Whitepaper – Univocal framework for post-calculation and 5D BIM – 2nd edition

Benchmarking building costs in Flanders - and by extension in Belgium - is a very tricky issue. Everyone shares their own definition of cost through their own calculation of m² of built floor space to arrive at a reference price per m² of floor space.

Agentschap Facilitair Bedrijf and PB calc & consult bv - which in 2008 received subsidies from the IWT, now VLAIO, in order to develop a new model/calculation system for the construction process, called BouwData (no.080429) - are joining forces to come up with a solution: a Belgian NEN2699, Investment and operating costs of property - Terminology and classification.

In addition, in collaboration with Bimplan, we make the link to the BIM model to determine the required quantities in a uniform way.

Objective of the whitepaper

The objective of this white paper is to provide designers with an scientifically based and practice-tested framework into which they can 'slide' their existing costing structure at the start of the design process.

In this way, a standardised way of collecting unit costs is created that can also be used by the client at the very beginning of the design process of his/her new project to benchmark this initial assessment of the funds required.

Difference with "business as usual"

The major difference from 'business as usual' is in two areas:

1. We very explicitly wish to be able to distinguish the influence of geometry. We will therefore make estimates per m² of façade, per m² of roof area, per m² of foundation footprint, per circulation core, ... Matters such as interior finishing and technical installations are related to the m² of floor area. Regarding the site and floor area, we resolutely choose to measure this in accordance with the 2011 European Facility Management standard NBN EN 15221-6. Why? Simple, it is European, has no rounding rules - which is compatible with the use of BIM modelling software - and the facility manager has the longest involvement in the life cycle of the building.

2. We also wish to open the debate on indirect costs. Overheads and the profit/risk percentage remain included in the cost indices and unit prices, but we would like to see the integral costs for work preparation, project supervision and site preparation with deployment of all its equipment estimated up front in a separate chapter. The costs for site preparation are preferably divided into a fixed start-up cost, a monthly cost during execution and a fixed break-down cost at provisional acceptance.

   After all, the pure production cost is virtually the same for all contractors. The difference is therefore to be found in the management provided by contractors and their know-how related to the deployment of equipment. It gives the client insight into the process and raises awareness that changes at the start of work preparation have a very different financial impact than a few weeks before provisional acceptance.

History of standards

Onthis subject, please refer to the first edition of the white paper[1]

Framework for the proces

RIBA plan of work[2]

On 31 August '23, Buildwise published an article written by Louis Casteleyn, Stefan Boeykens and Peggy Bovens on phasing in construction[3].

A first possible step towards harmonising our construction sector seems to be defining a roadmap for the process itself with a defined content, a 'plan of work'.

RIBA plan of work 2020 is its accepted interpretation in the UK but is also widely used in an international context. It is therefore not illogical to use it as a starting point.

This does have two important consequences:

❑ Tendering and contracting are not seen as a separate phase, but are an activity that recurs in different phases.

❑ The building permit request is not seen as a separate phase, but as a deliverable to be delivered within a certain phase.

---

[1] https://www.vlaanderen.be/vlaamse-overheid/werking-van-de-vlaamse-overheid/bouwprojecten-van-de-vlaamse-overheid/whitepaper-bouwkost
[2] https://www.architecture.com/knowledge-and-resources/resources-landing-page/riba-plan-of-work
[3] Cfr https://www.buildwise.be/media/p5ua5lwd/bim-artikel-phases-bouwindustrie-nl.pdf

Standard tasklist (STL)

In Belgium, we also have the Standard Task List.

This is a table in which all tasks and responsibilities associated with a construction project are listed and can be completed by all parties involved in the design and realisation of construction projects. The document helps the parties involved agree on who takes on which task and improve cooperation between all actors in the construction process.

The list was prepared by the G30, ORI and VBA-ADEB taking into account feedback from the UPSI-BVS, NAV and Buildwise. However, it was not explicitly inscribed in any of the standards studied in Buildwise's phasing article mentioned above.

Meanwhile, Martine Deloz and Peggy Bovens aligned the STL with RIBA plan of work and the updated list was published by Buildwise in November '23[4]

Overview of the phases

BouwData has opted for RIBA plan of work since 2013 as it is entirely consistent with the scheme that resulted from the IWT study in 2008.

Characteristic images were added to make things easier to understand:
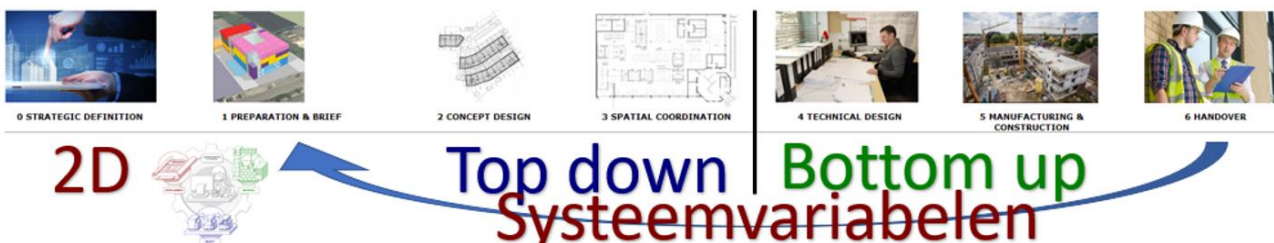
This **white paper** is situated in **phase or stage 1 preparation & brief**.

In this phase, the task is to fit the list of requirements and corresponding required floor areas into a volumetric model that architecturally fits best with the surroundings and urban design guidelines. And then to make an estimate for this volumetric model on the basis of element clusters.

---

[4] https://www.bimportal.be/nl/standaard-taken-lijst-stl/#:~:text=De%20Standaard%20Takenlijst%20is%20een,en%20de%20realisatie%20van%20bouwprojecten

New insights from CEN/TC442

The aim of the European standards committee CEN/TC 442 'Building Information Modelling' is to develop a number of European standards in the coming years that aim to facilitate 'across-the-border cooperation' in BIM projects.

One of the ISO standards they are scrutinising is the 2015 ISO 12006-2 Building construction - Organisation of information about construction works - Part 2: Framework for classification, which was also published as an NBN standard in 2020.

The new draft currently on the table offers very good additional insights that are necessary to know, if one wishes to put this white paper in the right perspective.

Space Aspects

The BouwData diagram on previous page mentions 'system variables'.

In the first edition, these were discussed under the section 'Identification under Cuneco Classification System' where they are called 'object classes'.

These correspond almost entirely to what are called 'space aspects' in the new draft of ISO 12006-2.

Below we list them again including continuity with what we know to date:

❑ **[C] Construction Complex**

TU Delft defines this in relation to the Elements method (table 1 BB-SfB) as follows: a complex is a collection of several related structures.

Usually this corresponds to the entire project. For this, a unique ID should preferably be created that is used by all parties. If this is not possible, an unambiguous conversion table should be created in the BIM execution plan.

❑ **[E] Construction Entity[5]**

This corresponds to a structure or building.

TU Delft defines this in relation to the Elements method (table 1 BB-SfB) as follows: a structure is the complete collection of functional objects and/or physical objects required to meet a need for accomodation.

If the project consists of several buildings, a list of unambiguous IDs for each building should also be made, to be used consistently by each partner in the project.

---

[5] In the new draft of ISO 12006-2, they use this term only in the context of 'physical aspects' and jump from complex directly to zones. Something that in practice is too big a jump. That is why we stick to CCS.

❑ **[P] Subprojects[6]**

This is a class that exists exclusively within the BouwData methodology and its purpose is to define subprojects. These subprojects each have an investment that is plotted out over time where the funding required for this subproject can be clarified.

If the project consists of several contractually defined subprojects, here too a list of unambiguous IDs for each subproject must be created and used consistently by each partner in the project.

❑ **[S]Storey**

This corresponds to a floor or building layer. In the first edition of the white paper, we used the definition of Rijksvastgoedbedrijf in Nederland BIM namely specification v.1 .1.c paragraph 2.1.9. However, after ample consultation with various actors, this proved to be difficult to achieve in practice for both the structural engineering offices and BIM modellers. Hence, we now locate the division between building layers on the **top of the load-bearing structure**. This means the foundations form a separate building layer but equally so the roof finish of the top floor.
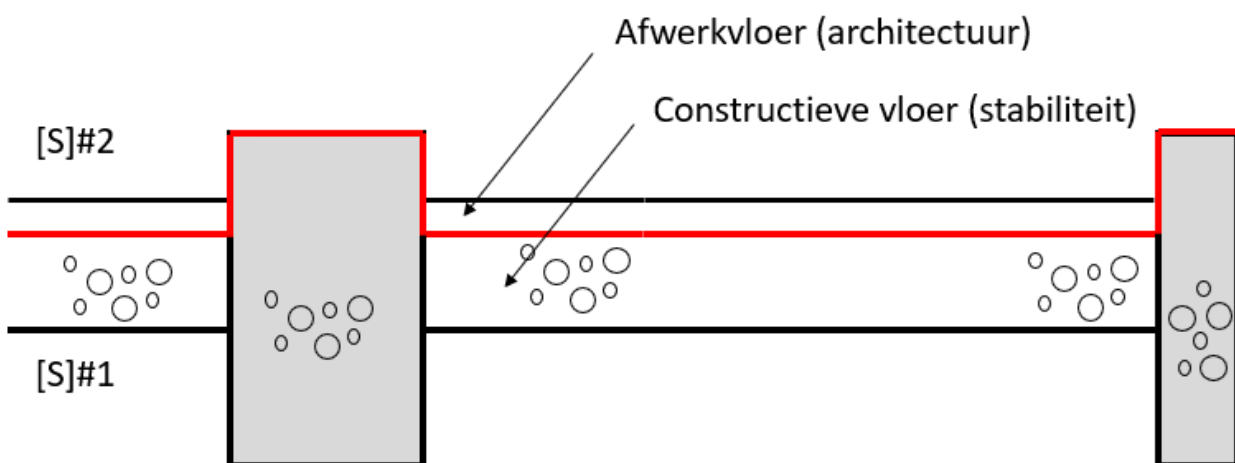
Er dient een lijst gemaakt te worden met éénduidige ID's voor elke bouwlaag van elke entity die door elke partner in het project consequent gebruikt wordt.

---

[6] In the first edition still referred to as 'phases' but as part of the research of the article on phasing commissioned by Buildwise, this term was changed to 'subprojects'.

❑ [Z] Zones

The new draft of ISO 12006-2 pushes this space aspect more explicitly than the 2015 edition. Especially for large projects, it is important to introduce this already in phase S1 preparation & brief[7] because each zone will generate a very distinct set of unit costs[8].

e.g. in a hospital, one distinguishes operating theatres, care wards, delivery quarters, central sterilisation, ...

A list should be made with univocal IDs for each zone of each storey of each entity, to be used consistently by each partner in the project.

In large projects, it is advisable to start drawing up this list in phase S1 preparation & letter, but it becomes definitive only in phase S2 concept design.

❑ [B] Built Space

Built Spaces only come into the picture from phase S2 concept design onwards and become definitive only in phase S3 spatial coordination. However, for the sake of completeness of the breakdown, we also discuss them in advance in this white paper.

This corresponds to a space.

TU Delft defines this in relation to the Elements method (Table 1 BB-SfB) as follows: a space is an area (belonging to a structure) that is bounded in theory or in reality.

Built Spaces can be classified in several ways, however, the first way (according to EN 15221-6) is always mandatory[9] . The other ways may be done additionally when required by the client's or contractor's own processes:

1. In accordance with NBN EN 15221-6, being:

   - PA Primary Area
   - CA Circulation area
   - AA Amenity Area
   - TA Technical Area

2. Conforming Uniclass Spaces (advisable for large projects)
3. Conforming CCS Spaces (advisable for small projects)
4. Project-specific classification[10]

---

[7] Only in phase S2 concept design should these be finalised.

[8] Unit costs (KKG) = characteristic costs per unit of cost carrier for the whole structure, a spatial part thereof, an element cluster, an element, or per functional unit

[9] See also further in this white paper regarding modelling

[10] This only allows benchmarking within its own organisation

❑ **[A] Activity Space**

Activity Spaces only come into the picture from phase S2 concept design onwards and become definitive only in phase S3 spatial coordination. However, for the sake of completeness of the breakdown, we also discuss them in advance in this white paper.

In CCS, a theoretical space falls under this class.

E.g. an open kitchen in a flat or house is an activity space.

An <u>enclosed</u> kitchen however is a Built Space.

Functional system versus technical system

In the BouwData diagram on page 3 regarding phasing, there is talk of 'top-down' versus 'bottom-up'.

The 'top-down' reasoning or 'functional system' as mentioned in the new draft of ISO 12006-2 occurs in phases S1 preparation & brief, S2 concept design and S3 spatial coordination and emphasises function. How exactly you will execute things is of secondary importance. The associated construction cost is determined on the basis of unit costs obtained from financially completed projects.

The 'bottom-up' reasoning or 'technical system' as mentioned in the new draft of ISO 12006-2 occurs in phases S4 technical design, S5 manufacturing & construction and S6 handover and emphasises materialisation. What exactly it serves for has already been defined in the previous phases and can therefore fade into the background. You determine the corresponding construction cost by asking prices in the market for the project to be realised.

Measurements

Concerning oiur motivation as to why we prefer EN 15221-6 to NEN 2580, we would also like to refer to the first edition of the white paper.

