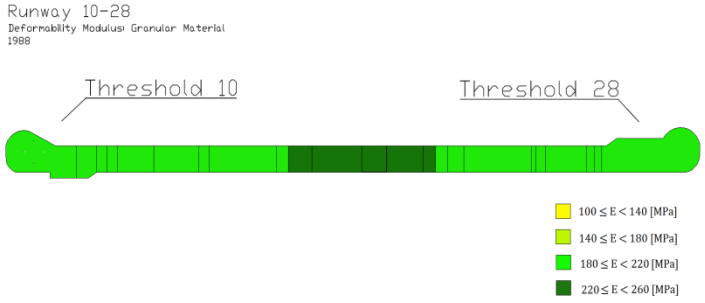
- BIM in transport infrastructures – Airport pavements





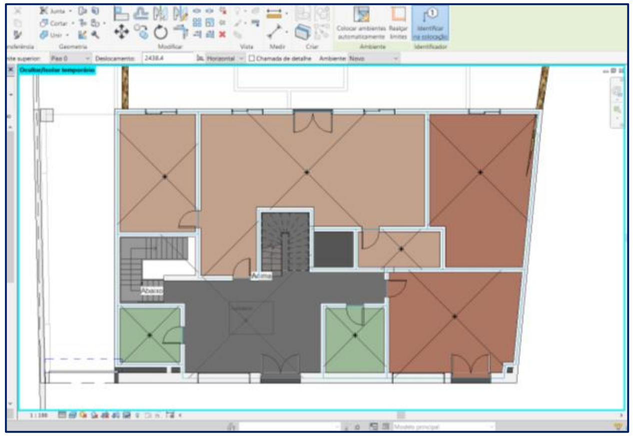






4. BIM and Digital Transformation

- BIM in Real estate



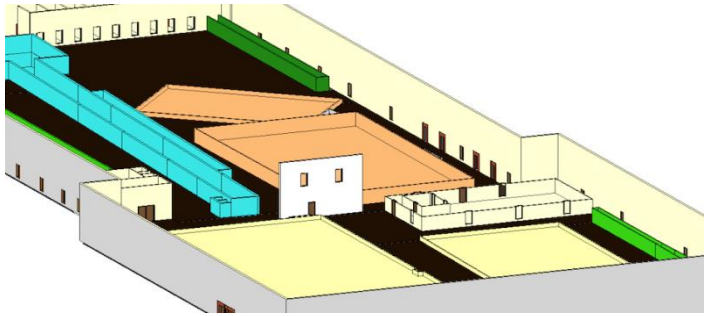
<Valor patrimonial>

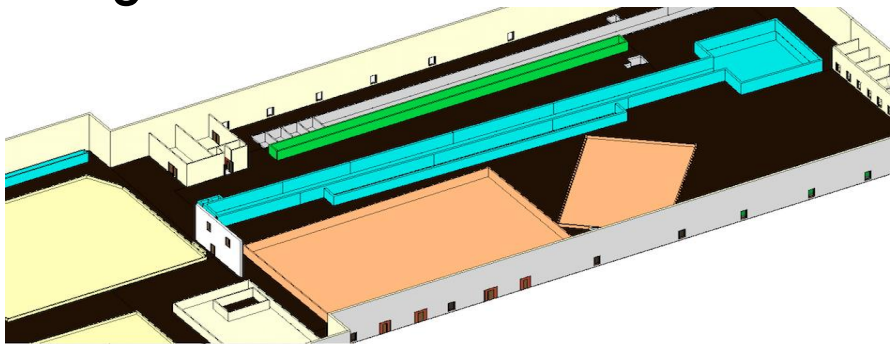
A	B	C	D	E	F	G	H	I	J	K	L
Ambientes Fração	Área	Area de Implantação	Area Bruta Privativa	Area terreno	Areas Ambientes Aa	Ab	Ac	Ad	Caj	Area Ajustada	Area (A)
Area Dependentes	261 m²	0	261	0	261	78.3	13.03	-0.07		0	0
Fração A	151 m²	317	151	1044	151	78.3	7.55	36.50	1	235	279
Fração B	176 m²	317	176	1044	176	78.3	8.81	52.16	1	264	325
Fração C	163 m²	317	163	1044	163	78.3	8.15	46.94	1	249	304
Fração D	161 m²	317	161	1044	161	78.3	8.04	52.16	1	248	308
Fração E	338 m²	317	338	1044	338	78.3	16.89	62.56	1	427	507
Fração F	188 m²	317	188	1044	188	78.3	9.39	67.81	1	278	355
Fração Loja	69 m²	317	69	1044	69	78.3	3.43	10.42	1	148	162
Fração Restaurante	96 m²	317	96	1044	96	78.3	4.82	15.64	1	177	197
	1602 m²		1602		1602		80.12	344.12		2026	2438

