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Scenario modelling for life-cycle analyses

an explorative use of conventional 3D BIM

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How many dimensions can be modelled in BIM? In literature typically five are mentioned: the three dimensions of space, time and costs. These are also the dimensions that are considered in life-cycle costing analyses (LCC). Consequently, BIM has the potential to collect in one place all necessary information to perform life-cycle analyses and hence facilitate the comparison of large series of design alternatives.

space + time + costs

After some experiments it was found that it was not evident to use BIM for life-cycle costing, in particularly not for modelling the complex life-cycle of a building. In this presentation we illustrate, starting from our expectations, how BIM did and did not meet our requirements. Thereafter, developments to bridge the remaining gap between BIM and LCC are proposed.

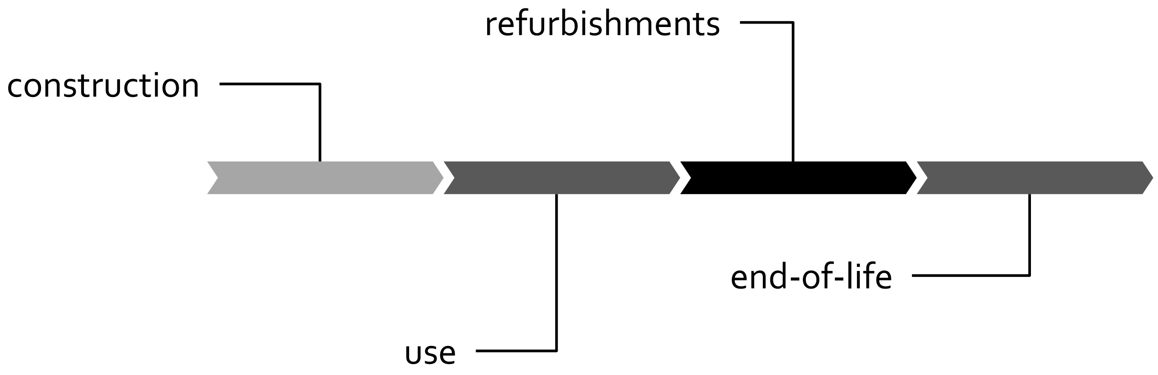
what we **expected** from BIM

how BIM did (not) **meet** our expectations

how we **tweaked** BIM to do so

First expectation is that BIM supports the modelling of a building's complete life-cycle including its construction, use, future refurbishments and decommissioning. Including all life-cycle stages is important because some alternatives might have a high initial cost but low use, refurbishment or end-of-life cost. Only considering the complete life-cycle will bring sufficient insight to compare correctly the different proposals at the table.

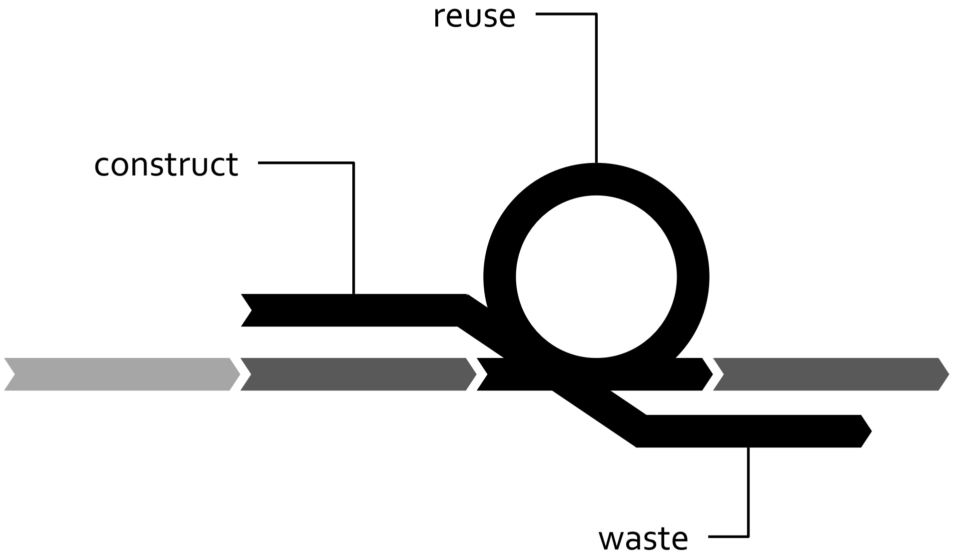
Expectation 1. BIM supports the description of a design alternative its complete life-cycle.