Floor areas according to NBN EN 15221-6:2011

We no longer talk about gross and net floor area, but use the following terms:

❑ Art. 5.2 '**Level Area (LA)** is a measured area for one level, including all areas contained inside and measured to the outside permanently finished surface. This includes penthouses and mezzanines, basement and enclosed/covered connecting walkways and linkways'.

❑ Art. 5.3 '**Non-functional Level Area (NLA)** is a measured area, consisting of voids, atriums and cavities '

Concretely, this means that areas within the built volume where at the bottom of the considered volume there is no closing load-bearing floor slab or fireproof barrier, belong to the NLA.

In other words, a crawl basement belongs to GFA,A. However, if it is backfilled completely with soil, it belongs to the NLA.

❑ Art. 5.4 '**Gross Floor Area (GFA)** is the calculated area of Level Area (LA) excluding the Non-functional Level Area (NLA): LA-NLA=GFA

For further break down, we refer to the standard itself and jump here at once to:

❑ Art. 5.10 '**Net Room Area (NRA)** is the sum of all floor areas measured to the internal surface of each room'. NRA is further subdivided into:

▪ **Primary Area (PA)**

▪ **Circulation Area (CA)**

In terms of 'circulation', it is important that a circulation path of e.g. 1,50m wide always exists between the four types of NRA when the areas need to be integrally accessible. Only when a PA is adjacent to a PA, there is no need for a defined circulation path.

e.g. a landscape office (i.e. a Built Space with multiple Activity Spaces) where on one side is the entrance hall with stairs and lifts (CA) and on the other side is the sanitary block (AA), then across the landscape office (PA) the shortest possible route has to be demarcated by a line. The length of the line multiplied by 1.50m gives the additional CA to be subtracted from the PA of the landscape office.

However, if e.g. there are more than 3 workplaces in a row with a circulation area on one side only, then in order to reach the workplaces beyond place 3, a 'branch' from this circulation area will also be needed.

Another example: a corridor with a waiting area e.g. in front of registration desks in a hospital is considered as follows: if the seats are in a clear inlet, then that area is considered an activity space of type PA. The corridor itself, even if there are chairs in it, is an activity space of type CA. Both together form a Built Space with thus multiple types of NRA.

Circulation Area (CA) versus system variable [Z] zone:

➢ When a CA serves multiple [Z], then this CA should be assigned its own separate [Z] ID

➢ When a CA is purely within one [Z], then it is only that concerned Built Space [B] that falls under CA

▪ **Amenity Area (AA)**

What one understands by 'amenity' is to be defined per project and cannot depend on whether there is a sanitary unit in it or not.

E.g. for hospitals, this can be defined differently than for an office building.

From a facility management point of view, it is in one's interest to label as many NRA as possible as PA, given that PA are associated with the highest maintenance budgets.

From the point of view of the cost expert, one mainly looks at the construction cost per sq m and tries to take similar things together.

Collective accomodations (youth institutions, hospitals, etc.) often have rooms with their own sanitary cell. The latter falls under AA. Thus, one can determine a ratio of sleeping/working area (PA) and sanitary cell (AA) and convert this into a design requirement if needed.

▪ **Technical Area (TA)**
Both accessible (with full-sized door) and non-accessible (only with inspection hatch) shafts belong to the NRA type TA.

The above surfaces are measured at the top of the finished floor.

Annex B.4 clearly states that the following applies to stairs and sloping surfaces:

❑ The height to be bridged is less than or equal to 1.5m: the horizontal projection of this staircase belongs integrally to the same floor level.

❑ The height to be bridged is greater than 1.5m: the horizontal projection from the first step onward belongs to the next floor level.

Regarding the space <u>under</u> stairs (both open and closed), on each level the full NRA between the walls is taken into account, except for the void between stairs when there are intermediate landings. The latter is NLA. The justification is:

❑ One will namely never interrupt the foundation slab because a staircase is present, even in an enclosed tube where the lower flight is completely enclosed and serves no purpose.

❑ A staircase between storeys should actually be regarded as a 'collapsible attic staircase' where one measures in 'collapsed condition'.

At the lowest storey, the space under the stairs belongs to type 'Circulation Area' by default. Only if it is an enclosed space with a clear function description will this change to the 'amenity' type if, for example, it contains a toilet or is a storage area.

Regarding the space under a pitched roof, sloping wall or column: The standard does not establish a relationship between the Net Room Area (NRA) and the available free height above it. This is in contrast to the Dutch building code, where a relationship is established and a clear height lower than 1.50 m is not considered.
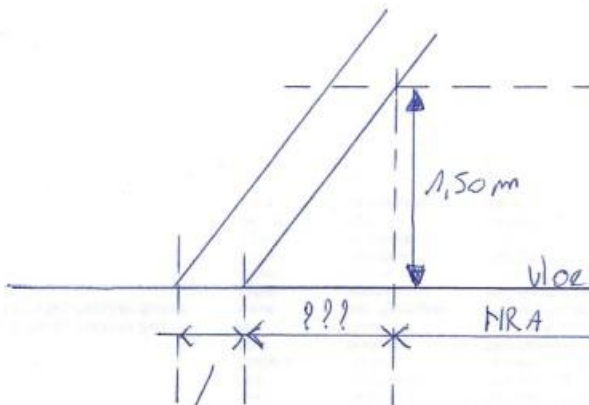
After consultation, the Agentschap Facilitair Bedrijf decided to follow NBN EN 15221-6 and also call the part of the space with a clear height lower than 1.50m NRA. This is partly to avoid disturbing the breakdown from LA to NRA and partly because it is up to the user to decide what to do under the sloping wall, stairs or slope and whether to leave this shell or finish it completely like the rest of the room.

If the user nevertheless wishes to set a limit at 1.50m, the NRA with free height equal to or greater than 1.50m is called NRA,a and the NRA with free height less than 1.50m is called NRA,b.

If the sloping wall above is a pitched roof construction and there is a light wall in plasterboard on the vertical dotted line, for example, then the whole package from the outside to the light wall projected on the horizontal plane of the floor pass will be ECA (exterior construction area). On further analysis, you will then see that the ECA/IFA (internal floor area) ratio for that project will be rather unfavourable.

The ratio of Gross Floor Area to Level Area gives an idea of the 'architectural freedom'. After all, voids largely determine the perception of a building.

The ratio between Net Room Area and Gross Floor Area gives an idea of how much space the structure itself occupies. Professional literature in the Netherlands reports 8%, architects in Flanders generally use 10%, but effective calculation in as-built files tells us that this falls between 12% and 15%. But this can even rise to more than 20%.

This percentage is calculated as 1 - NRA/GFA.

So suppose you have a GFA of 707 m² and an NRA of 623 m², then the proportion taken by the construction is 1 - 623/707 = 11.88%.

All the above categories belong, in theory according to the standard, to one of the following types:

❑ **Type A**: spaces which are entirely covered and enclosed on all sides up to their full height

❑ **Type B**: spaces which are entirely covered but not enclosed on all sides up to their full height (e.g. recessed balconies)

❑ **Type C**: spaces which are not covered, but contained within components (e.g. open balconies)

However, this theoretical approach means that for a series of purely cantilevered terraces, the upper one belongs to type C and the lower one to type B while they all have the same surface area and building cost.

Hence, we propose the following correction:
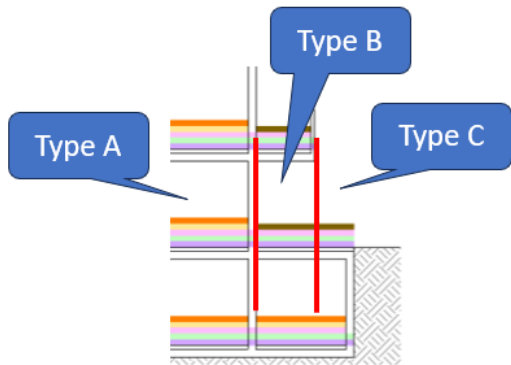
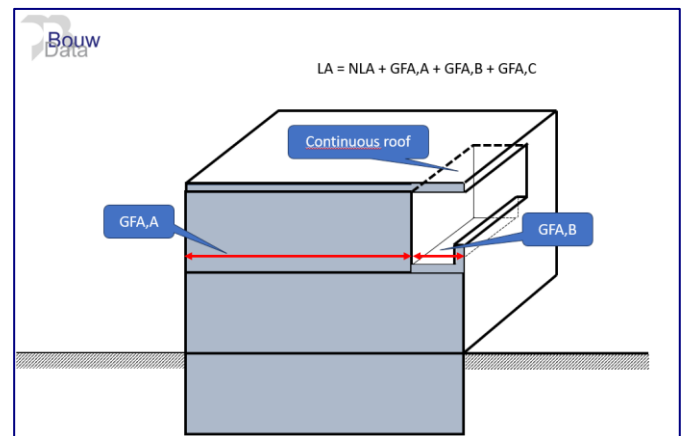Strikte definitie norm NBN EN 15221-6
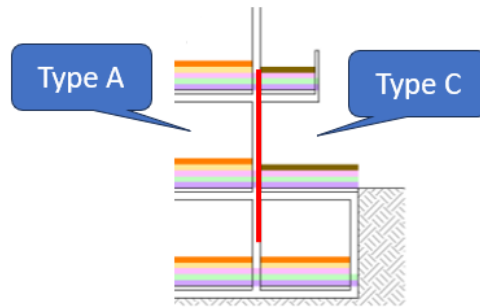
Aangepaste definitie norm NBN EN 15221-6:
Type B: covered by
  - acclimatized interior space
  - continuous roof (zie volgende slide)
Type C: not covered or covered by
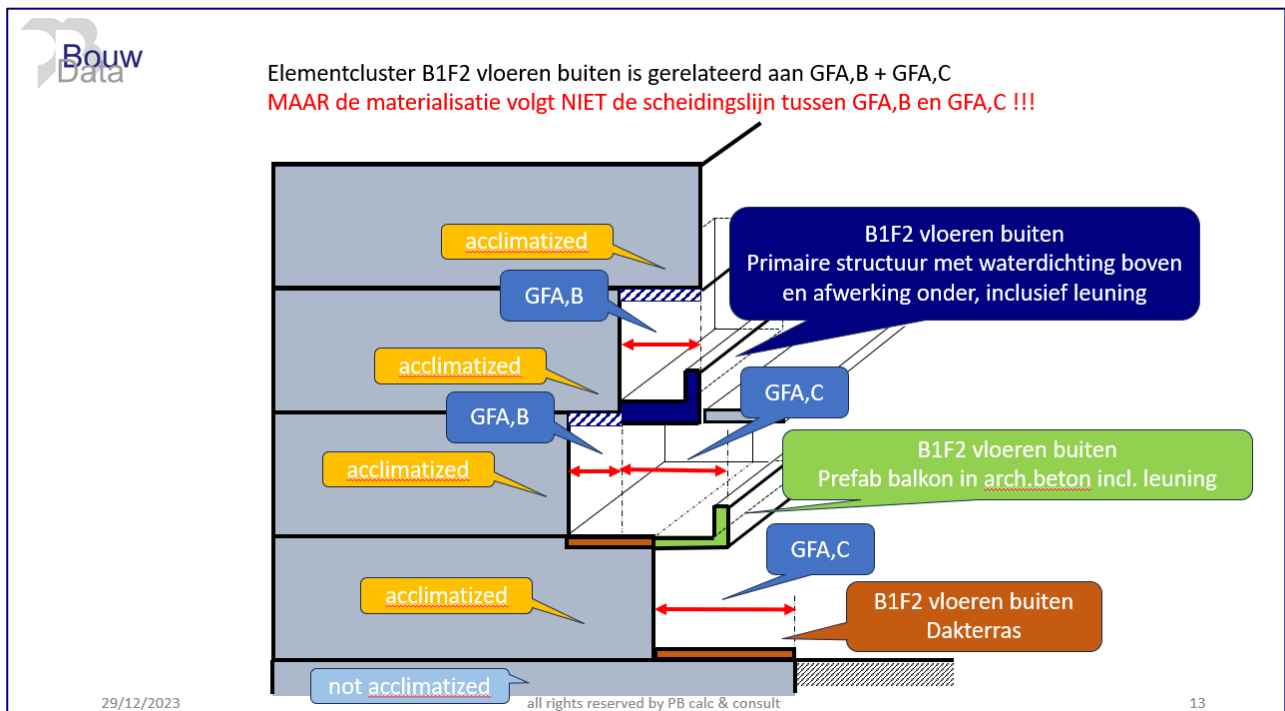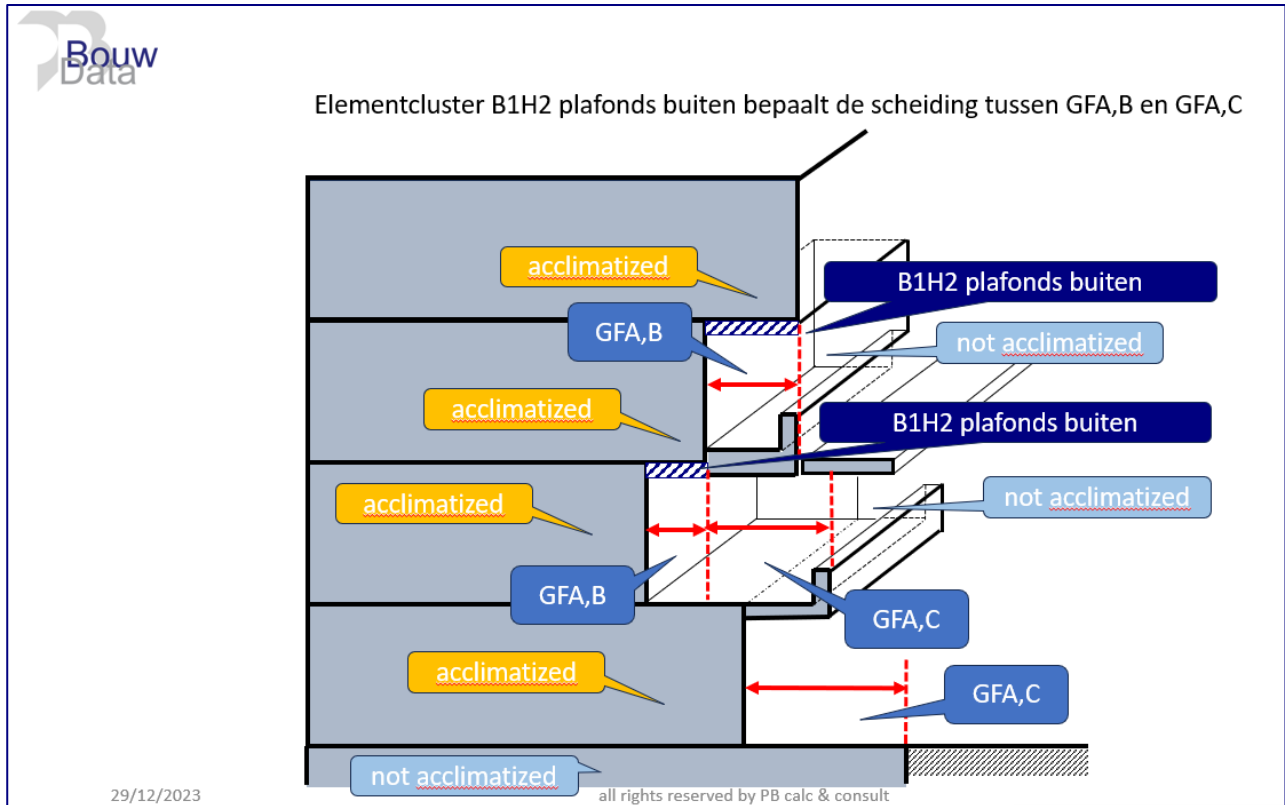 - not acclimatized interior space
  - outside space