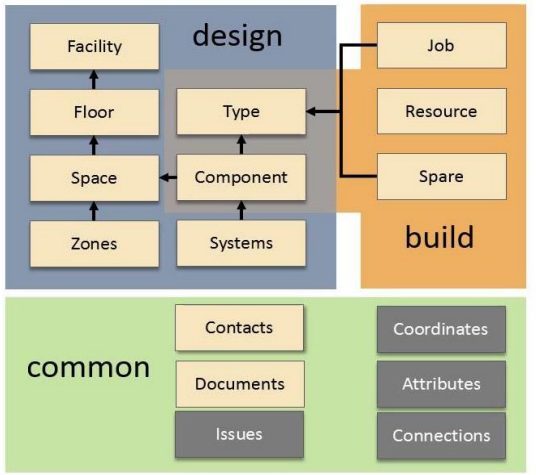
M	N	O	P	Q	R
Localização (coordenadas)	Vc	Ca	Cl	Cq	Cv
		0			
38.7212600708008,-9.14834690093994	603.0€	1	3.1	1.17	0.9
38.7212600708008,-9.14834690093994	603.0€	1	3.1	1.17	0.9
38.7212600708008,-9.14834690093994	603.0€	1	3.1	1.17	0.9
38.7212600708008,-9.14834690093994	603.0€	1	3.1	1.17	0.9
38.7212600708008,-9.14834690093994	603.0€	1	3.1	1.17	0.9
38.7212600708008,-9.14834690093994	603.0€	1	3.1	1.17	0.9
38.7212600708008,-9.14834690093994	603.0€	1	3.1	1.17	0.9
38.7212600708008,-9.14834690093994	603.0€	1	3.1	1.17	0.9