The second expectation is that BIM could trace the complex life-cycle of a building and its parts. For example refurbishments are not just another life-cycle stage of the building but the addition of new elements, removal of other elements and why can't we reuse building components? Modelling complex life-cycle events is particularly important since it is during these events we expect different life-cycle savings from different design proposals.

In our research team we develop for example demountable and reusable building elements and versatile structures that facilitate future refurbishments. To be able to evaluate the gains of those design measures it is important to include in our life-cycle model the associated costs and advantages.

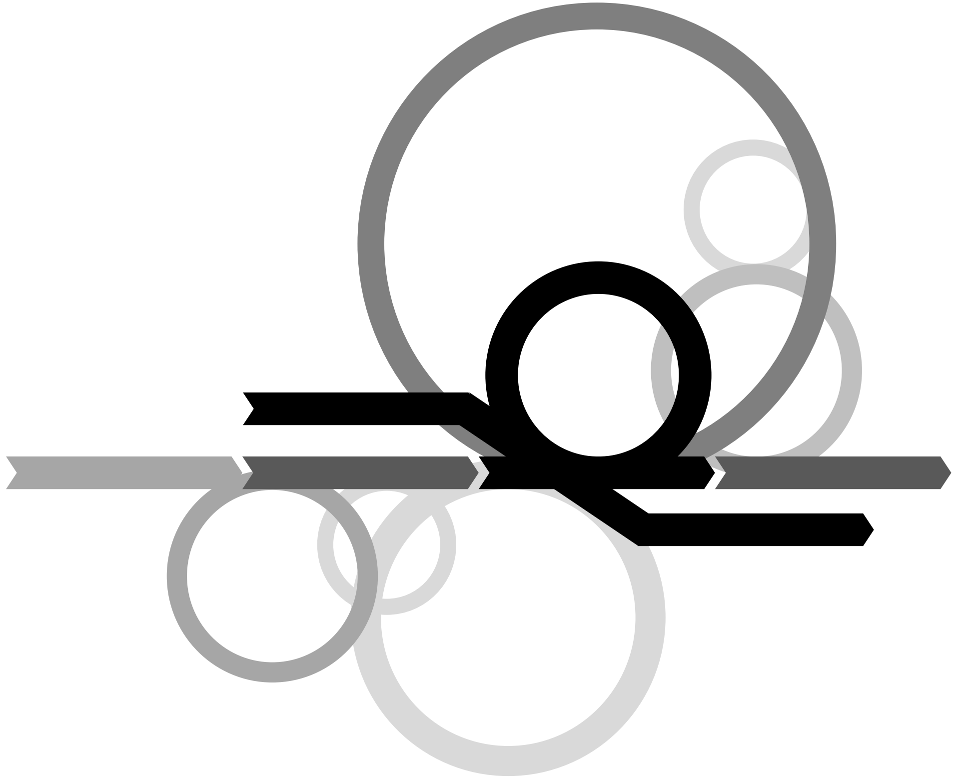
Expectation 2. BIM can trace the complex life-cycle of the building and its elements.



Expectation 3. With BIM it is possible to model very diverse life-cycle scenarios.

To acquire insight in an unpredictable future, it is not only necessary to model the expected life-cycle, but also to assess very diverse scenarios. What if our building is not refurbished at all? What if our reusable building elements are not reused but recycled? What if our building's function changes very early? Or if it is left before we expected it?

It might be clear that the life-cycle of a building is not just the linear continuation of its initial construction. Buildings change, their quantities change, just like their costs do.



On the one hand BIM is a multi-use and generic frame meeting some of our expectations. It allows for example to gather information at various levels.

At project level it is possible to save economic parameters like tax and growth rates. At element level it is possible to save valuation parameters like labour costs and material prices or technical characteristics like the replacement frequency and reuse potential. Further, in subsequent phases the future refurbishments can be modelled.

Finding 1. BIM allows to assemble information at various levels.

project + **element** + **phases**

On the other hand, BIM does not give any meaning to those economic parameters, prices and phases. The levels are not linked to each other.

