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## **IEA EBC Annex 72: The be2226 office building in Lustenau: Architectural characteristics, BIM model and LCI**

Martin Röck, Graz University of Technology (TU Graz)

71st LCA Discussion Forum,  
18 June 2019,  
ETH Zürich, Switzerland

# Reference building: be2226



# Reference building: be2226

**Architect:** Baumschlager & Eberle

**Client:** AD Vermietung OG

**Construction year:** 2013

**Context:** suburban  
(Millennium Park, Lustenau)

**Net floor area:** 2700 m<sup>2</sup>

**Heating demand:** 8 W/m<sup>2</sup> (covered  
by waste heat from users and  
appliances)

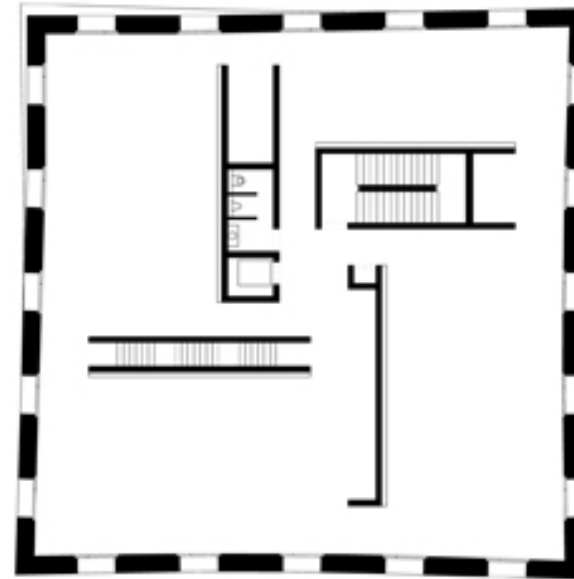
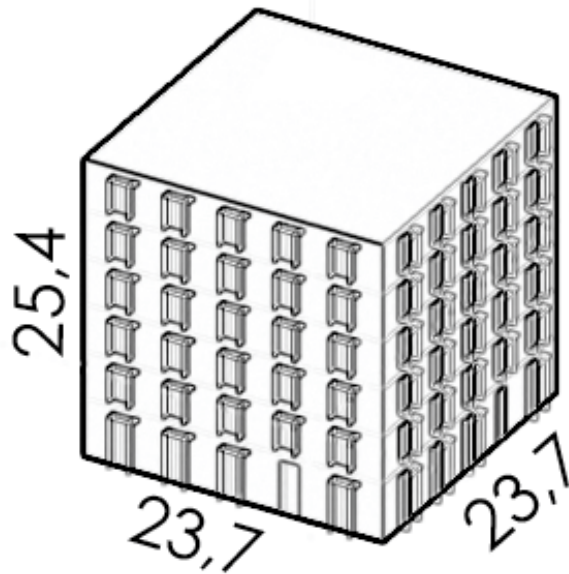
**Represents:** advanced building  
concept (passive, no heating/cooling)



Eberle, D., & Aicher, F. (Eds.). (n.d.). Die Temperatur der  
Architektur Portrait eines energieoptimierten Hauses - be 2226.

# Reference building: be2226

- Compact shape, insulated to passive standard
- Monolithic brick structure (thermal mass)
- Open floorplan (flexibility, crossventilation)



# Reference building: be2226



Eberle, D., & Aicher, F. (Eds.). (n.d.). Die Temperatur der  
Architektur Portrait eines energieoptimierten Hauses - be 2226.

# Reference building: be2226



Eberle, D., & Aicher, F. (Eds.). (n.d.). Die Temperatur der Architektur Portrait eines energieoptimierten Hauses - be 2226.

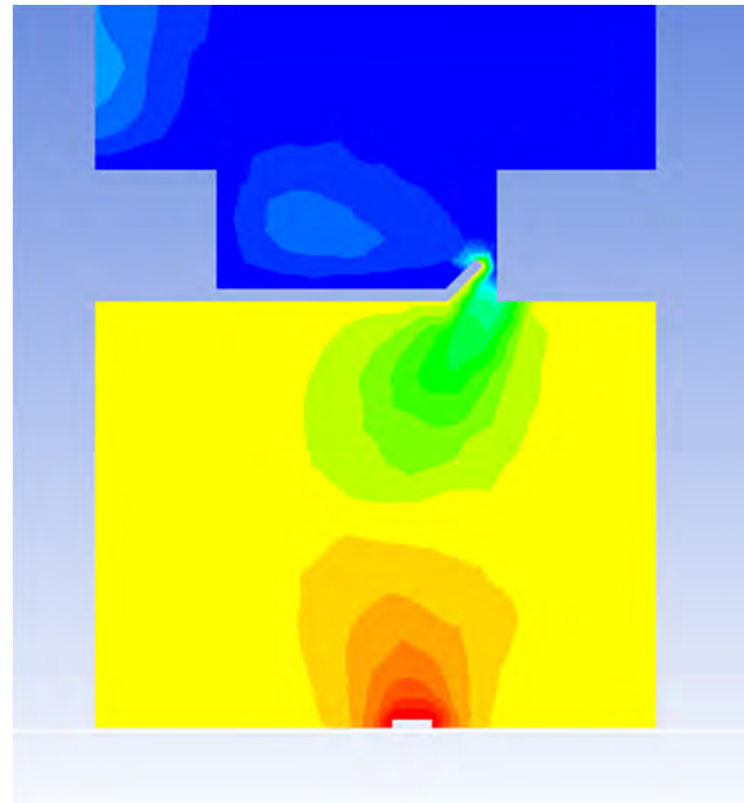
# Reference building: be2226



Eberle, D., & Aicher, F. (Eds.). (n.d.). Die Temperatur der Architektur Portrait eines energieoptimierten Hauses - be 2226.

# Controlled passive ventilation

- CFD simulation to analyze air drag from vertical façade openings during design phase



Eberle, D., & Aicher, F. (Eds.). (n.d.). Die Temperatur der Architektur Portrait eines energieoptimierten Hauses - be 2226.