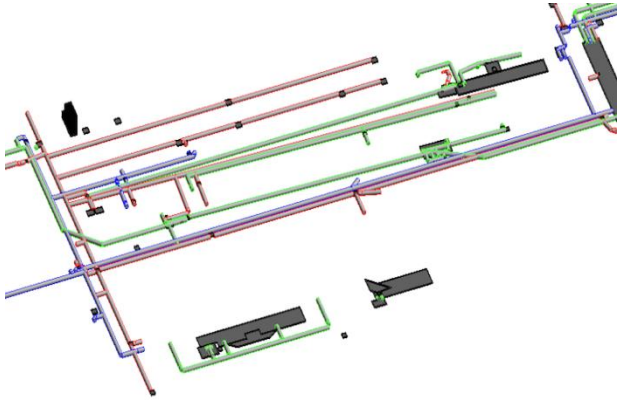
4. BIM and Digital Transformation

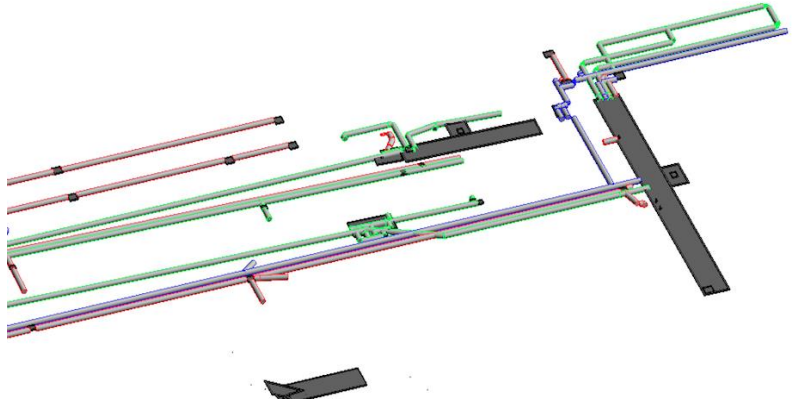
- BIM in Facility and asset management









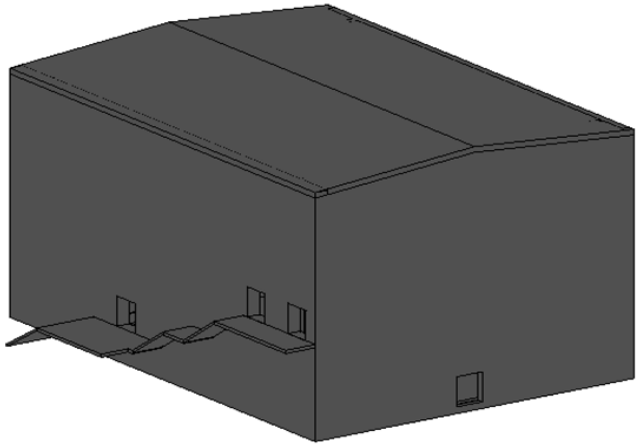


Name	CreatedBy	CreatedOn	Category	FloorName	Description	ExtSystem	ExtObject	ExtIdentifier	RoomTag	UsableHeight	GrossArea
G100_WC	a39027@isel.	2018-08-1	Space	Piso 0	WC	Autodesk	Autodesk	5676	G100	n/a	n/a
G101_WC	a39027@isel.	2018-08-1	Space	Piso 0	WC	Autodesk	Autodesk	5633	G101	n/a	n/a
G120_Circulação	a39027@isel.	2018-08-1	Space	Piso 0	Circulação	Autodesk	Autodesk	5643	G120	n/a	n/a
G121_Circulação	a39027@isel.	2018-08-1	Space	Piso 0	Circulação	Autodesk	Autodesk	5667	G121	n/a	n/a
G122_Circulação	a39027@isel.	2018-08-1	Space	Piso 0	Circulação	Autodesk	Autodesk	5609	G122	n/a	n/a
G123_Circulação	a39027@isel.	2018-08-1	Space	Piso 0	Circulação	Autodesk	Autodesk	5698	G123	n/a	n/a
G124_Circulação	a39027@isel.	2018-08-1	Space	Piso 0	Circulação	Autodesk	Autodesk	5609	G124	n/a	n/a
G125_Circulação	a39027@isel.	2018-08-1	Space	Piso 0	Circulação	Autodesk	Autodesk	5609	G125	n/a	n/a
G140_Tanque_1	a39027@isel.	2018-08-1	Space	Piso 0	Tanque_1	Autodesk	Autodesk	5612	G140	n/a	n/a
G142_Tanque_2	a39027@isel.	2018-08-1	Space	Piso 0	Tanque_2	Autodesk	Autodesk	5624	G142	n/a	n/a
G143_Tanque_3	a39027@isel.	2018-08-1	Space	Piso 0	Tanque_3	Autodesk	Autodesk	5653	G143	n/a	n/a
G146_Tanque_4	a39027@isel.	2018-08-1	Space	Piso 0	Tanque_4	Autodesk	Autodesk	5664	G146	n/a	n/a
G148_Tanque_5	a39027@isel.	2018-08-1	Space	Piso 0	Tanque_5	Autodesk	Autodesk	5677	G148	n/a	n/a
G149_Tanque_6	a39027@isel.	2018-08-1	Space	Piso 2	Tanque_6	Autodesk	Autodesk	5676	G149	n/a	n/a
G150_Tanque_7	a39027@isel.	2018-08-1	Space	Piso 1	Tanque_7	Autodesk	Autodesk	5621	G150	n/a	n/a

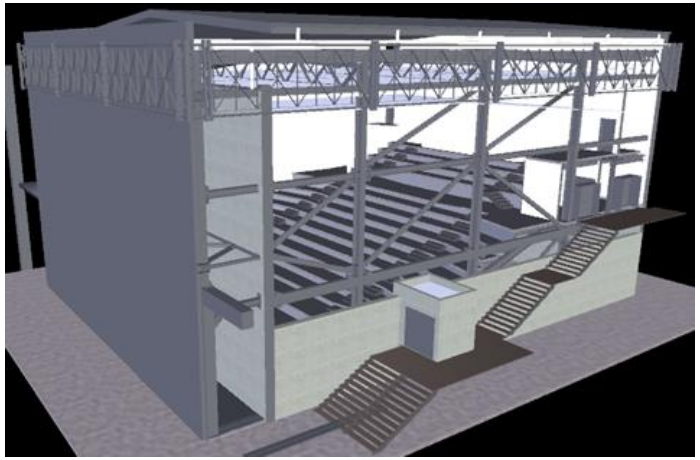
Instruction | Contact | Facility | Floor | Space | Zone | Type | Component | Sy