In an element take-off it is for example not visible how many element can be reused during a refurbishment. Neither can be extracted at which time how many elements need to be replaced and at which cost that will happen. Nevertheless, these costs can make the difference between the assessed design alternatives.

Finding 2. BIM might be semantically not rich enough to model a scenario.

project + **element** + **phases**

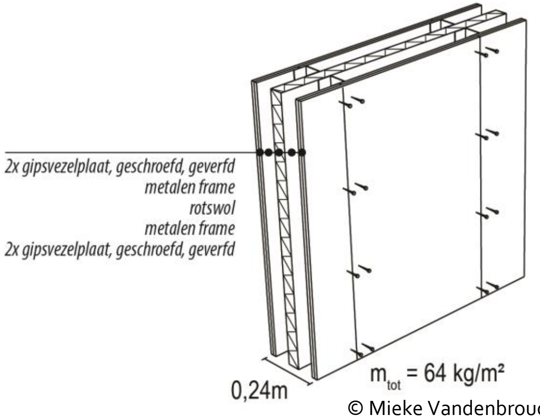
?

?

As BIM allows to store the expected information in a structured way, but just doesn't link it, we tried to link it ourselves using Visual Basis scripts to interpret element take-offs from BIM.

Imagine we want to assess the life-cycle cost of a demountable and reusable space dividing wall. Its take-off is presented, with the instances sorted by year of construction ($\boldsymbol{y_i}$) and year of demolition ($\boldsymbol{y_f}$). These are two properties assigned to each instance when modelling phases. To each of the resulting sub-life-cycles corresponds a quantity, i.e. the wall's area $\boldsymbol{a}$.

With the use of VBA-scripts BIM-data can be linked and interpreted.



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Element type: Space div. wall

$\boldsymbol{n}$	$\boldsymbol{y_i}$	$\boldsymbol{y_f}$	$\boldsymbol{a}$ [m²]
5	0	60	100
3	0	15	100
1	15	30	20
3	30	45	100
1	45	60	20

The same quantities can also be organised in arrayQ: vertically the year of construction and horizontally the demolition year.

Since this is a demountable wall, we should take advantage of its reuse as much as possible and avoid the creation of waste and consumption of new elements. For every year the building is refurbished (i.e. year 15, 30 and 45) we can verify if there are as many elements demolished as constructed and write this reused amount in arrayM.

With the use of VBA-scripts BIM-data can be linked and interpreted.

Array Q

y_i \ y_f	0	15	30	45	60
0		100	0	0	100
15			20	0	0
30				100	0
45					20
60					

Array M

y_m	
0	
15	20
30	20
45	20
60	

Element type: Space div. wall

n	y_i	y_f	a [m²]
5	0	60	100
3	0	15	100
1	15	30	20
3	30	45	100
1	45	60	20

If an amount is reused, its sub-life-cycle is not as short as arrayQ pretends. To include all the reuses we have to combine the sub-life-cycles to longer ones. This is done with a script verifying for every possible sub-life-cycle if it is possible to compose it out of two shorter ones. After this script the 5 initial sub-life-cycles are transformed to three sub-life-cycles including all possible reuses.

From these new sub-life-cycles we can calculate the actual life-cycle cost and add separately the cost to disassemble and reinstall the reused elements.

With the use of VBA-scripts BIM-data can be linked and interpreted.

Array Q

y_i \ y_f	0	15	30	45	60
0		100	0	0	100
15			20	0	0
30				100	0
45					20
60					

Array M

y_m	
0	
15	20
30	20
45	20
60	

Array Q’

y_i \ y_f	0	15	30	45	60
0		80	0	0	120
15			0	0	0
30				80	0
45					0
60					

Array M’

y_m	
0	
15	0
30	0
45	0
60	

Although our expectations were very high, BIM allowed to assemble a lot of information. Unfortunately, this information is not linked within BIM, so it is difficult to extract for example the potential reuse of elements.

The reuse of elements is of course only one example of the implications of a complex life-cycle. Other implications might be the effect of a changing function on maintenance costs, or the effect of a changing insulation performance.

Therefore, new features should be developed that support life-cycle analyses of different design alternatives through linking BIM information and acknowledging all the dimensions of a building’s life-cycle in particular its complex time dimension.

space + time + costs