# Controlled passive ventilation

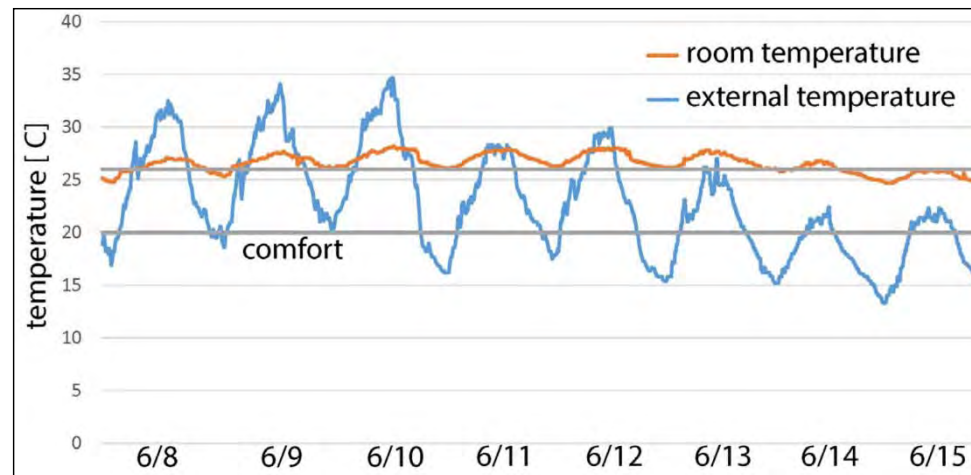
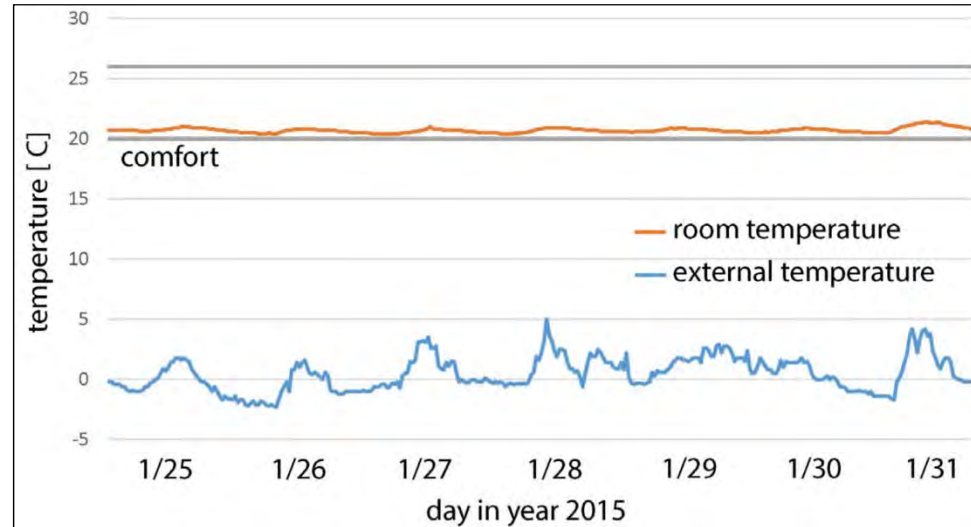
## 2015 measurement

### Min. temperature

- January
- Northern zone

### Max. temperature

- July
- Western zone



Eberle, D., & Aicher, F. (Eds.). (n.d.). Die Temperatur der Architektur Portrait eines energieoptimierten Hauses - be 2226.

# Life Cycle Assessment (LCA)

## General information & scope

### General information

<b>Name</b>	<b>be2226</b>
Location	Lustenau, Austria
Year of completion	2013
Architect	Baumschlagler Eberle
Client	AD Vermietung OG

Building information	acc. Architects	acc. BIM model
GFA (Gross floor area)	3201.00	3378 m <sup>2</sup>
NFA (Net floor area)	<b>2421.00</b>	2659 m <sup>2</sup>
GBV (Gross building volume)		13300 m <sup>3</sup>

Window/wall ratio	13.60	-	%
Total energy consumption	<b>38.95</b>	-	kWh/m <sup>2</sup> a

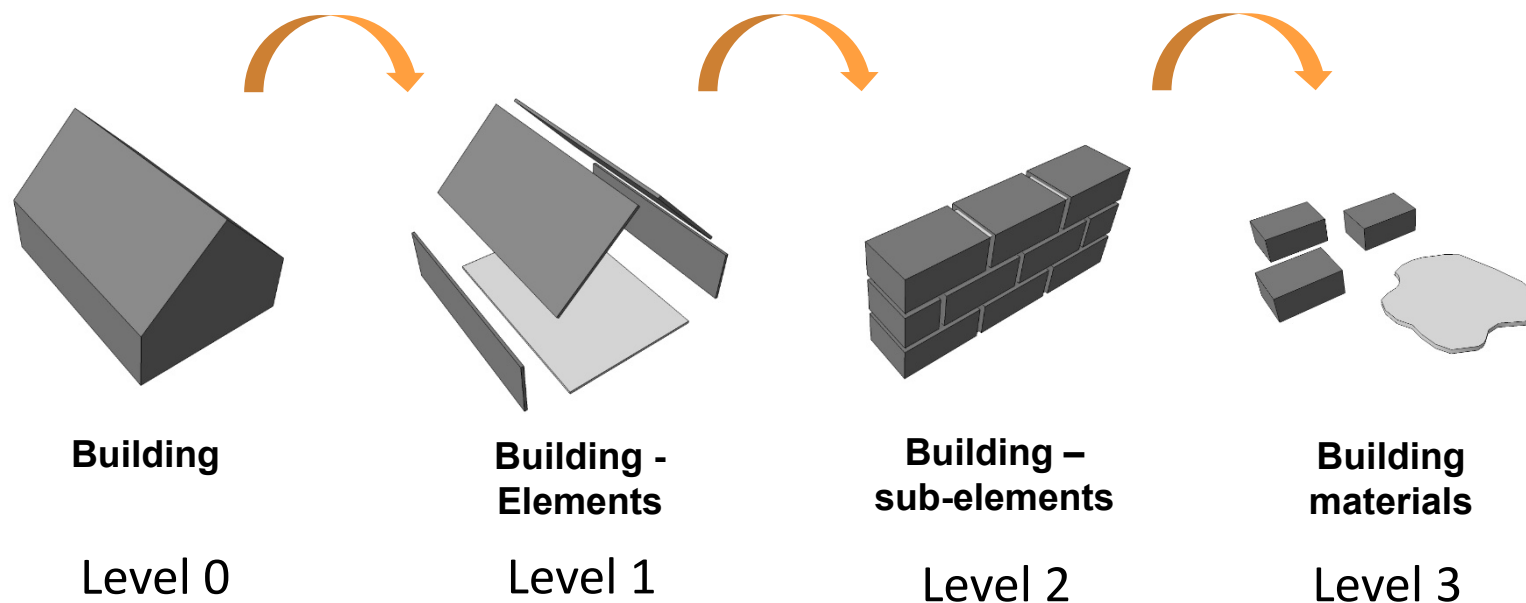
Details on consumption	acc. Architects	
	Total Electricity	
Energy consumption (100% ele	<b>131581</b>	kWh
Energy consumption (100% ele	<b>196</b>	MJ/m <sup>2</sup> NFA*a
Operational water consumptio	<b>80</b>	m <sup>3</sup> /a