LA = NLA + GFA,A + GFA,B + GFA,C

The difference between external area type B/C and external area on the ground floor lies in whether there is a finish directly on top of the watertight layer needed to protect the underlying basement (in which case it is type B/C depending on whether or not there is an upper area type A above it) or whether there is a soil volume on top.

So a floor slab that remains in place during a renovation but no longer encloses a basement floor and now forms a patio is external area.
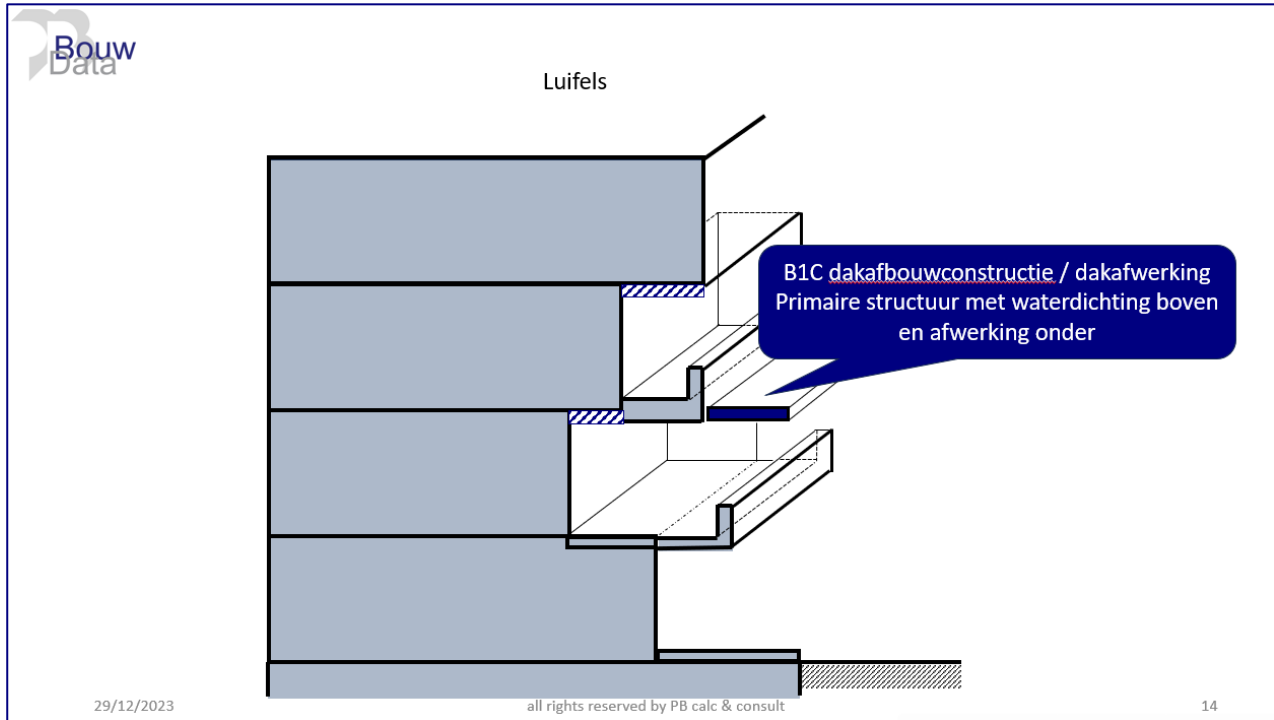
In the case of an **entrance to an underground car park**, the separation between GFA type B/C and GFA type A is situated on the separating element (gate or fence).

Anticipating the definitions of the various element clusters later in this whitepaper, we provide below some characteristic images that make things more comprehensible:

Luifels

B1C dakafbouwconstructie / dakafwerking
Primaire structuur met waterdichting boven
en afwerking onder

Terrain areas in accordance with NBN EN 15221-6:2011

With regard to areas outside the building, the following definitions are the most important ones:

- ❑ Art. 6.1.1 '**Plot Area**: area of land delineated by its boundaries, which may be referenced by authorities'.
- ❑ Art. 6.1.4 '**Building Footprint**: area of those parts of a building which are at ground level, when projected on a horizontal plane'
- ❑ Art. 6.1.8 '**External Area**: parts of the plot area which is not covered with buildings according to their footprint'

The above means that - and this is confirmed in Figure 19 in the standard - when the concrete slab of an underground building volume is finished and serves as a parking space this belongs to the building footprint type C.

If this underground volume is covered with a paved surface for parking cars, it belongs to the External Area.

For correct benchmarking, it is best to make a distinction between:

- ❑ '**Public'** when part of the Plot Area becomes public space where funding partly comes from a government. AWV's SB250 will apply to this part of the Plot Area. In NEN 2699 - see also later in this article - this belongs to cluster A3 Infrastructure Facilities.
- ❑ '**Communal'** when this part of the plot area forms a common garden for the occupants of the plot.
- ❑ '**Private'** when this part of the plot is accessible only to an individual occupant of the plot.
- ❑ '**Wasteland'** when part of the plot remains fallow.

Here are a few images to make things clearer:

Building footprint versus foundation footprint

LA versus external area
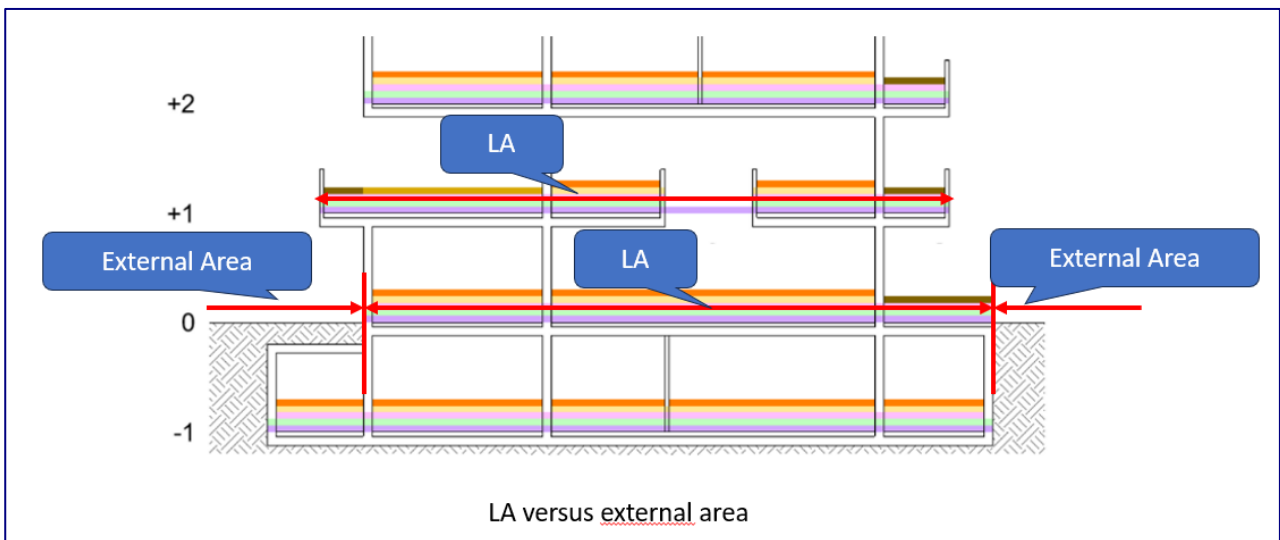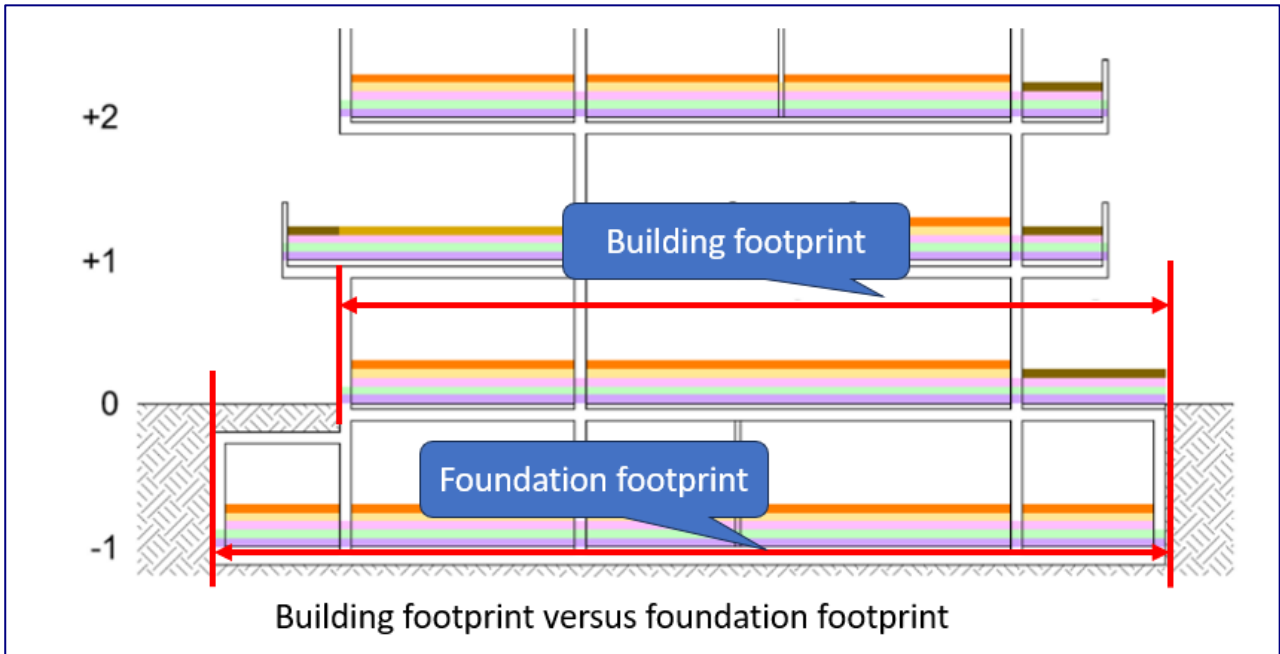
Facade area

General rule on facade measurement:

- For a detached building, per storey, the perimeter of GFA type A is multiplied by the storey height (from finished floor level to finished floor level).

- For a semi-detached building or building between two or more existing buildings, per storey, the length of the common wall(s) is subtracted from the perimeter of GFA type A before multiplying by the storey height (from finished floor level to finished floor level).

- For the upper storey, the height from the finished floor level to the eaves if no overhang or to the intersection of the façade with the slope of the roof
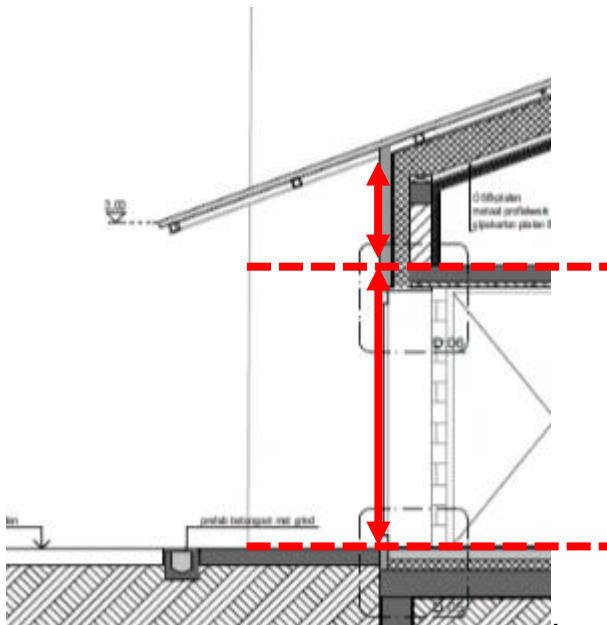
- For a pitched roof, the height is initially from the finished floor level to bottom of gutter to which the area of the gables is added.