4. BIM and Digital Transformation

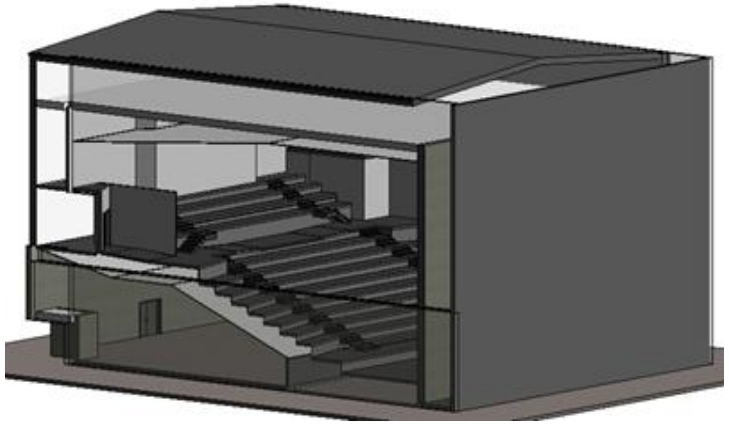
- Level of information needed in BIM



Preliminary studies



Execution project



Use, maintenance and operation

CONTENTS

5. Life Cycle Cost Assessment and Circular Economy

- Case study for gathering, organizing and generating information and performance indicators

- Portfolio of 166 Portuguese public school buildings
  - Constructed area of 2.404.500 m^2

5. Life Cycle Cost Assessment and Circular Economy

70 years
1942 a (2007-2011)

60 years
(2007-2011) a 2071

Buildings originally constructed from 1942 onwards and cost predictions for those same buildings until 2071

Life-cycle of 130 years

INFORMATION SOURCES

- ✓Ministry of Education (1928-1989)
- ✓Directorate-General for School Facilities (1989-2007)
- ✓ProNIC database (2007-2011)
- ✓*Parque Escolar* (2011-2018)
- ✓School clusters (1989-2018)

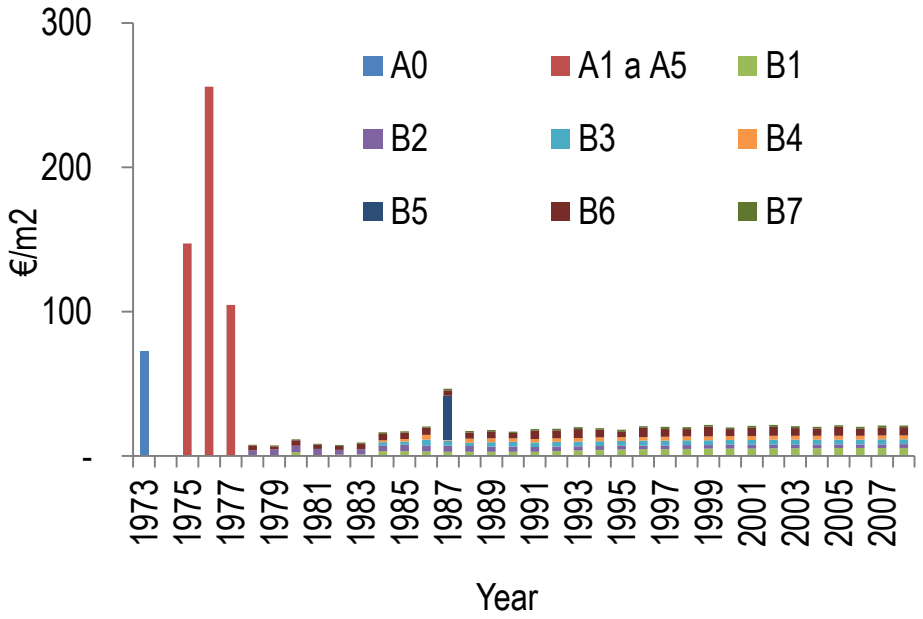
5. Life Cycle Cost Assessment and Circular Economy