### Overall building structure, elements with respective sub-elements and materials

Building element	Building Element
<b>Foundation</b>	FN01_Structural foundation, driven piles new, d42.0
	FN02_Structural foundation, slab-on-grade slab, reinf. Concrete, 25.0
	FN03_Structural foundation, special
	FC01_Perimeter insulation (slab-on-grade)
<b>External walls</b>	EW01_Exterior wall, outer brick + plaster, 40.5
	EW02_Exterior wall, brick attica, 38.0
<b>Floor structure</b>	FS01_Floor structure, upper floors, concrete slab+plaster, 24.5
<b>Roof structure</b>	RS01_Roof structure, concrete slab, 24.0
<b>Stairs</b>	ST01_Stair primary, concrete, w100.0
	ST02_Stair secondary, wood, w100.0
<b>Internal walls</b>	IW01_Interior wall, brick + plaster 27.0
	IW02_Interior wall, brick + plaster 17.0
	IW03_Interior wall, brick+plaster, 12.0
<b>Flooring</b>	FL01_Floor finish, ground floor, 29.5
	FL02_Floor finish, upper floors, 14.5
<b>Roofing</b>	RF01_Roofing, sealing+insulation+foil+gravel, 36.0
<b>Windows</b>	WE01_Windows exterior, ground floor, incl. side panel
	WE02_Windows exterior, upper floors, incl. side panel
<b>Doors</b>	DE01_Door exterior, ground floor, incl. side panel
	DI01_Door interior, wooden door + frame
	DI02_Door interior, glas door (modelled as wall), 5.5
	DI03_Door interior, wooden door + frame
<b>Building services</b>	SA01_Sanitary equipment
	EL01_Elevator

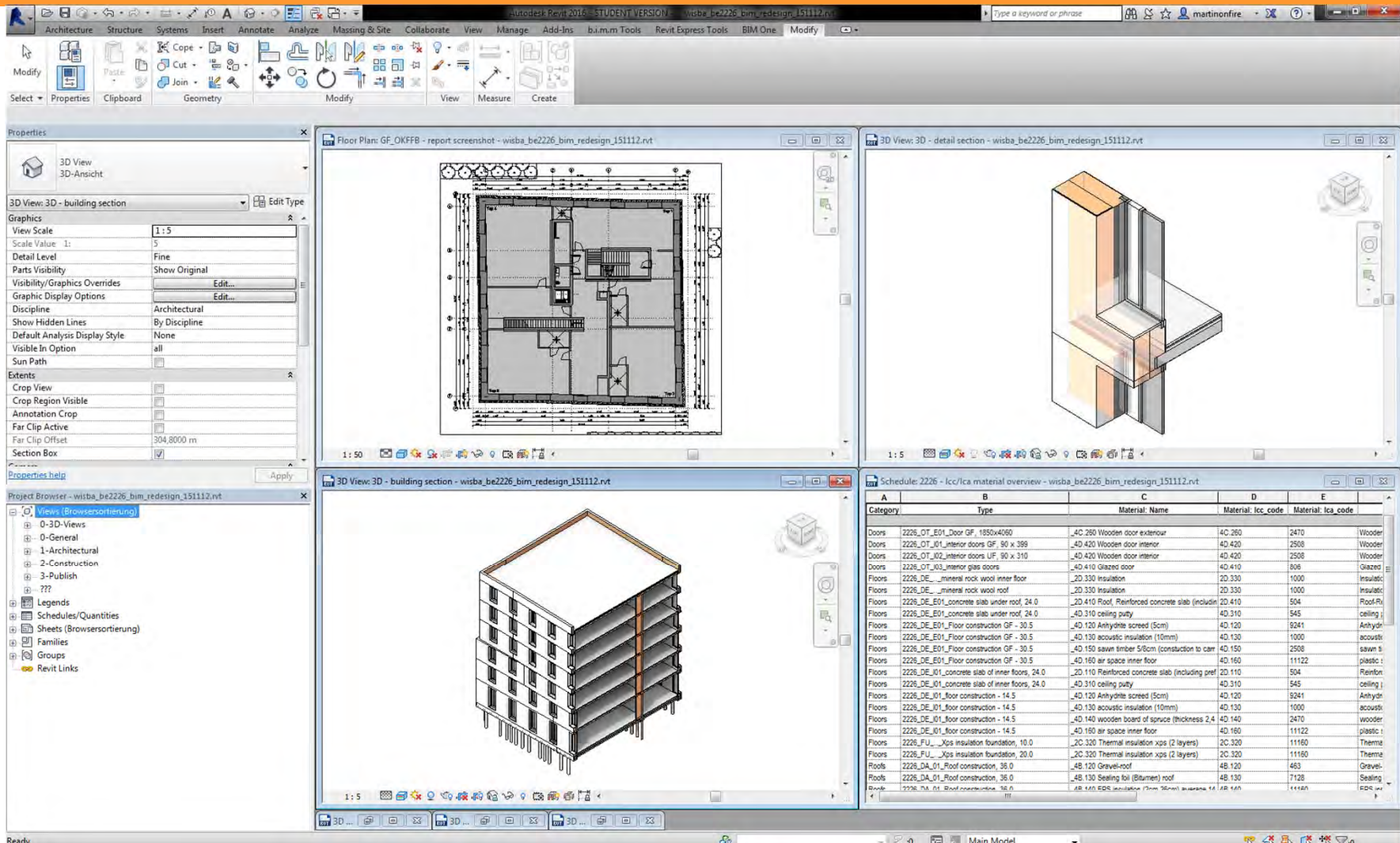
# Life Cycle Inventory (LCI)