The above rule implies that all wall structures including their finishes, that surround a GFA type B or type C, are NOT part of the facade area.

Their cost will be allocated to the element cluster B1F2 floors outdoors. This will lead to a great variety for the cost per m² GFA type B and C. A description will therefore always be needed for exterior spaces.

In addition, e.g. the cladding item from the bill of quantities will have to be allocated via proportionately to, on the one hand, B1D façade construction / façade finishing and, on the other hand, B1F2 floors outdoors.

Tip to know the separation between B1F2 and B1D is: what drops out if the exterior space is not built? All façade elements that drop out belong to B1F2 floors outdoors.

For building layers that are half below ground, half above ground, the facade area is measured according to the general rule and then a percentage of it is taken that is effectively above ground.

Cladding of free-standing outdoor columns is part of the façade area, as the floor area of these columns must be included in the Level Area according to NBN EN 15221-6. And as there is no non-functional level area for free-standing columns outside, this also belongs to the gross floor area. The height is the same as that of the relevant storey unless, in the case of a sloping site, it is set much lower. In this case, the height is the difference between the finished floor level of the level above and ground level.

Boundary between facade area and roof area:
- One makes a "wrap" around the execution model. The boundary between the horizontal or sloping roof surface and the vertical plane of the facade forms the boundary. Deck bricks on cavity walls are therefore covered by B1C Roof construction/roof finishing
- In buildings where the façade flows seamlessly into the roof in a curved shape, the entire area will be considered as roof area. The element cluster B1D Façade construction/roof finishing remains empty.

Exterior stairs

An external staircase with intermediate landings and its own cover is measured by piece per storey. All associated costs (foundation, external staircase itself, finishing, handrails, cover, etc.) belong to element cluster B1G2 stairs and ramps outdoors.

Tip to know the separation between B1G2 and B1D is: what drops out if the external staircase is not built? All façade elements that drop out belong to B1G2 stairs and ramps outdoors.

Cost structure in a functional system: NEN 2699

NEN 2699 has 6 levels, 4 of which were given concrete content.

- ❑ Niv 1 headings
- ❑ Niv 2 clusters
- ❑ Niv 3 element cluster
- ❑ Niv 4 elements
- ❑ Level 5 free - i.e. technical solutions
- ❑ Niv 6 free - i.e. STABU / MAMO rules

However, this standard does provide a structure for cost classification but does not say by which unit this should be divided to arrive at a unit cost.

Solving this gap forms a large part of the pre-normative study N° 080429. The adjustments were highlighted in red in the first edition. However, for the sake of readability, this has not been repeated below.

Level 1 headings

- ❑ A LAND COSTS

    total costs of acquiring the land, providing infrastructure, and making the land suitable for building on it
    ⇨ related to the m² Plot Area

- ❑ B INITIAL BUILDING COSTS under the link to EN 15221-4/6

    Costs arising from commitments for the physical realisation (= building) of the construction works
    ⇨ related to the Σ^{11} m² Level Area broken down by [E] entity

- ❑ C FURNISHING COSTS

    costs incurred in order to be able to use the building or buildings in accordance with its or their purpose
    ⇨ best expressed as a % of B

- ❑ D ANCILLARY COSTS

    costs relating to preparation and supervision
    ⇨ best expressed as a % of S(A+B+C)

- ❑ E UNFORESEEN EXPENSES

    surcharge on the basic estimate to cover future uncertainties
    ⇨ best expressed as a % over S(A+B+C)

---

[11] Summation across all floors of the entity concerned

❑ F TAXATION = VAT (in the construction world, prices are always quoted exclusive of VAT - sometimes confusing for non-profit organisations that are subject to tax)

❑ G FINANCING

⇨ this is usually excluded from the scope of benchmarking

❑ X OPERATING COSTS

full or partial use, maintaining ready for use and ownership of a property
⇨ it is advisable to replace this substantiation with this in accordance with NBN EN 15221-4

❑ Z BENEFITS ⇨ this is usually excluded from the scope of benchmarking but could thus be capitalised to accommodate the value of materials 'stocked' in the building and thus 'released' on demolition. But for this to be decided definitively, the cost control surrounding circularity needs to be a little further along.

Level 2 clusters

In the context of this white paper, we focus on section B INITIAL BUILDING COSTS. This is divided into the following clusters, with some additions to clarify matters for the Belgian market:

❑ B1 Construction works

⇨ related to the Σ m² Level Area split per [E] entity

❑ B2 Technical installations

⇨ related to the Σ m² Level Area split by [E] entity

❑ B3 Fixed furnitures and fittings

⇨ related to the Σ m² Level Area split by [E] entity

❑ B4 Land

⇨ related to m² External Area, communal & private[12]

❑ B5 General execution costs / miscellaneous

= costs of equipment and/or labour required for the execution of a construction project, insofar as these costs are not related to resources, such as materials, that remain on the construction site upon completion

⇨ best expressed as a % of Σ (B1+B2+B3+B4)

---

[12] External Area type public falls under cluster A3 Infrastructures and External Area type wasteland has no costs and therefore should not be taken into account (if one were to do so, this would lead to a 'dilution' of the unit costs and an underestimation if one were to use it when estimating a subsequent project)

Level 3 elementclusters

When one wishes to estimate a volumetric study or sketch of a new project, one needs to be able to calculate many scenarios in a short time. Level 1 Headings and Level 2 clusters are too coarse to weigh design A at site X versus design B at site Y. It is also important to realise that modelling software that automatically generates schedules with quantities is very labour-intensive and will not be used at this early stage of a project. People will rather work with modelling software that can quickly give the customer a good insight into the experience of the design. In other words, working parametrically is not yet an issue here. Therefore, one will not make a detailed distinction between various [S] storeys and [Z] zones for all element clusters. Only when one of these system variables needs a very clearly different unit cost, it's worth to spend time on this.

Each cluster breaks down into element clusters. Each element cluster in turn breaks down into elements. At this level, we recognise Table 1 of the SfB. However, to benchmark smoothly and precisely, this needs considerable tinkering. Also, at this level, benchmarking is best broken down further from [E] entities to [Z] zones.

Estimates are better made via element clusters than via a 'flat' m² price. Simply because one can then take better account of the architectural design.

In mutual consultation, the Agentschap Facilitair Bedrijf and PB calc & consult came to the following classification and corresponding measurement in order to arrive at a unit costs that can easily be used when estimating subsequent projects.

The most important deviations between the original NEN2699 and the belgian version are marked in red.

Important note on **demolition works**:

❑ Global demolition falls under section A Ground costs

❑ Local demolition or dismantling falls under the heading B Initial Construction Costs and, in accordance with the philosophy of the BB-SfB Plus from 2008, is counted as part of the element cluster for which the demolition works are required

This applies equally to asbestos removal or removal of other hazardous materials.

This implies that unit costs for renovation works may vary widely, whereas for new construction projects it will be easier to draw statistically sound averages.

B1 Structural works

B1A Foundation

This does not include site sanitation or prior demolition works.

Only the removal of topsoil, excavation work including backfilling, any deep foundations, elevator pits and pump wells, the general foundation slab and soil and water retaining walls. It is best to make a note whether this involves one, two or three underground building layers. After all, each will generate a different unit cost. As a rule, each additional underground construction layer doubles the unit cost.

Unit: m² foundation footprint, split by [E] entity

B1B Skeleton

This includes the entire load-bearing structure of the built volume type A including the structure within the underground watertight building pit and the roof slabs.

Protruding terraces are therefore not included here.

Stairs and intermediate landings are also excluded from this element cluster. These are integrally included in element cluster B1G1 or B1G2 depending on whether they are inside or outside.

Unit: Σ m² gross floor area type A, broken down per [E] entity and possibly per [Z] zone if they have clearly distinguishable load-bearing structures, each with its own cost identifier.

Attention point 1: In B1A Foundation and B1B Skeleton, horizontal support structures have priority over vertical support structures

e.g. a roof slab or floor slab at ground level continues over the basement wall

Attention point 2: B1B Skeleton has 2 possible interpretations, each with its own cost attribute:

❑ *Underground building layer: load-bearing inner structure + covering floor slab*

❑ *Above ground building layer: load-bearing inner structure + bearing facade structure + covering floor slab or roof slab*

B1C Roof construction/dakafwerking

This includes non-load-bearing primary structures as well as roof openings and roof finishes for areas accessible for maintenance only.

Unit: m² roof area (according to slope, no projection), split by [E] entity[13]

*Attention point 1: in roofing, the first distinction made is accessibility*

❑ *If only accessible to maintenance personnel => element cluster B1C - to be linked to roof area*

❑ *If also accessible to other persons => element cluster B1F2 - to be linked to GFA, B/C*

   i.e. also large intensive green roof between flat blocks that will be located directly on top of a continuous underground parking layer

Attention point 2:

❑ *a "bulge" of interior space in the roof plane is a dormer or roof lantern. All associated costs fall under element B1C(37) roof openings*

"uitstulping"

dakkapel   daklantaarn
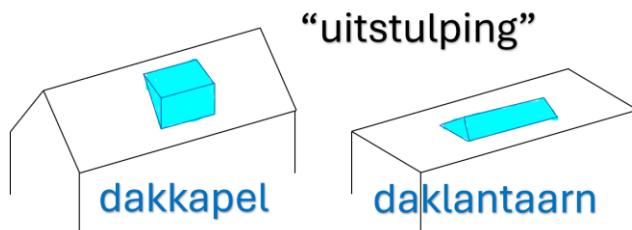
❑ *A "bulge" of exterior space in the roof plane is a roof terrace. The load-bearing structure falls under B1B Skeleton , the wall finish under B1D Façade construction/façade finish and the floor finish under B1F2 Floors outside*

"instulping"
dakterras

---
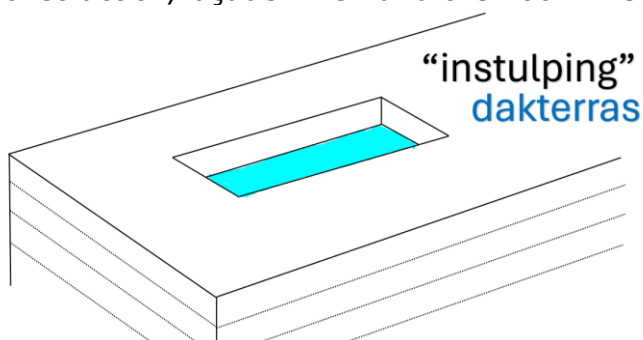
[13] The "envelope" of the building (façade and roof) is determined per entity and divided into zones on a pro rata basis per m² GFA. Division by zone is only relevant for openings. However, the distinction between closed and open parts of the envelope is only made at level 4 elements when preparing a budget.

B1D Façade construction/façade finishing

This includes non-load-bearing primary structures as well as facade openings and facade finishes.

Here, we follow the international SfB philosophy, as a result of which this element cluster with regard to the façade openings also includes all exterior and interior accessories. So also the finishing of the wall opening or interior sun blinds.

Unit: m² facade area (according to slope, no projection), split per [E] entity

B1E Interior wall construction/interior wall finishing

This includes non-load-bearing primary structures (i.e. also non-load-bearing masonry, plaster block walls, lightweight walls, etc. as well as interior doors, windows and grilles and all interior wall finishes, including the inside of external walls).

Unit: Σ m² gross floor area type A, split by [E] entity and [Z] zone

The diagram below of an exterior wall with window shows in blue what belongs to B1D Façade construction/façade finishing and in rust brown what belongs to B1E Interior wall construction/interior wall finishing:
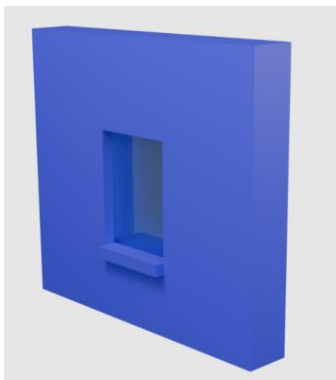
View outside   View inside

B1F1 Floor construction/floor finishing indoors

This includes the entire floor package above the supporting slab in the building volume type A, all floor openings (including those for technical installations) and the associated parapets.

Unit: Σ m² gross floor area type A, split per [E] entity and [Z] zone

B1F2 Fllors outdoors

This includes the cantilevered floor slabs attached to the building volume type A by means of a continuous thermal break, the entire floor package above the load-bearing slab and technical installations (rainwater drainage, lighting, etc.) in the building volumes types B and C, all floor openings and the associated parapets.