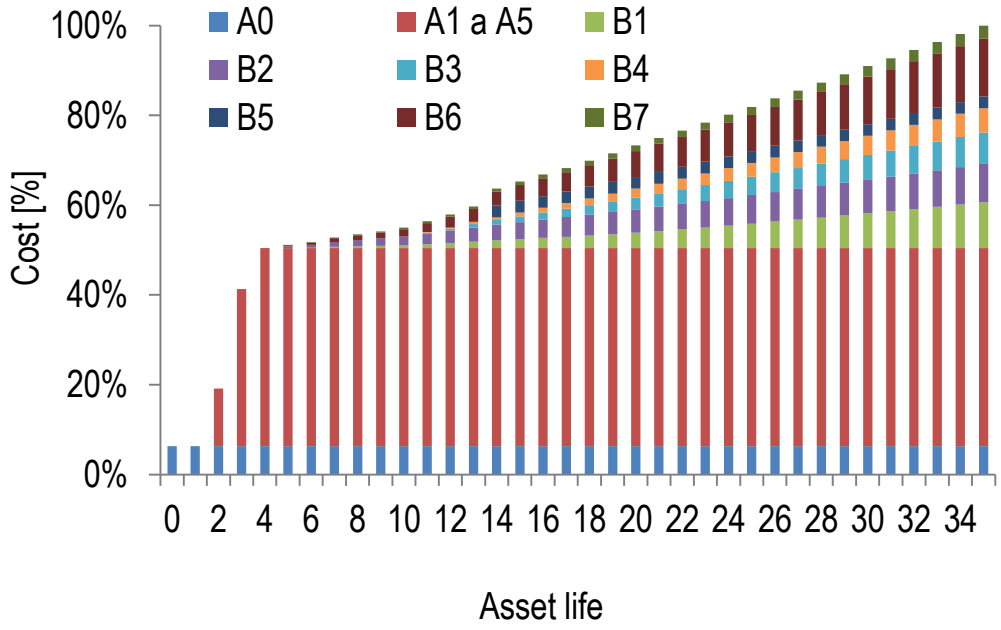
- Structure for economic LCC data collection organizes the economic information into modular life cycle stages of constructed assets
- ISO 15686-5, EN 15643-4 and EN 16227

MODULE A BEFORE USE STAGE	MODULE B USE STAGE	MODULE C AFTER USE STAGE
PRE-CONSTRUCTION **A0** - LAND AND ASSOCIATED FEES/ADVICE PRODUCT STAGE **A1** - RAW MATERIAL SUPPLY **A2** – TRANSPORT **A3** – MANUFACTURING CONSTRUCTION PROCESS **A4** – TRANSPORT **A5** – CONSTRUCTION INTALLATION PROCESS	USE STAGE **B1** – USE **B2** – MAINTENANCE **B3** – REPAIR **B4** – REPLACEMENT **B5** – REFURBISHMENT **B6** – OPERATIONAL ENERGY USE **B7** – OPERATIONAL WATER USE	END OF LIFE STAGE **C1** – DESCONSTRUCTION **C2** – TRANSPORT **C3** – WASTE PROCESSING **C4** – DISPOSAL

5. Life Cycle Cost Assessment and Circular Economy

- 155 economic performance indicators were generated
- The structuring and organization of these results is being used to develop a web-based database, composed by dynamic charts and tables





5. Life Cycle Cost Assessment and Circular Economy

Indexes	Building system	Landscaping subsystem	Structure subsystem	External elevations and roofs subsystem	Interior divisions subsystem	Services and Equipment subsystem
Depreciation rates [%]	2,75	2,64	2,67	2,84	2,70	2,77
Cost [€] per student	5 951,63	447,97	1 471,91	1 407,91	1 919,88	1 151,93

Relative ratios	Result [-]
Operation costs (B1+B2+B3+B4+B6+B7) / Capital costs (A0 to A5)	1 / 1,61
Construction stage costs (module A) / use stage costs (module B)	1 / 0,68
Rehabilitation costs / demolition costs	1 / 0,04
Rehabilitation costs / Construction costs	1 / 2,65