- Hierarchical decomposition of the building
  - Framework for classification acc. ISO 12006-2
  - Element-method adopted from Trigaux et al. 2014



Trigaux, D., Allacker, K., & De Troyer, F. (2014). Model for the environmental impact assessment of neighbourhoods. <https://doi.org/10.2495/EID140091>

# Building Information Model (BIM)



The screenshot displays the Autodesk Revit software interface for a BIM project. The main workspace is divided into four viewports:

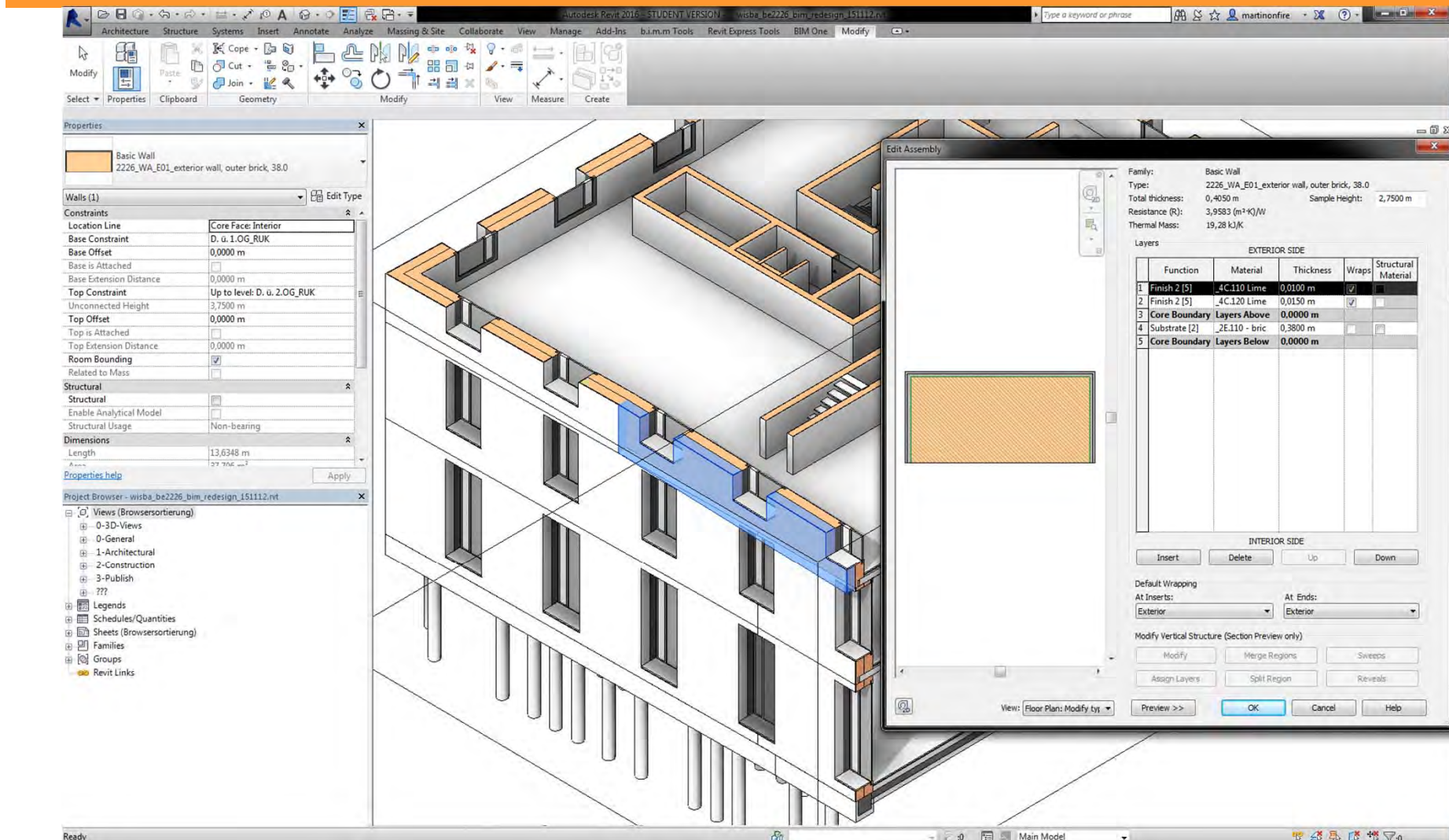
- Top Left:** A 2D floor plan view showing the layout of a building with rooms, corridors, and structural elements.
- Top Right:** A 3D detail section view of a window or door assembly, showing the internal structure and materials.
- Bottom Left:** A 3D building section view showing the overall structure of a multi-story building.
- Bottom Right:** A material schedule table listing various building components and their material properties.