Unit: Σ m² gross floor area split by type B or C, [E] entity and [Z] zone

An example:
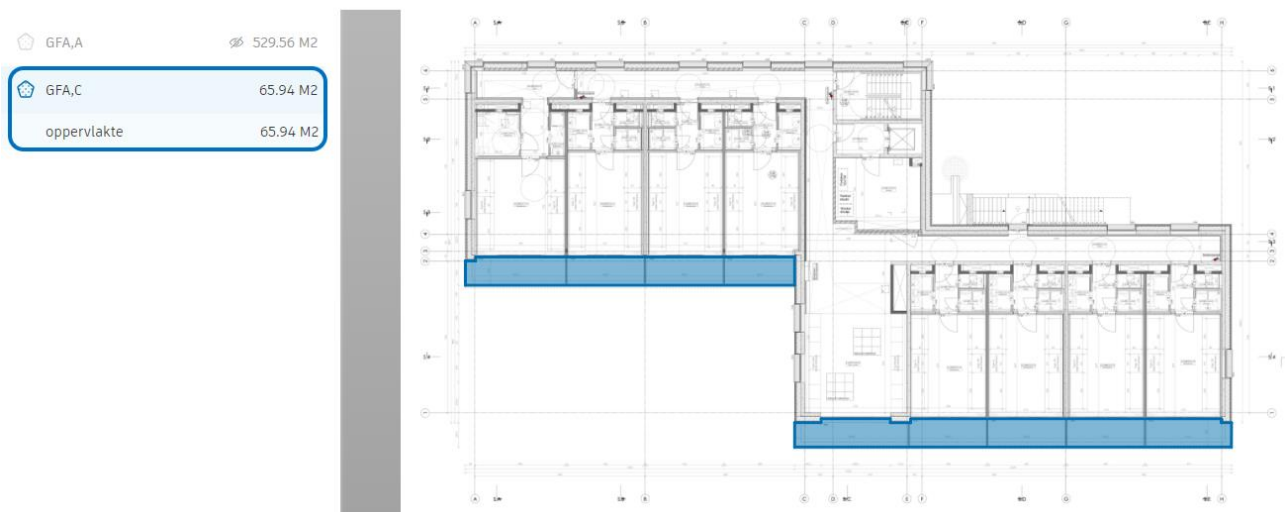
For all floors, one measures the GFA,C as indicated above.

If the terraces are type B, then of course one proceeds in the same way.

All construction costs for the blue highlighted items in the picture below should then be divided by this sum to arrive at a unit cost for B2F1 floors outdoors per m² GFA,C for this project.

B1G1 Stairs and ramps indoors

This includes the supporting structure of stairflights and intermediate landings, balustrades, handrails and finishes of the treads and risers and intermediate landings in building volume type A.

Unit: p,[S] (per unit per storey) in building volume type A, split per [E] entity and [Z] zone

B1G2 Stairs and ramps outdoors

This includes the supporting structure of flights of stairs and intermediate landings, balustrades, handrails and finishes of the treads and risers and intermediate landings in building volumes types B and C.

Unit: p,[S] (per unit per storey) per type B or C, [E] entity and [Z] zone

B1H1 Ceilings indoors

This includes suspended ceilings and ceiling finishes incl. all openings for technical installations in the building volume type A.

Unit: Σ m² gross floor area type A, split per [E] entity and [Z] zone

B1H2 Ceilings outdoors

This includes suspended ceilings and ceiling finishes including all openings for technical installations in building volumes type B and C.

Unit: Σ m² gross floor area split by type B or C, [E] entity and [Z] zone

B2 Technical installations

The substantiation of this cluster is based on the latest version of Table 1 of the Nl-SfB on installations published in December 2019.

Each element cluster is broken down into 'standard' and 'special'. The latter can be used if highly project-specific installations are co-executed by the contractor(s) responsible for the construction volume. Project-related installations by in-house specialised contractors (e.g. medical devices) belong to cluster C1 Company installations.

B2A1 Technical installations fluids: installations for liquids and gases - standard

This includes the evacuation and supply of water and gases (incl. any rainwater recovery) from the connection point - the connection cost itself is included in cluster D Additional costs - for building volume type A.

Unit: Σ m² gross floor area type A, split per [E] entity and [Z] zone

B2A2 Technical installations fluids: installations for liquids and gases - special

e.g. medical gases in hospitals.

Unit: tp

B2B1 Technical installations fluids: air conditioning installations - standard

This includes air conditioning, cooling and heating[14] of the building volume type A. The electrical installations required for this are included in B2D1.

Unit: Σ m² gross floor area type A, split per [E] entity and [Z] zone

B2B2 Technical installations fluids: air conditioning installations - special

e.g. logistics areas at deep-freeze temperature.

Unit: tp

B2C1 Technical installations fluids: fire fighting installations - standard

This includes sprinkler systems, reels, extinguishers, etc. for building volume type A.

Unit: Σ m² gross floor area type A, split by [E] entity and [Z] zone

---

[14] This is taken together because, on the one hand, the NEN 2699 standard mentions it this way but, on the other, because there are also more and more hybrid systems. It is also only in phase S2 Concept Design, when drawing up the technical guidance document on installations, that the breakdown into elements separates these three items.

B2C2 Technical installations fluids: fire fighting installations - special

Unit: tp

B2D1 Electrical installations: central facilities - standard

Central supplies includes everything from the electrical installation to the last distribution board for all technical installations (including HVAC, elevators, etc.).

Earthing and lightning protection are also included in this element cluster.

The connection cost itself is included in section D Additional costs.

All distribution cables up to the terminal units are also included.

Unit: Σ m² gross floor area type A, split per [E] entity and [Z] zone

B2D2 Electrical installations: central facilities - special

Unit: tp

B2E1 Electrical installations: power supply for user connections and lighting- standard

This includes the cabling, user facilities regarding electricity and data as well as the lighting from the distribution boards on, for the building volume type A.

Unit: Σ m² gross floor area type A, split per [E] entity and [Z] zone

B2E2 Electrical installations: power supply for user connections and lighting - special

Unit: tp

B2F1 Electrical installations: communication and security - standard

This includes access control, camera surveillance, ... from the distribution boards on, for the building volume type A.

Unit: Σ m² gross floor area type A, split by [E] entity and [Z] zone

B2F2 Electrical installations: communication and security - special

E.g. nurse call systems in hospitals

Unit: tp

B2G1 Transport - standard

This includes elevator installations for building volume type A.

Unit: p,[S] (per unit per level, i.e. per stop), split by [E] entity

B2G2 Transport - special

E.g. tube stations in hospitals

Unit: tp

B2H Monitoring and control systems and building management system

This element cluster includes both the measurement, control and maintenance of the operation of the HVAC system in the building and the more comprehensive building management system (BMS) that integrates the control and monitoring of various building-related systems, including - in addition to the HVAC measurement and control systems mentioned above - also lighting, access control, energy management, etc.

Unit: Σ m² gross floor area type A, broken down by [E] entity

B3 Fixed furnitures and fittings

In the original NEN2699, the description of cluster and element cluster is the same and the following can only be found at level 4 elements. However, in practice one wishes to be able to bring enough nuance to the project budget from the start. Hence in the belgian version this has moved up one level.

B3(71) Fixed circulation equipemnts[15]

This includes all emergency signs, evacuation plans, fixed floor mats at the entrance, ...

Unit: Σ m² gross floor area, split by [E] entity and by [Z] zone

B3(72) Fixed user equipments

This includes fixed equipments for resting and working e.g. reception desk

Unit: Σ gross floor area, split per [E] entity and per [Z] zone

B3(73) Fixed kitchen equipments

This includes both coffee corners, kitchenettes, and full kitchens.

Unit: st (per whole) split by [E] entity and by [Z] zone

B3(74) Fixed sanitary equipments

This includes all sanitary appliances such as toilets, showers, washbasins, sinks, etc. incl. accessories. It is advisable to pay due attention to this because in belgium people are used to count this as part of the installations (cluster B2).

Unit: st (incl. taps and accessories), split per [E] entity and per [Z] zone

B3(75) Fixed maintenance equipments

E.g. central vacuum cleaning system

Unit: Σ gross floor area, split per [E] entity and per [Z] zone

B3(76) Fixed storage equipments

This includes all fixed cupboards. If it also forms the partition between Built Spaces, it should be included in element cluster B1E interior wall c/inonstruction/ interior wall finishing. In this case, it is best to make a footnote to the unit cost.

Unit: Σ gross floor area, split per [E] entity and per [Z] zone

---

[15] This is the terminology followed in the NI-SfB and NEN 2699; the BB-SfB refers to fixed circulation facilities

B3(77) Fixed equipment for special activities

This is an element cluster that will only be used if these facilities are executed by the construction contractor(s).

Unit: Σ gross floor area, split per [E] entity and per [Z] zone

B4 Land

B4A Ground works

This includes all ground work still to be done outside the building(s) after general demolition and sanitation (both estimated under cluster A2 demolition works-environmental costs)

Unit: m² external area with split into communal & private

B4B Structures (small buildings, shelters, etc.)

Unit: concerned m² external area with split into communal & private

B4C Fencing and finishing

Unit: concerned m² external area with split into communal & private

B4D Technical installations for the site

Unit: m² external area with split into communal & private

B4E Landscaping

Unit: m² external area with breakdown into communal & private

B5 General execution costs (GEC)

In the Netherlands, people have long been familiar with 'tail costs', things like insurance, general operating costs (AK), profit/risk that are explicitly reported in the bid via a percentage.

In Belgium, we have 'indirect costs' that include part of the construction site preparation, work preparation (with, in the case of techniques, often a lot of engineering work that the designers cannot determine because it depends on the materials purchased by the contractor), project management, the contractor's overheads and profit/risk.

This figure, which easily adds up to 18% to 30% of the pure production cost, will be 'judiciously' distributed by the contractor's estimator across the items in the bill of quantities. All this makes the comparison of bids a very precarious business!

Hence, a very strong plea to get this subject out on the open and have an open, mature debate about it.

Agentschap Facilitair Bedrijf and PB calc & consult propose the following format:

❑ **B5A Site description and state comparison**

Unit: tp

❑ **B5B General execution costs (project)**

Unit : % relative to production cost B1 tem B4

These costs also include the integral costs for work preparation and project management during execution so that the "uplift" only includes the AK and W/R. If possible, it is best to break this further down into:

▪ Site start-up - unit : tp.

▪ During the construction - unit : months.

One can place this as a 'presumed quantity' in the bill of quantities so that contractors have an opportunity to show their efficiency.

Furthermore, by asking for a price per month, one gets additional insight into the team and equipment used.

Importantly, the part of the deployed equipment that is normally placed in the production post is also collected here in this element cluster.

This element cluster also includes all tests, material identification, inspections and commissioning of both equipment, material and technical installations.

▪ Breakdown yard [tp]

❑ **B5C Coordination costs of independent contractors**

Unit : % of production cost B1 to B4

To be clear, this element cluster includes the coordination cost between pure independent contractors (i.e. contractors from another lot) and not the coordination

cost associated with subcontractors performing part of the lot assigned to the main contractor.

❑ **B5D Overheads (company)**

Unit : % of production cost B1 to B4

Generally, in Belgium it is requested that the unit prices quoted by the contractor in his bid include his general costs (the so-called AK being the contractor's own office, fleet of employees, costs for general departments such as accounting, HR, legal department, etc.).

❑ **B5E Profit and risk (company)**

Unit : % of production cost B1 to B4

It is usually requested in Belgium that the unit prices quoted by the contractor in his bid include his profit-risk percentage.

❑ **B5F As built dossier**

Unit : tp

here it should be specified very clearly what is expected : a BIM model with 2D layers inserted, a fully modelled BIM, attached technical sheets, asset list for building management systems, ...

❑ **B5G Training of Technical installations' staff**

Unit : tp

Within the BouwData© calculation system, both level 4 elements and level 5 components have already been defined. To that purpose, we looked at the substantiation of Table 1 by the original 1990 BB-SfB, Prof Frank De Troyer's 2008 research as part of BB-SfB-plus and the new interpretation of the installations NL-SfB as issued in 2019.

Level 6 is referring to STABU and is a 'flip over' rather than further 'folding out'. That's because NEN 2699 is purely function-oriented with top down reasoning, while STABU is material-oriented with bottom up reasoning.

But both previous paragraphs are outside the scope of this whitepaper.

The objective of this whitepaper is to provide all designers in Belgium with a scientifically based and practice-tested framework into which they can 'slide' their existing structure and operation.

Once this is in place, we can review the next levels of NEN 2699.

Cost structure in a technical system: BBW[16]

Today, the vast majority of projects are still carried out using traditional tendering in the S4 technical design phase.

Architects very often base their specifications on the belgian Building Specifications for Residential Construction (BBW) and the associated list of items[17]

In order to facilitate the 'insertion' of a traditional specification based on the BBW specification into the structure of element clusters, the Agentschap Facilitair Bedrijf has already carried out this exercise in collaboration with Wonen in Vlaanderen.

It is attached in Excel format to this white paper.

Below are some **points of attention[18]**:

❑ Global items such as e.g. reinforcement

▪ First check whether the reinforcement is only for the concrete cast on site or also for the precast concrete?

▪ If also precast concrete: check whether this is for all precast concrete?