5. Life Cycle Cost Assessment and Circular Economy

Porfolio of 166 buildings

2,4 millions of m^2

130 years

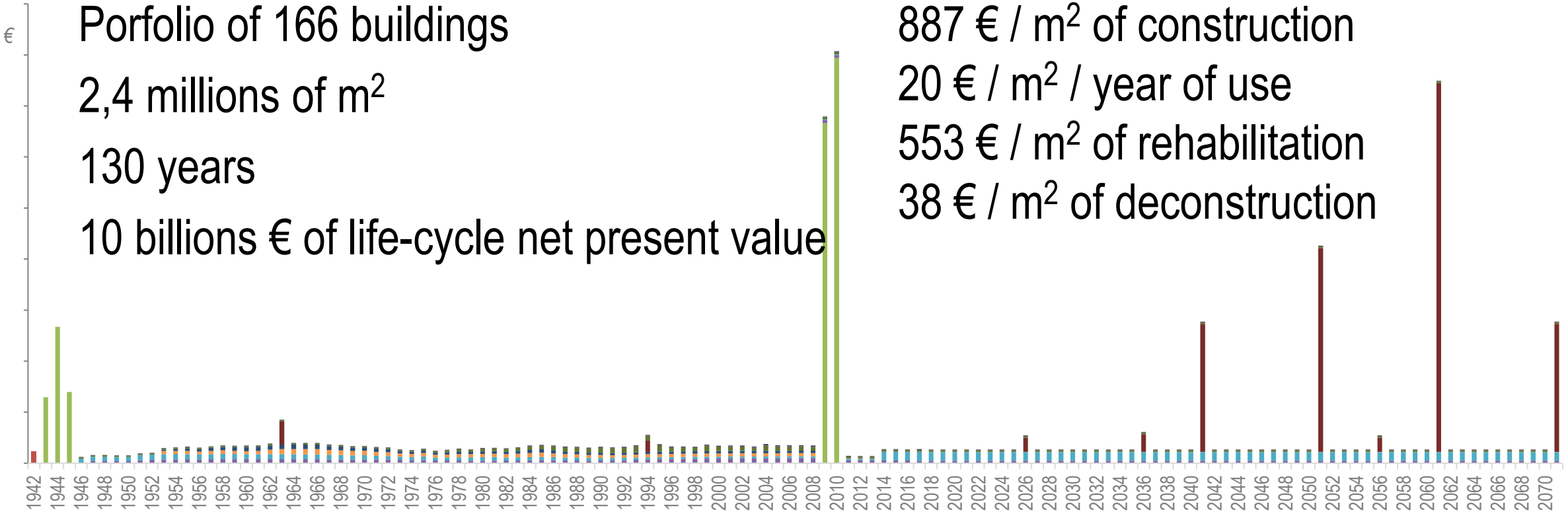
10 billions € of life-cycle net present value