The material schedule table is as follows:

A	B	C	D	E	
Category	Type	Material Name	Material: lcc_code	Material: lca_code	
Doors	2226_OT_E01_Door GF, 1850x4060	_4C 260 Wooden door exterior	4C 260	2470	Wooder
Doors	2226_OT_E01_interior doors GF, 90 x 399	_4D 420 Wooden door interior	4D 420	2508	Wooder
Doors	2226_OT_E02_interior doors UF, 90 x 310	_4D 420 Wooden door interior	4D 420	2508	Wooder
Doors	2226_OT_E03_interior glass doors	_4D 410 Glazed door	4D 410	806	Glaazed
Floors	2226_DE_interior rock wool inner floor	_2D 330 insulation	2D 330	1000	Insulatio
Floors	2226_DE_mineral rock wool roof	_2D 330 insulation	2D 330	1000	Insulatio
Floors	2226_DE_E01_concrete slab under roof, 34.0	_2D 410 Roof, Reinforced concrete slab (includi	2D 410	504	Roof/Rei
Floors	2226_DE_E01_concrete slab under roof, 24.0	_4D 310 ceiling putty	4D 310	545	ceiling j
Floors	2226_DE_E01_Floor construction GF - 30.5	_4D 120 Antydyte screed (5cm)	4D 120	9241	Antydyte
Floors	2226_DE_E01_Floor construction GF - 30.5	_4D 130 acoustic insulation (10mm)	4D 130	1000	acoustic
Floors	2226_DE_E01_Floor construction GF - 30.5	_4D 150 sawn timber 5/8cm (construction to carr	4D 150	2508	sawn 5
Floors	2226_DE_E01_Floor construction GF - 30.5	_4D 160 air space inner floor	4D 160	11122	plastic i
Floors	2226_DE_E01_concrete slab of inner floors, 24.0	_2D 110 Reinforced concrete slab (including pref	2D 110	504	Reinfor
Floors	2226_DE_E01_concrete slab of inner floors, 24.0	_4D 310 ceiling putty	4D 310	545	ceiling j
Floors	2226_DE_E01_floor construction - 14.5	_4D 120 Antydyte screed (5cm)	4D 120	9241	Antydyte
Floors	2226_DE_E01_floor construction - 14.5	_4D 130 acoustic insulation (10mm)	4D 130	1000	acoustic
Floors	2226_DE_E01_floor construction - 14.5	_4D 140 wooden board of spruce (thickness 2.4	4D 140	2470	wooder
Floors	2226_DE_E01_floor construction - 14.5	_4D 160 air space inner floor	4D 160	11122	plastic i
Floors	2226_FU_xps insulation foundation, 10.0	_2C 320 Thermal insulation xps (2 layers)	2C 320	11160	Therma
Floors	2226_FU_xps insulation foundation, 20.0	_2C 320 Thermal insulation xps (2 layers)	2C 320	11160	Therma
Roofs	2226_DA_01_Roof construction, 38.0	_4B 120 Gravel-roof	4B 120	463	Gravel-
Roofs	2226_DA_01_Roof construction, 36.0	_4B 130 Sealing foil (Bitumen) roof	4B 130	7128	Sealing
Roofs	2226_DA_01_Roof construction, 36.0	_4B 140 EPS insulation (2cm 35mm) awnings, 14	4B 140	41460	EPS ins

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# Building Information Model (BIM)



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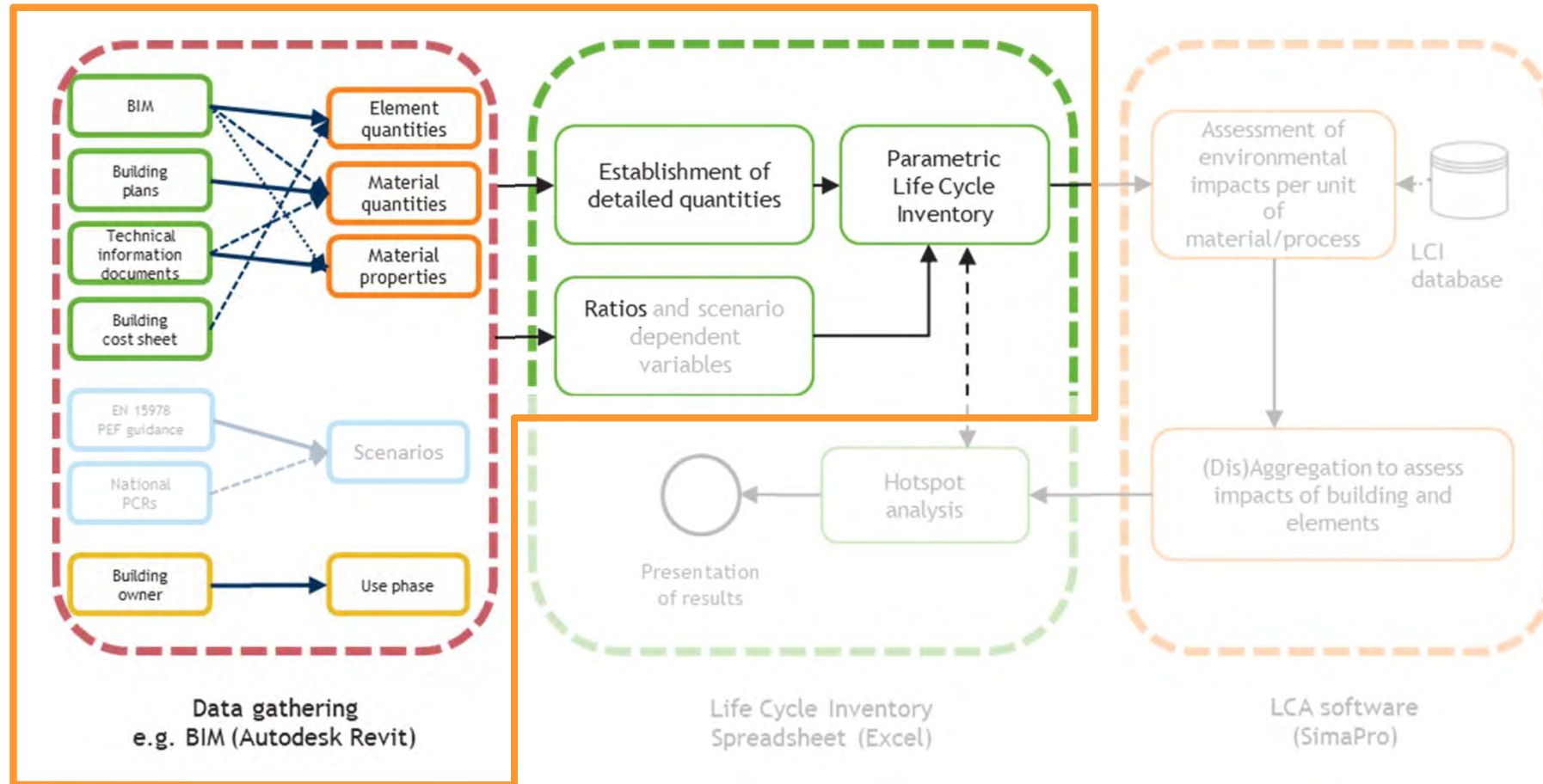
# Building Information Model (BIM)