▪ When it is clear for which posts the reinforcement serves, determine the ratio between the amount of on-site cast and precast concrete in B1A Foundation and B1B Skeleton

▪ Divide the amount of reinforcement in proportion to the amount of related precast or non-cast concrete between B1A and B1B

❑ All forms of earthing belong to B1D (i.e. also earthing loops or earthing pins usually listed with foundations)

❑ Polished floor:

▪ If the article contains both concrete work directly on soil and polishing ⇒ B1A Foundation

▪ If the article includes both the concrete works on top of the supporting slab and the polishing or if it only refers to the act of polishing inside the building ⇒ B1F1 Floor construction/floor finishing indoors

---

[16] The BBW or in full the Bouwtechnisch Bestek Woningbouw is made available by Wonen in Vlaanderen as a compulsory model specification for the (re)construction of social housing projects. In practice, this is often referred to as the 'VMSW' specifications.'' However, since 1 January 2023, the Vlaamse Maatschappij voor Sociaal Wonen (VMSW) has merged with Wonen-Vlaanderen to form the new agency Wonen in Vlaanderen. The VMSW continues to exist as the financial manager of the housing companies. All other tasks were attributed to the agency Wonen in Vlaanderen.

[17] The BBW can be downloaded free of charge at https://www.vlaanderen.be/sociaal-woonbeleid/sociale-woningen/realiseren-van-sociale-woonprojecten/woningbouw-en-infrastructuur/ontwerp-en-bestek/bouwtechnisch-bestek-woningbouw

[18] I.e. doubtful cases that surfaced during test cases last year and where, after consultation, the decisions below were taken.

- If the item includes both the concrete work on top of the load-bearing slab and the polishing or if it only involves the act of polishing outside the building ⇒ B1F2 Floors outside

☐ Masonry without indication of whether it is load-bearing or non-load-bearing:

- Thickness < 140mm ⇒ B1E Interior wall construction/interior wall finishing

- Thickness ≥ 140mm ⇒ B1B Skeleton

- If clearly a roof curb ⇒ B1C Roof construction/roof finishing regardless of thickness

- If clearly parament or related to the facade ⇒ B1D Facade construction/façade finishing regardless of thickness

☐ Insulation in walls can occur in different element clusters:

- Residential separating insulation (even when building against an existing building) falls under element cluster B1E Interior wall construction/interior wall finishing

- Insulation in sandwich panels with a load-bearing component falls under element cluster B1B Skeleton

- Insulation applied after the installation of the inner building envelope falls under element cluster B1D Facade construction/façade finishing

☐ Acoustic enclosures of technical piping fall under element cluster B1H Ceilings indoors or under element cluster B1E Interior wall constructon/interior wall finishing depending on whether they are located horizontally at the top of Built Space [B] or vertically against its wall

☐ Finishes on the sides of an opening are covered by:

- Element cluster B1D Façade construction/facade finishing for exterior wall openings (this includes both exterior finishing e.g. bluestone window sill and interior finishing e.g. plastering of the inner faces)

- Element cluster B1C Roof construction/roof finishing for roof openings (this concerns both the finishing on the outside e.g. dome upstand and on the inside e.g. finishing of the opening with plasterboard)

- Element cluster B1E Interior wall construction/interior wall finishing for interior wall openings (so also includes the inner sill or the continuation of the floor covering in the doorway; after all, from the BIM model comes automatically the NRA of the Built Space which does not take into account doorways - so the finishing at the bottom of the interior doorway has to be added anyway)

☐ Awnings:

- If suspended from the façade above the entrance ⇒ B1D Façade construction/facade finish regardless of thickness

- If complete, self-supporting construction separate from the building ⇒ B4B Structures (small buildings, shelters, etc.)

- External painting of a gutter belongs to element cluster B1C Roof construction/roof finishing

- Electric locks and magnet holders:
    - To go outside/enter $\Rightarrow$ B1D Façade construction/facade finishing
    - Inside the building $\Rightarrow$ B1E Interior wall finishing/Interior wall finishing

- Accessories of technical installations e.g. fire dampers, fire sleeves, water and air tightening, drilling holes, etc. should be broken down by element cluster for which they are to be carried out.

- Boiler (instantaneous water heater) for domestic hot water falls under B2A1 Technical Installations fluids: installations for liquids and gases - standard

  A buffer tank for central heating hot water falls under B2B1 Technical Installations fluids: air conditioning installations - standard

- Airtightness:
    - Tests fall under B5B General execution costs (project)
    - Measures to ensure airtightness fall under:
        - If not specified: under B1D Façade construction/facade finishing
        - If specified: under relevant element cluster

- Letterbox flaps embedded in the façade fall under element cluster B1D Façade construction/façade finishing. Letterbox assemblies in an apartment building (both in the entrance hall and outside at the front door) fall under element cluster B3(71) fixed circulation equipments .

- Lines on the floor or walls belong to B3(71) fixed circulation equipments .

- Cabinets and kitchen appliances:
    - Fixed to floor or wall or recessed:
        - If combined with other function e.g. nursing station $\Rightarrow$ B3(72) Fixed user equipment
        - If pure storage e.g. bookcases in a library $\Rightarrow$ B3(76) Fixed storage equipment
    - On wheels or freestanding $\Rightarrow$ C2A Loose furnishing

- Bicycle racks outside fall under B4E Landscaping Bicycle racks inside the building fall under B3(76) Fixed storage equipments

- Mock-ups (both those that are part of the building and those off site) fall under B5B General implementation costs (project)

Use of BIM models in phase S1 preparation & brief

As a BIM advisor to the Agentschap Facilitair Bedrijf, Bimplan is closely involved in the definition of efficient working methods with BIM. For example, cost control is an important part of the project where BIM can provide the necessary support, which we also call 5D BIM. The Agentschap Facilitair Bedrijf has therefore included this as a requirement for all future in-house BIM projects.

BIM models are used throughout the entire life cycle of a building, as early as the programming and design phase. The models are a tool for better communication between all parties involved in the project team, but are especially strong to support the design and provide insight to the client.

Contractual determination of floor area in a PoR

Regarding floor area, in accordance with NBN EN 15221-6:2011, we only use the following terms in phase S1 preparation & letter:

❑ Level Area (LA)

❑ Non-functional Level Area (NLA)

❑ Gross Floor Area (GFA)

Further detailing is only provided in subsequent phases.

However, these are difficult concepts for the client because he/she is only interested in the primary area, i.e. what space does he/she need to carry out his/her core business?

It is therefore important to contractually define the path from primary area to level area via percentages. These will then be the KPIs[19] that you will monitor in each subsequent phase.

Below we give an **example** to make this process transparent:

❑ You need 1000m² of primary area (PA). From analysis of previous analogue buildings, you know that you need e.g. an additional 25% for the associated circulation area (CA), amenity area (AA) and technical area (TA).
In other words, you need 1250m² of net room area.
That 25% is a **first requirement** that you have to agree on: the factor you apply to PA to arrive at NRA,A.

---

[19] Key Performance Indicator

- Then the team decides how much % they want to pay for the construction area as a whole (i.e. ECA, ICA and PWA together). In the Netherlands, they assume 8% but we know from post-calculations that 12% can be considered a minimum. In Belgium, architects generally take 10%. If you agree e.g. 12%, then you know that the required gross floor area is 1250m² x 1.12 = 1400m².
  That 12% is the **second requirement** you have to agree on: the factor you apply to NRA,A to arrive at GFA,A.

- Then you have to agree how much architectural freedom you want to give the design team to include atria and voids in their design. There are no known standard percentages of this because it is so project-specific. Say you are willing to fund 5% extra NLA area then the level area becomes type A (because we are only talking about interior spaces so far here): 1400m² x 1.05 = 1470m².
  This 5% is the **third requirement** you have to agree on: the factor you apply to GFA,A to arrive at LA,A.

- If you want to have outdoor spaces in addition to all of the above, you need to clarify whether the design team can include type B (covered by indoor spaces) in their design or restrict themselves to only type C (if covered, this is outdoor-outdoor only). And in both cases, of course, the maximum percentage compared to type A.
  This is the **fourth requirement** to be formulated at the start of phase S1 preparation & brief.

Extracting quantities from a BIM model

As an example to illustrate the various applications of BIM in cost calculation, the new construction project Belpaire of the Agentschap Facilitair Bedrijf is used. This is purely informative and was drawn up retrospectively by Bimplan. It is separate from the BIM applications used in this project by various partners.

We start by creating a **volumetric model**, this can be done by creating Area plans based on the Level Area according to NBN EN 15221-6.
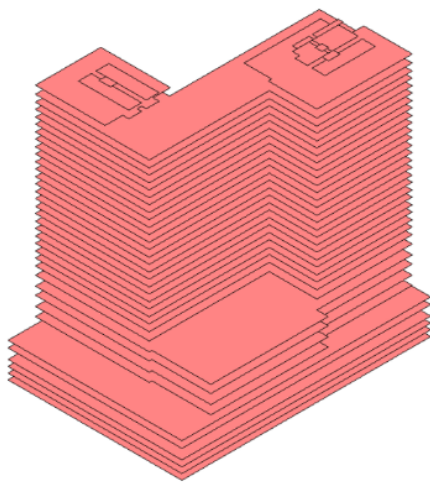
Area's LA

Level	Oppervlakte
B050	10832 m²
B040	10832 m²
B030	10832 m²
B020	10832 m²
B010	10832 m²
B005	10832 m²
L000	8927 m²
L010	8998 m²
L020	6511 m²
L020_Annex	1155 m²
L030	6475 m²

Dit is een voorbeeld, de m² zijn indicatief

Illustration Belpaire – LA per storey

These Level Areas can then be used to build a volume model so that the required m² of façade, roof and footprint can be determined.
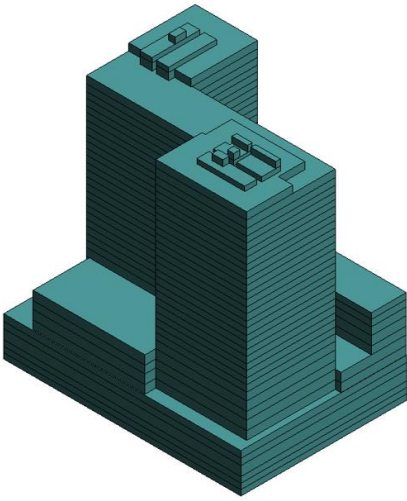
BIM volume model

Illustration Belpaire – volume model

These volumes can be built in different ways in different software. The example is built in Revit but this can also be done in other modelling software.

It is important that the volume is **measurable** in different surface areas and that the volumes are split per floor.

When we divide the project into different zones, we also work out smaller volumes per zone in addition to the LA volumes. We use these smaller volumes to visualise and measure the m² of the programme. The LA volumes are used to calculate the m² of façade, roof and footprint.

It is important that the right volumes are used. This is because working with large volumes and extracting their area from the model will give the area of the total volume. These are not the surface areas that are needed. In Revit, 'Mass walls', 'Mass floors', 'Mass roofs' have to be created in order to obtain the required volumes.

From these volumes, some derived quantities are important for cost calculation purposes.

Building Footprint

Looking from bottom to top, the visible plane is the Foundation Footprint.
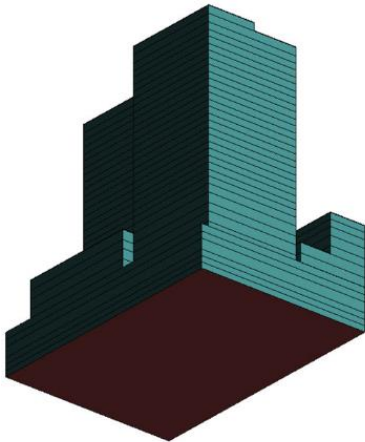
BIM footprint

Level	Oppervlakte
B050	10832 m²

Illustration Belpaire - footprint

This quantity comes from a 'Mass floor' area, please note that the entire footprint is modelled in the volume.

Façade and roof areas

The sides of each storey make up the required facade area and all visible upper sides make up the required roof area.

It is important, however, to distinguish between the roof area that is only accessible for maintenance (to be related to element cluster B1C roof construction/roof finishing) and the roof area that is accessible to the public (to be related to element cluster B1F2 outdoor flooring).
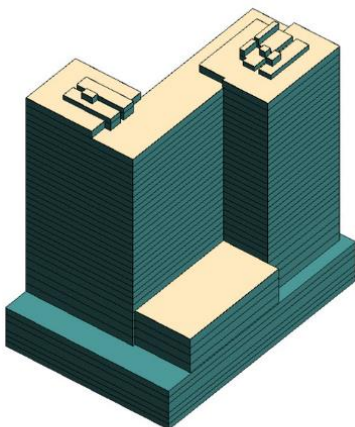
BIM dakoppervlakte

Level	Oppervlakte
L020	1423 m²
L030	36 m²
L040	1730 m²
L070	1220 m²
L290	1827 m²
L300	2161 m²
L310	608 m²
L320	102 m²

Dit is een voorbeeld, de m² zijn indicatief

Illustration Belpaire – roof area

'Mass roofs' are used for the roofs, attention should be paid to the fact that not all volumes have a roof. For example, an underground car park has no roof.
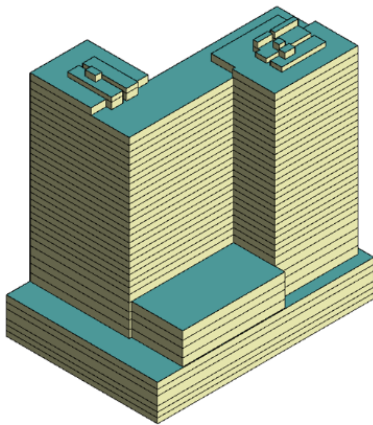
BIM gevelopervlakte		
Level	Oppervlakte	Hoogte
B050	1228 m²	2900
B040	1228 m²	2900
B030	1271 m²	3000
B020	2118 m²	5000
B010	1402 m²	3310
B005	1478 m²	3490
L000	1742 m²	4410
L010	1896 m²	4800
L020	2269 m²	3970
L030	2654 m²	4720
L040	2217 m²	4020

Dit is een voorbeeld, de m² zijn indicatief

Illustration Belpaire – façade area

For the façade we use 'Mass walls', here it is important that the masses are built completely over the LA, otherwise additional walls will need to be created where there is no façade.