887 € / m^2 of construction

20 € / m^2 / year of use

553 € / m^2 of rehabilitation

38 € / m^2 of deconstruction



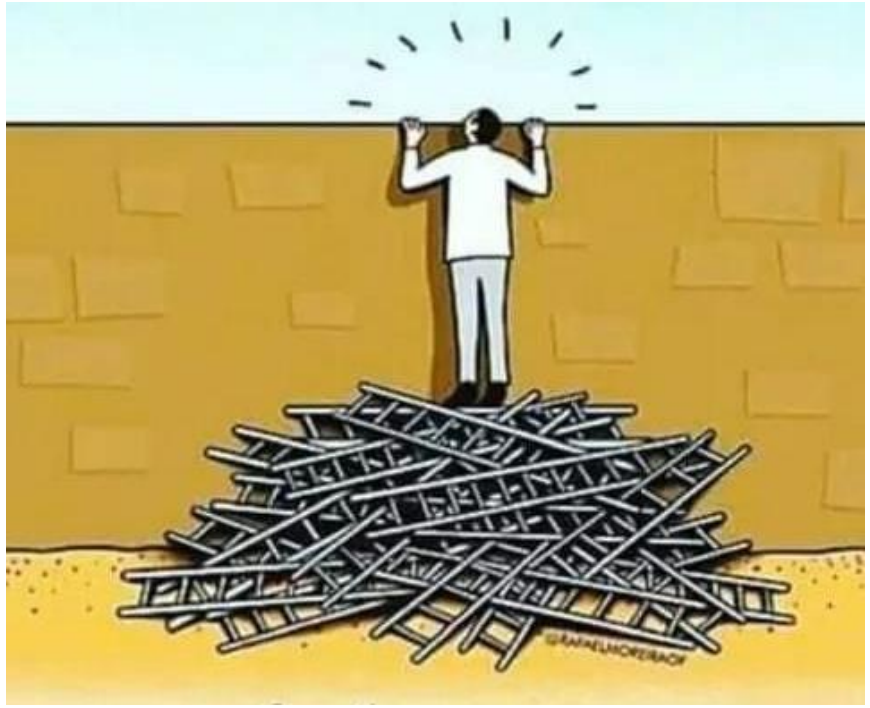
CONTENTS

6. Final remarks

- Existing assets represent an important legacy, so the application of decision support methodologies in Portuguese built heritage investment projects is a major support to decision-makers;
- Life-cycle cost informed decisions in Building Management activity depend on the widespread and consistent application of the life-cycle cost concept, namely by generating and making available the adequate quantity and quality of data;
- Interoperability between projects and procedures, standardization of procedures, the involvement of the Government and the various stakeholders, as well as the creation of a collaborative network for managing Big Data generated and its digital transformation, are essential.

6. Final remarks

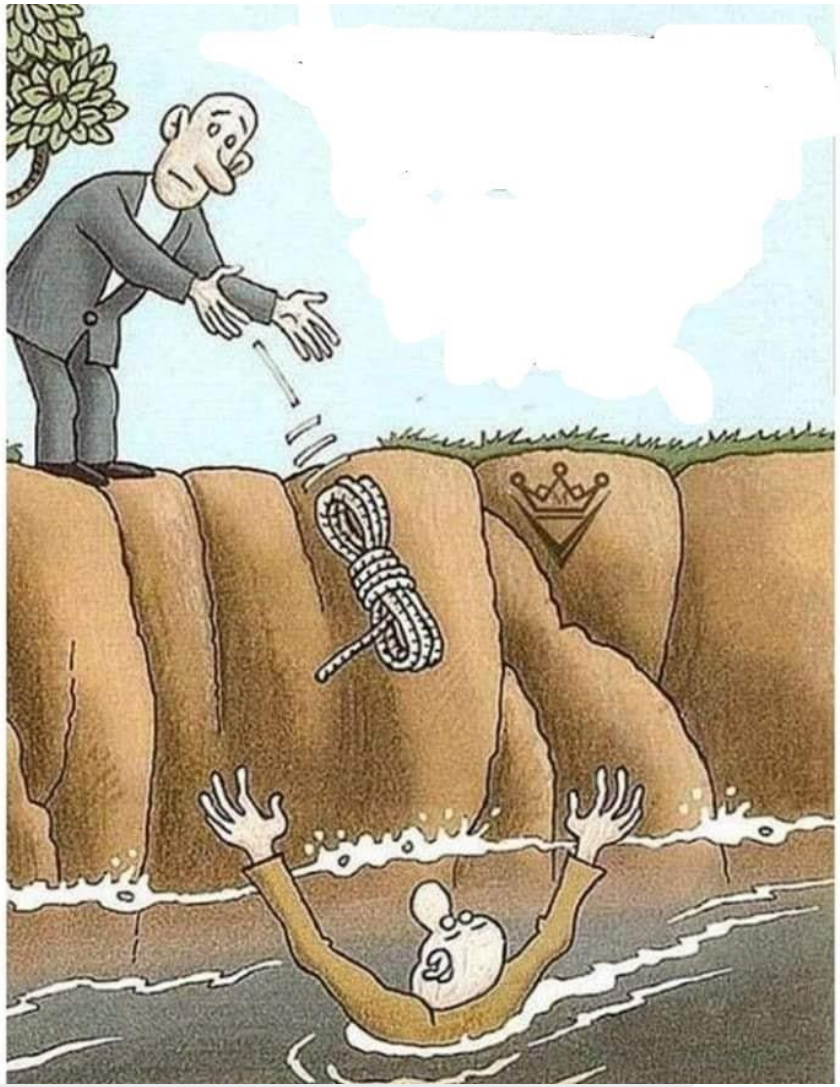
No matter how many resources You have



If You don’t know how to use them, it will never be enough

6. Final remarks

knowledge is useless if we don't know how to use it



LABORATÓRIO NACIONAL DE ENGENHARIA CIVIL

THANK YOU FOR YOUR ATTENTION

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Arab Council of Operations & Maintenance