- Modelled based on architect's information
- Building elements modelled LOD 200
- Quantity take-off (Level 1: Building elements)
- Element, material composition

## Outlook:

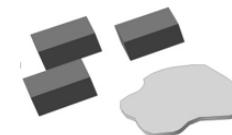
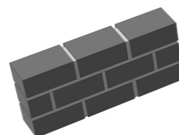
- Container for building related information, e.g.
  - Element and material properties
  - Environmental impact values
  - Etc.

# Life Cycle Inventory (LCI) Data sources



VITO, KU Leuven, & TU Graz. (2018). <https://doi.org/10.2779/23505>

# Life Cycle Inventory (LCI) Hierarchical structure



Level 1: Building element				Level 2: Building sub-element			Level 3: Building material				
Building Element	Quantity element	Quantity sub-element	Unit	Building sub-element	Unit	Ratio sub-element / building element	Material	Material unit	Ratio material/sub element		
Concrete floor on earth	1148	1148	m <sup>2</sup>								
			m <sup>2</sup>	Vinyl Tiles	m <sup>2</sup>	1					
									<i>Vinyl Tiles</i>	<i>m<sup>2</sup></i>	<i>1.0</i>
									<i>Butyl Acrylate</i>	<i>kg</i>	<i>0.3</i>
			1148	m <sup>2</sup>	Concrete Screed	m <sup>2</sup>	1				
									<i>Concrete In Situ</i>	<i>m<sup>3</sup></i>	<i>0.1</i>
			1148	m <sup>2</sup>	PUR	m <sup>2</sup>	1				
									<i>Polyurethane Flexible Foam</i>	<i>kg</i>	<i>3.0</i>
1148	m <sup>2</sup>	Concrete Floor	m <sup>2</sup>	1							
							<i>Reinforcing Steel</i>	<i>kg</i>	<i>22.2</i>		
							<i>Concrete In Situ</i>	<i>m<sup>3</sup></i>	<i>0.3</i>		