Visualisation of a PoR using a volumetric model

In order to use a BIM model to support costing, it is important to agree on the right expectations at the different steps of the process. This is because a BIM model can manifest itself in different forms and levels of detail.

In phase S1 preparation & brief, a model does not yet consist of detailed elements, but one wants to check whether the program of requirements and corresponding required floor areas can be fitted into a volumetric model that architecturally fits in best with the surroundings and urban development preconditions.

Although not strictly necessary yet, at this stage one will already look at the different zones in an entity and especially how the relationships between these different zones relate. However, they will only be completely finalised in phase S2 Concept Design.

To draw up a program of requirements (PoR), one usually starts with an **organisational chart** in which users, functions, clustering, circulation, etc. are shown schematically.

For example:
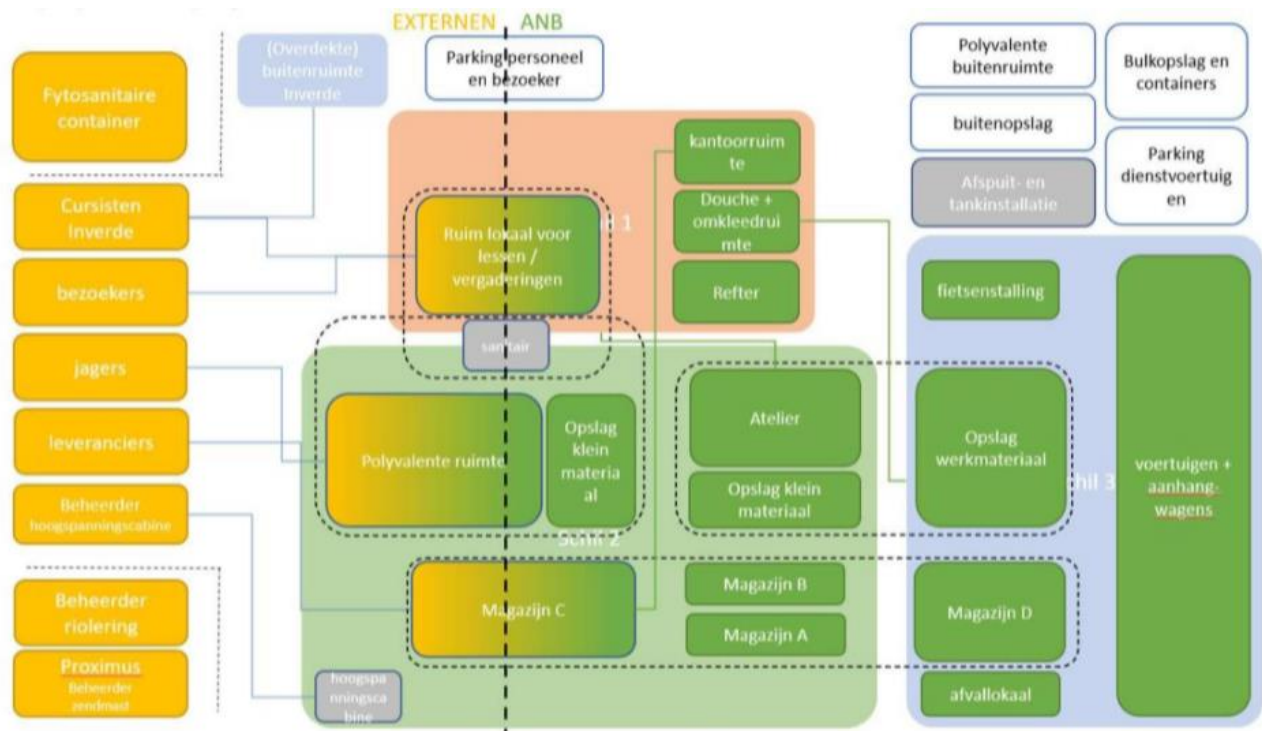
In the above example, there are three levels of energy groups:

❑ Layer 1 (highlighted orange-red): highest comfort requirements
❑ Layer 2 (highlighted green): medium comfort requirements
❑ Layer 3 (highlighted in blue): lowest comfort requirements

Such an organisational chart is accompanied by

❑ a **note** on the desired operation, appearance, further explanation, ... of the envisaged facility and all preconditions known so far.

❑ A **list of surfaces**

For example:

2.4.6 Oppervlaktetabel

			netto opp	bruto opp	
Schil 1				245	351 m²
2.4.1.1	werkplekken			44	
2.4.1.2	cockpit			8	
2.4.1.3	EHBO lokaal			6	
2.4.1.4	Reprolokaal			6	
2.4.1.5	Kleedruimtes en sanitair			60	
2.4.1.6	droogruimte			13	
2.4.1.7	poetsberging			5	
2.4.1.8	algemene berging			5	
2.4.1.9	refter met kitchnette			26	
2.4.1.10	vergaderruimte / leslokaal			63	
2.4.1.11	Sanitair bezoekers			10	
Schil 2				1.264	1.364 m²
2.4.2.1	Atelier			316	
2.4.2.2	opslagruimte klein materiaal			17	
2.4.2.3	polyvalente ruimte met opslagruimte			200	
2.4.2.4	Centraal magazijn			656	
	magazijn A	106			
	magazijn B	314			
	magazijn C	236			
bestaand	datalokaal			21	
bestaand	opslag brandgevaarlijke producten			30	
bestaand	hoogspanningscabine			24	
Schil 3				1.456	2.111 m²
2.4.3.1	inverde			26	
2.4.3.2	MAGAZIJN D			441	
2.4.3.3	Voertuigenpark			676	
2.4.3.4	Opslag werkmateriaal			251	
2.4.3.5	afvalzone			37	
2.4.3.6	Fietsenstalling			24	
Terrein / omgeving					1.808 m²
2.4.4.1	Tankinstallatie			44	
2.4.4.2	Containerpark met bulkopslag		bestaand		
2.4.4.3	Buitenopslag		bestaand		
2.4.4.4	Parking personeel en bezoekers			504	
2.4.4.5	Parking dienstvoertuigen			260	
2.4.4.6	Polyvalente buitenruimte (onverhard)			1000	
bestaand	afspuitinstallatie			48	
bestaand	fythosanitaire container			12	

In this example, one wishes to renovate and reconfigure an existing shed to house the above mentioned shells 1 to 3.

I.e. you turn the existing volume into a volumetric model, following the principle mentioned above.

For example:
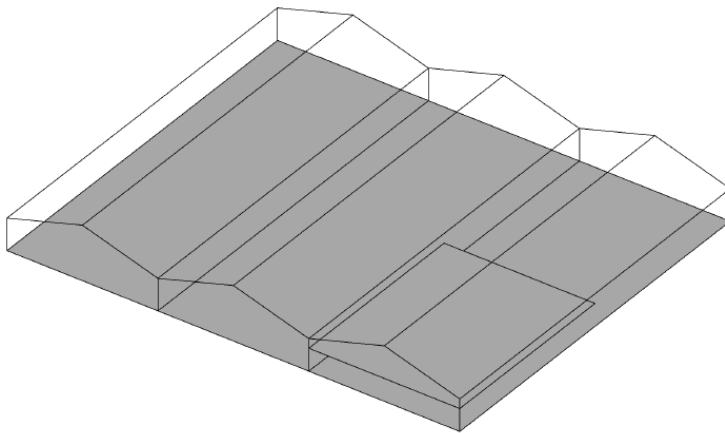
To visualise the PoR, we are going to create a number of smaller volumes per zone in the large volumetric model.

To accommodate the programme of layers 1 to 3 in this existing combination of sheds, we need to know not only the GFA,A per layer but also these per listed zone.

For each layer, we apply the same 'factor' as calculated from the total.

We arrive at the following list:

	netto / NRA, PA	bruto / GFA,A	overslag	
Schil 1	246	351	29,9%	
2.4.1.1 werkplekken	44	63		
2.4.1.2 cockpit	8	11		
2.4.1.3 EHBO	6	9		
2.4.1.4 Reprolokaal	6	9		
2.4.1.5 Kleedruimtes	60	86		
2.4.1.6 droogruimte	13	19		
2.4.1.7 poetsberging	5	7		
2.4.1.8 algemene berging	5	7	incl. bij 2.4.1.7	
2.4.1.9 refter	26	37		
2.4.1.10 vergaderruimte	63	90		
2.4.1.11 Sanitair	10	14		
Schil 2	1264	1364	7,3%	
2.4.2.1 Atelier	316	341		
2.4.2.2 Opslagruimte klein materiaal	17	18		
2.4.2.3 Opslagruimte	200	216		
2.4.2.4 Centraal magazijn A	106	114		
2.4.2.4 Centraal magazijn B	314	339		
2.4.2.4 Centraal magazijn C	236	255		
bestaand datalokaal	21	23		
bestaand opslag	30	32		
bestaand hoogspanningscabine	24	26		
Schil 3	1455	2111	31,1%	
2.4.3.1 Inverde	26	38		
2.4.3.2 MAGAZIJN D	441	640		
2.4.3.3 Voertuigenpark	676	981		
2.4.3.4 Opslag	251	364		
2.4.3.5 afvalzone	37	54		
2.4.3.6 Fietsenstalling	24	35		

From each zone we now make a separate volume.

Attention: in the orange-red layer 1, we take 2.4.1.7 and 2.4.1.8 together because this has the same function and nowhere was it reported that they should be kept distinctly separate.
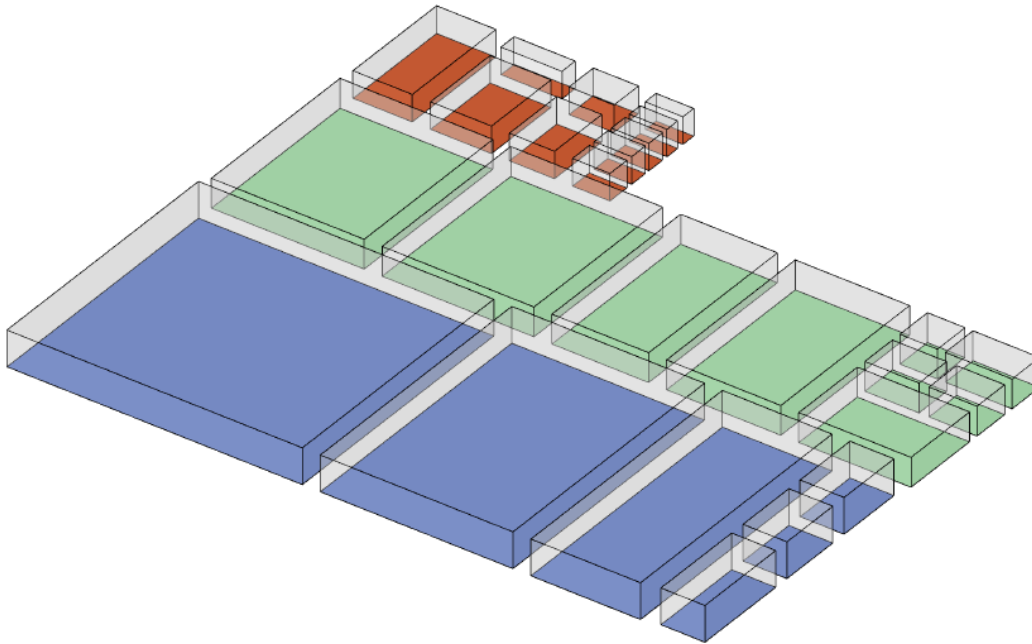
Once the building blocks are listed, we can start experimenting to see if we can get the requested zones properly inserted into the existing volume model.

One possible solution is the result below:
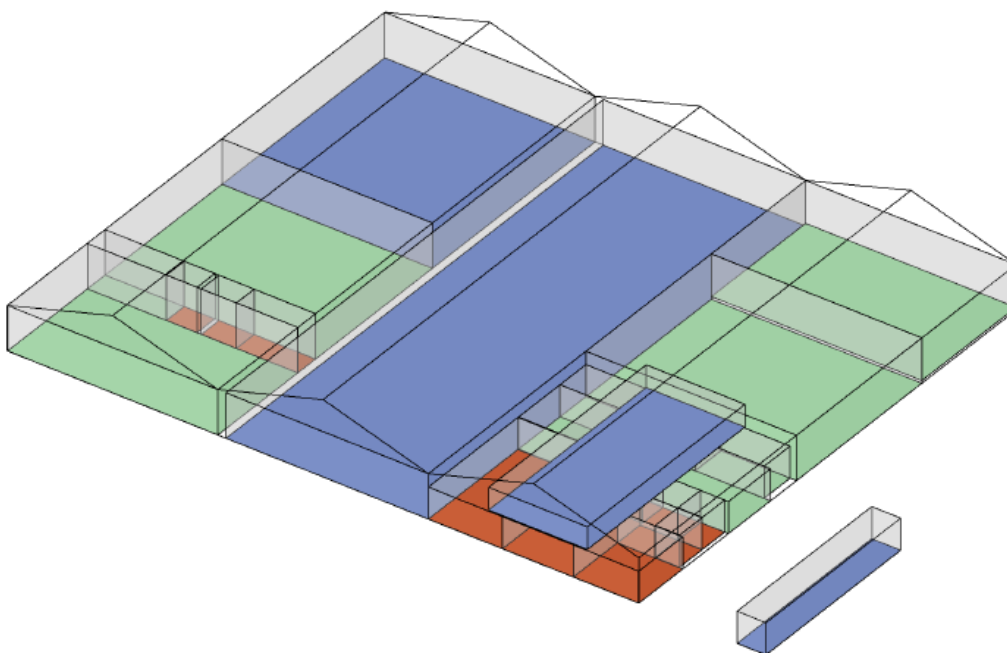
We note the following:

- ❑ The existing floor area is not sufficient to accommodate the full programme. We can provide some spaces outside the volume after consultation.
- ❑ There is not enough surface area on the ground floor. We are going to have to make a choice as to which programme may be located on the floor or have a limited free ceiling height.
- ❑ The middle bay will be fully occupied by the blue programme of layer 3.
- ❑ The green programme of layer 2 will not get into one bay. A division over the bays will be necessary.
- ❑ The orange-red programme of layer 1 can be compactly clustered on the ground floor.
- ❑ We can reduce the high overload of the blue programme by e.g. reducing the need for new circulation.
- ❑ The existing storey floor may be largely preserved.