VITO, KU Leuven, & TU Graz. (2018). <https://doi.org/10.2779/23505>



# be2226: Building composition

Element level data (L1)		Input		Subelement level data (L2)				Total		Material level data (L3)						Totals				
Level 1: Building element	Input quantity	Input unit	Number of layer/sub-element	Level 2: Sub-element (workblock/layer)	Ratio work block/building size (e.g. m <sup>2</sup> ) or element thickness (e.g. [m])	ratio for L2 unit (e.g. m <sup>3</sup> ) or thickness (e.g. [m])	Resulting unit	Quantity	Unit	Level 3: Material	Ratio material/work block	% (volume or area) of L2 (0-1)	resulting L3 unit	Density [kg/m <sup>3</sup> ]	resulting L3 unit	Quantity	Resulting unit	Quantity	Resulting unit	
= Name in Revit (Element Type)																				
																			4751095.83	kg
<b>FN01_Structural foundation, driven piles new</b>																				
	180.72	m <sup>3</sup>	01	ConcreteFoundationPilar	1	1	m <sup>3</sup>	180.72	m <sup>3</sup>											
	180.72	m <sup>3</sup>	01	ConcreteFoundationPilar	1	0.99	m <sup>3</sup>	180.72	m <sup>3</sup>	ConcreteInSitu	2277	0.99	m <sup>3</sup>	2300	kg	178.91	m <sup>3</sup>	411499.44	kg	
	180.72	m <sup>3</sup>	01	ConcreteFoundationPilar	1	1	m <sup>3</sup>	180.72	m <sup>3</sup>	ReinforcingSteel	78.5	0.01	m <sup>3</sup>	7850	kg	1.81	m <sup>3</sup>	14186.52	kg	
<b>FN02_Structural foundation, slab-on-grade slab</b>																				
	135.22	m <sup>3</sup>	01	ConcreteFoundationSlab	1	1	m <sup>3</sup>	135.22	m <sup>3</sup>											
	135.22	m <sup>3</sup>	01	ConcreteFoundationSlab	1	0.99	m <sup>3</sup>	135.22	m <sup>3</sup>	ConcreteInSitu	2277	0.99	m <sup>3</sup>	2300	kg	133.87	m <sup>3</sup>	307895.94	kg	
	135.22	m <sup>3</sup>	01	ConcreteFoundationSlab	1	1	m <sup>3</sup>	135.22	m <sup>3</sup>	ReinforcingSteel	78.5	0.01	m <sup>3</sup>	7850	kg	1.35	m <sup>3</sup>	10614.77	kg	
<b>FN03_Structural foundation, special</b>																				
	56.41	m <sup>3</sup>	01	ConcreteFoundationSlab	1	1	m <sup>3</sup>	56.41	m <sup>3</sup>											
	56.41	m <sup>3</sup>	01	ConcreteFoundationSlab	1	0.99	m <sup>3</sup>	56.41	m <sup>3</sup>	ConcreteInSitu	2277	0.99	m <sup>3</sup>	2300	kg	55.85	m <sup>3</sup>	128445.57	kg	
	56.41	m <sup>3</sup>	01	ConcreteFoundationSlab	1	1	m <sup>3</sup>	56.41	m <sup>3</sup>	ReinforcingSteel	78.5	0.01	m <sup>3</sup>	7850	kg	0.56	m <sup>3</sup>	4428.19	kg	
<b>FC01_Perimeter insulation (slab-on-grade)</b>																				
	127.41	m <sup>3</sup>	01	PerimeterInsulation	1	1	m <sup>3</sup>	127.41	m <sup>3</sup>											
	127.41	m <sup>3</sup>	01	PerimeterInsulation	1	1	m <sup>3</sup>	127.41	m <sup>3</sup>	XPS	35	1	m <sup>3</sup>	35	kg	127.41	m <sup>3</sup>	4459.35	kg	
<b>EW01_Exterior wall, brick + plaster, 83.0</b>																				
	1645.63	m <sup>2</sup>	01	LimePlasterExterior	1	0.025	m <sup>3</sup>	41.14	m <sup>3</sup>											
	1645.63	m <sup>2</sup>	01	LimePlasterExterior	1	0.025	m <sup>3</sup>	41.14	m <sup>3</sup>	LimePlaster	1800	1	m <sup>3</sup>	1800	kg	41.14	m <sup>3</sup>	74053.35	kg	
	1644.64	m <sup>2</sup>	02	BrickwallInsulating	1	0.38	m <sup>3</sup>	624.96	m <sup>3</sup>											
	1644.64	m <sup>2</sup>	02	BrickwallInsulating	1	0.38	m <sup>3</sup>	624.96	m <sup>3</sup>	Brick	617.5	0.95	m <sup>3</sup>	650	kg	593.72	m <sup>3</sup>	385914.78	kg	
	1644.64	m <sup>2</sup>	02	BrickwallInsulating	1	0.38	m <sup>3</sup>	624.96	m <sup>3</sup>	CementMortar	90	0.05	m <sup>3</sup>	1800	kg	31.25	m <sup>3</sup>	56246.69	kg	
	1644.64	m <sup>2</sup>	03	MortarLayer	1	0.02	m <sup>3</sup>	32.89	m <sup>3</sup>											
	1644.64	m <sup>2</sup>	03	MortarLayer	1	0.02	m <sup>3</sup>	32.89	m <sup>3</sup>	CementMortar	1800	1	m <sup>3</sup>	1800	kg	32.89	m <sup>3</sup>	59207.04	kg	
	1548.57	m <sup>2</sup>	04	BrickwallStructural	1	0.38	m <sup>3</sup>	588.46	m <sup>3</sup>											
	1548.57	m <sup>2</sup>	04	BrickwallStructural	1	0.38	m <sup>3</sup>	588.46	m <sup>3</sup>	Brick	709.65	0.95	m <sup>3</sup>	747	kg	559.03	m <sup>3</sup>	417598.23	kg	
	1548.57	m <sup>2</sup>	04	BrickwallStructural	1	0.38	m <sup>3</sup>	588.46	m <sup>3</sup>	CementMortar	90	0.05	m <sup>3</sup>	1800	kg	29.42	m <sup>3</sup>	52961.09	kg	
	1311.13	m <sup>2</sup>	05	LimePlasterInterior	1	0.01	m <sup>3</sup>	13.11	m <sup>3</sup>											
	1311.13	m <sup>2</sup>	05	LimePlasterInterior	1	0.01	m <sup>3</sup>	13.11	m <sup>3</sup>	LimePlaster	1800	1	m <sup>3</sup>	1800	kg	13.11	m <sup>3</sup>	23600.34	kg	
<b>EW02_Exterior wall, brick attica, 38.0</b>																				
	134.23	m <sup>2</sup>	01	BrickwallInsulating	1	0.38	m <sup>3</sup>	51.01	m <sup>3</sup>											
	134.23	m <sup>2</sup>	01	BrickwallInsulating	1	0.38	m <sup>3</sup>	51.01	m <sup>3</sup>	Brick	709.65	0.95	m <sup>3</sup>	747	kg	48.46	m <sup>3</sup>	36197.40	kg	
	134.23	m <sup>2</sup>	01	BrickwallInsulating	1	0.38	m <sup>3</sup>	51.01	m <sup>3</sup>	CementMortar	90	0.05	m <sup>3</sup>	1800	kg	2.55	m <sup>3</sup>	4590.67	kg	
	134.23	m <sup>2</sup>	02	LimePlasterInterior	2	0.025	m <sup>3</sup>	6.71	m <sup>3</sup>											
	134.23	m <sup>2</sup>	02	LimePlasterInterior	2	0.025	m <sup>3</sup>	6.71	m <sup>3</sup>	LimePlaster	1800	1	m <sup>3</sup>	1800	kg	6.71	m <sup>3</sup>	12080.70	kg	
<b>FS01_Floor structure, upper floors, concrete slab</b>																				
	2493.99	m <sup>2</sup>	01	ConcreteFloor	1	0.24	m <sup>3</sup>	598.56	m <sup>3</sup>											
	2493.99	m <sup>2</sup>	01	ConcreteFloor	1	0.24	m <sup>3</sup>	598.56	m <sup>3</sup>	ConcreteInSitu	2376	0.99	m <sup>3</sup>	2400	kg	592.57	m <sup>3</sup>	1422172.86	kg	
	2493.99	m <sup>2</sup>	01	ConcreteFloor	1	0.24	m <sup>3</sup>	598.56	m <sup>3</sup>	ReinforcingSteel	78.5	0.01	m <sup>3</sup>	7850	kg	5.99	m <sup>3</sup>	46986.77	kg	
	2493.99	m <sup>2</sup>	02	PlasterCeiling	1	0.01	m <sup>3</sup>	24.94	m <sup>3</sup>											
	2493.99	m <sup>2</sup>	02	PlasterCeiling	1	0.01	m <sup>3</sup>	24.94	m <sup>3</sup>	LimePlaster	1800	1	m <sup>3</sup>	1800	kg	24.94	m <sup>3</sup>	44891.82	kg	

VITO, KU Leuven, & TU Graz. (2018). <https://doi.org/10.2779/23505>

# be2226: Building totals

Level 3 - Material amounts (per building element)				
Material	Amount	Unit	Amount	Unit
Element-Code_Subelement-Number_Name-of-material	[pcs, m <sup>2</sup> , m <sup>3</sup> ]			[kg]
<b>CHECKSUM:</b>			4751095.83	kg
FN01_01_ConcreteInSitu	178.91	m <sup>3</sup>	411499.44	kg
FN01_01_ReinforcingSteel	1.81	m <sup>3</sup>	14186.52	kg
FN02_01_ConcreteInSitu	133.87	m <sup>3</sup>	307895.94	kg
FN02_01_ReinforcingSteel	1.35	m <sup>3</sup>	10614.77	kg
FN03_01_ConcreteInSitu	55.85	m <sup>3</sup>	128445.57	kg
FN03_01_ReinforcingSteel	0.56	m <sup>3</sup>	4428.19	kg
FC01_01_XPS	127.41	m <sup>3</sup>	4459.35	kg
EW01_01_LimePlaster	41.14	m <sup>3</sup>	74053.35	kg
EW01_02_Brick	593.72	m <sup>3</sup>	385914.78	kg
EW01_02_CementMortar	31.25	m <sup>3</sup>	56246.69	kg
EW01_03_CementMortar	32.89	m <sup>3</sup>	59207.04	kg
EW01_04_Brick	559.03	m <sup>3</sup>	417598.23	kg
EW01_04_CementMortar	29.42	m <sup>3</sup>	52961.09	kg
EW01_05_LimePlaster	13.11	m <sup>3</sup>	23600.34	kg
EW02_01_Brick	48.46	m <sup>3</sup>	36197.40	kg
EW02_01_CementMortar	2.55	m <sup>3</sup>	4590.67	kg
EW02_02_LimePlaster	6.71	m <sup>3</sup>	12080.70	kg
FS01_01_ConcreteInSitu	592.57	m <sup>3</sup>	1422172.86	kg
FS01_01_ReinforcingSteel	5.99	m <sup>3</sup>	46986.77	kg
FS01_02_LimePlaster	24.94	m <sup>3</sup>	44891.82	kg
RS01_01_ConcreteInSitu	118.40	m <sup>3</sup>	284156.29	kg
RS01_01_ReinforcingSteel	1.20	m <sup>3</sup>	9388.16	kg
RS01_02_LimePlaster	4.98	m <sup>3</sup>	4235.64	kg
ST01_01_ConcretePrefab	12.74	m <sup>3</sup>	30576.00	kg
ST02_01_SawnTimber	1.57	m <sup>3</sup>	863.50	kg
IW01_01_Brick	433.23	m <sup>3</sup>	345718.24	kg
IW01_01_CementMortar	22.80	m <sup>3</sup>	41042.93	kg
IW01_02_LimePlaster	36.48	m <sup>3</sup>	65668.68	kg
IW02_01_Brick	13.33	m <sup>3</sup>	11528.44	kg
IW02_01_CementMortar	0.13	m <sup>3</sup>	242.32	kg
IW02_02_LimePlaster	1.58	m <sup>3</sup>	2850.84	kg
IW03_01_Brick	5.22	m <sup>3</sup>	3916.84	kg
IW03_01_CementMortar	0.05	m <sup>3</sup>	94.95	kg

Level 3 - Material amounts (building total)				
Material	Amount	Unit	Amount	Unit
Element-Code_Subelement-Number_Name-of-material	[pcs, m <sup>2</sup> , m <sup>3</sup> ]			[kg]
<b>CHECKSUM:</b>			4751095.83	kg
ConcreteInSitu	1079.60	m <sup>3</sup>	2554170.10	kg
ReinforcingSteel	10.91	m <sup>3</sup>	85604.41	kg
XPS	337.80	m <sup>3</sup>	11823.07	kg
LimePlaster	129.83	m <sup>3</sup>	228963.93	kg
Brick	1652.99	m <sup>3</sup>	1200873.92	kg
CementMortar	119.10	m <sup>3</sup>	214385.69	kg
ConcretePrefab	12.74	m <sup>3</sup>	30576.00	kg
SawnTimber	40.39	m <sup>3</sup>	22212.70	kg
AnhydriteFloor	136.31	m <sup>3</sup>	272621.00	kg
PVCfoil	0.65	m <sup>3</sup>	780.53	kg
Rockwool	27.26	m <sup>3</sup>	954.17	kg
Plywood	63.21	m <sup>3</sup>	34764.66	kg
EPDM	1.31	m <sup>3</sup>	973.06	kg
Gravel	105.20	m <sup>3</sup>	89416.60	kg
SanitaryCeramics	12.00	pcs	162.00	kg
Aluminium	1.00	pcs	18.00	kg
Cast Iron	1.00	pcs	1070.00	kg
Copper	1.00	pcs	26.00	kg
Steel	1.00	pcs	1542.00	kg
Polyethylene	1.00	pcs	22.00	kg
Electronics	1.00	pcs	136.00	kg

VITO, KU Leuven, & TU Graz. (2018). <https://doi.org/10.2779/23505>

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## **IEA EBC Annex 72: The be2226 office building in Lustenau: Architectural characteristics, BIM model and LCI**

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