Very important in this exercise is that the (groups of) rooms are placed in the model with the corresponding numbering and colour code, so that the client gets a model that, although very abstract, clarifies a lot visually and, above all, clearly shows the bottlenecks.

This can be done in two ways:

- All the behind-the-scenes information contained with each room.
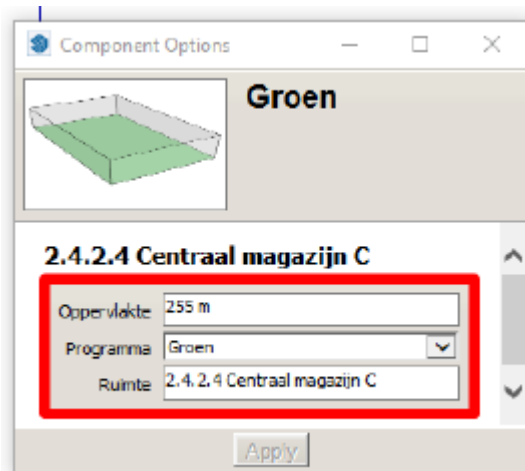
This allows cost experts to neatly retrieve all information at a later date, which of course requires both the cost expert and the client to have a good understanding of modelling in order to interpret this provided study.

❑ To make things understandable even for the modelling layman, you can visually add names. In this case, the space names are simplified or grouped and the codes are not displayed. This emphasises the use of this designation. It serves to provide a simplified indication to the broad outlines of the layout and is intended for those who do not need to see all the details. This has the advantage that you can still bend this naming scheme to your will to make things understandable. After all, in practice, it is often impossible to export a readable snapshot where all the information is displayed with each space.

But beware that in this case, an additional risk of failure is created, since by doing so we abandon the 'single source of truth' principle and put the same things into the model in two different ways.
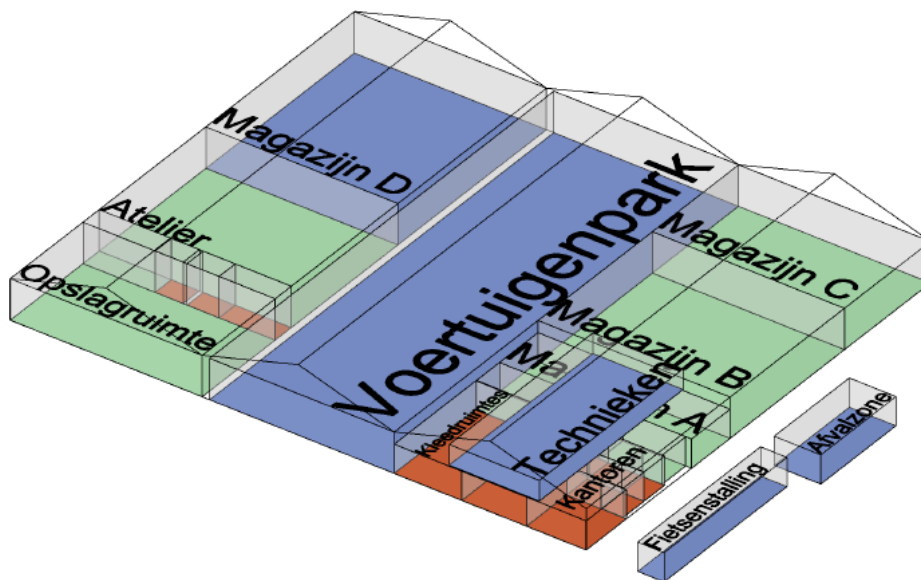
So it is important to weigh up smooth communication with a higher probability of failure cost against possible missing modelling skills among the partners around the table at this stage!

Modeling software

Different software was used to produce these different volumetric models. It is hereby shown that at this stage, the required information can come from different software.

We would like to mention here that the methodologies described above may differ depending on the design software. The applications shown above were simulated in the drawing programs Sketchup Pro and Revit.

It is possible to create templates and manuals to convert these methods to the most common BIM software packages. However, this needs further investigation, as it has not been established that it is easy to achieve exactly the same result with all drawing programmes. For example, it could be possible to replace 3D text indications with 'Labels' or even captions on a screenshot.

Conclusion

Based on a mass study and the quantities as determined above, a cost expert can make an estimate related to element clusters[20] for the entire entity during phase S1 preparation & brief.

In other words, from now on we will never work with a 'flattened' m² price but always take into account the geometry of the volumetric model!

Because the quantities come from the volumetric model, it is clear to both the client and the cost expert where they come from. Adjustments to the design, due to too high construction costs, for example, are thus much easier to make.

By always maintaining the link with the element clusters in the following phases - even when switching to a BBW specifications in phase S4 technical design - we can collect a clear set of cost indicators in phase S6 handover of each delivered and financially completed project.[21]

By systematically placing these sets in a data pool, our entire sector can benchmark unambiguously and a realistic construction cost will be the starting point.

By also considering the general execution costs as a separate cluster from this very first phase, the various contractors can bring forward their execution know-how very clearly from the start.

In other words, element clusters form the link between post-calculation of finished projects and estimates of volumetric studies for new projects.

Ir.Arch. Peggy Bovens for PB calc & consult

Ing. Mia Thoen, Ir.Arch. Andriy Bruyninck, Ing. Sacha Brabant for het Agentschap Facilitair Bedrijf

Ing. Matthise Gosselink en Ing. Wannes Schodts for Bimplan

Team Energie & Bouwtechniek for Wonen in Vlaanderen

Buildwise recognises the issues and supports this initiative. This paper cites certain references (RIBA, classification systems) needed to substantiate it. Buildwise is currently analysing the compatibility of these references with standardisation work in Belgium.

---

[20] It is very important to note that element clusters such as B1A Foundation, B1B Skeleton, B1C Roof construction/roof finishing and B1D Façade construction/façade finishing are always treated for the entire entity and distributed pro rata to the Gross Floor Area over all [Z] zones if an indication has already been made hereto in this phase.

[21] For large projects, this may be several sets depending on the number of [Z] zones.

Appendix – example of measurement

Measuring a foundation footprint when you only have pdf or dwg files is not always straightforward. Below is an example that requires some 'cutting and pasting'. This measurement was done using Autodesk Takeoff on pdf drawings.

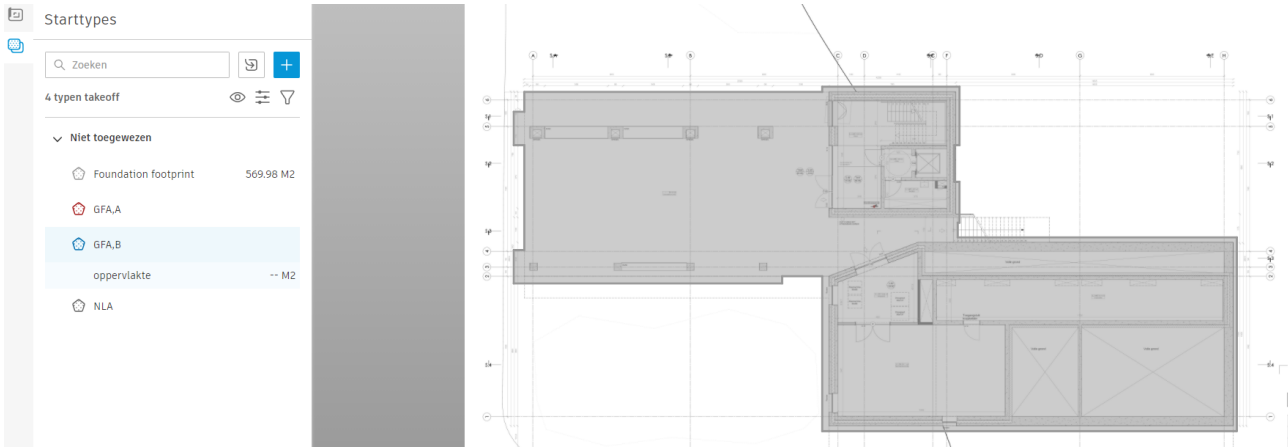The foundation footprint on the first foundation plan is 419.14m².
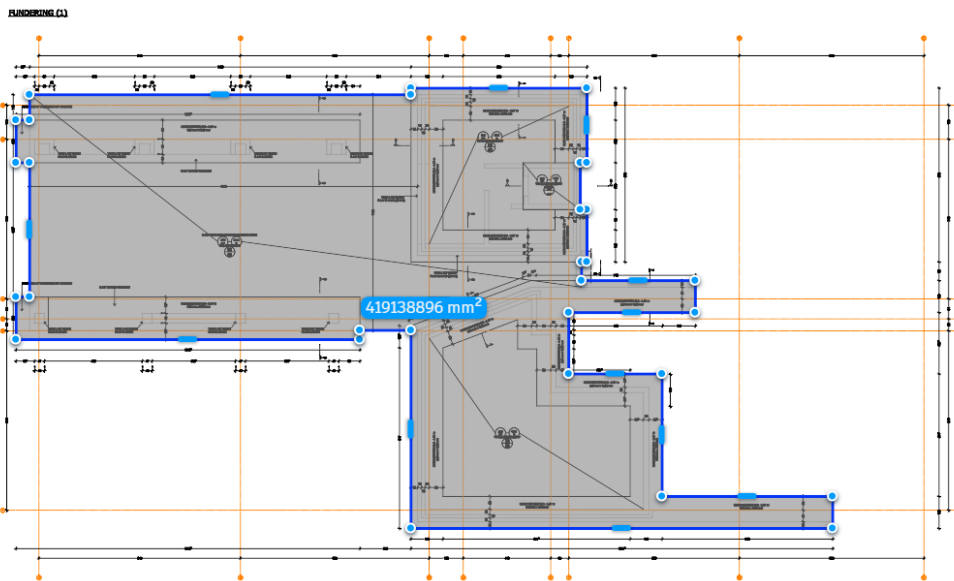
We then 'copy' this area to the second foundation plan to determine the additional foundation footprint: 150.76m².
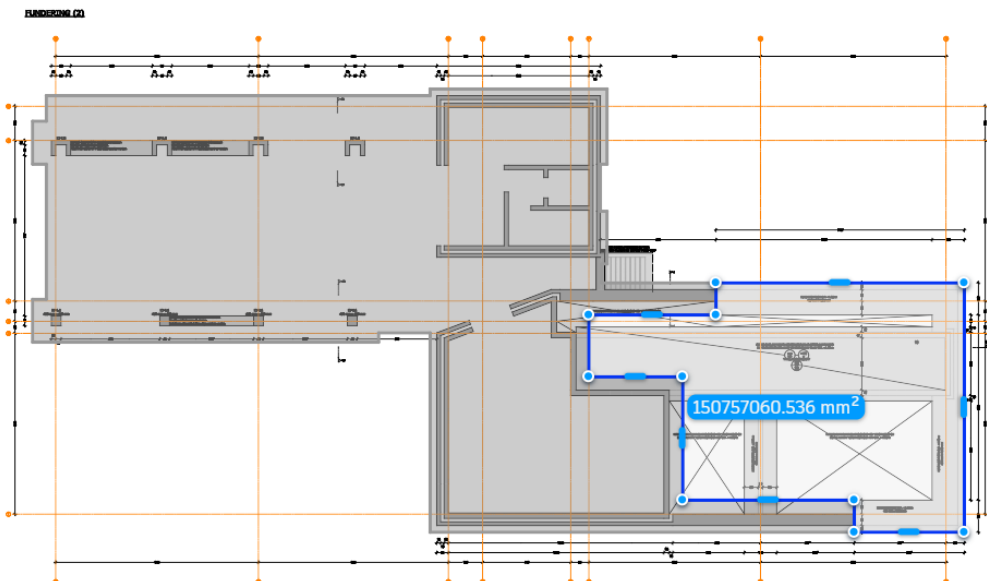
The white areas should also be counted here because there will also be a foundation slab above them. So the total foundation footprint here is:

419.14m² + 150.76m² = 569.9m².

We then transfer the entire foundation footprint to the architectural plan of that same building layer:

Using this foundation footprint as the "underlayer", we can determine GFA,B.
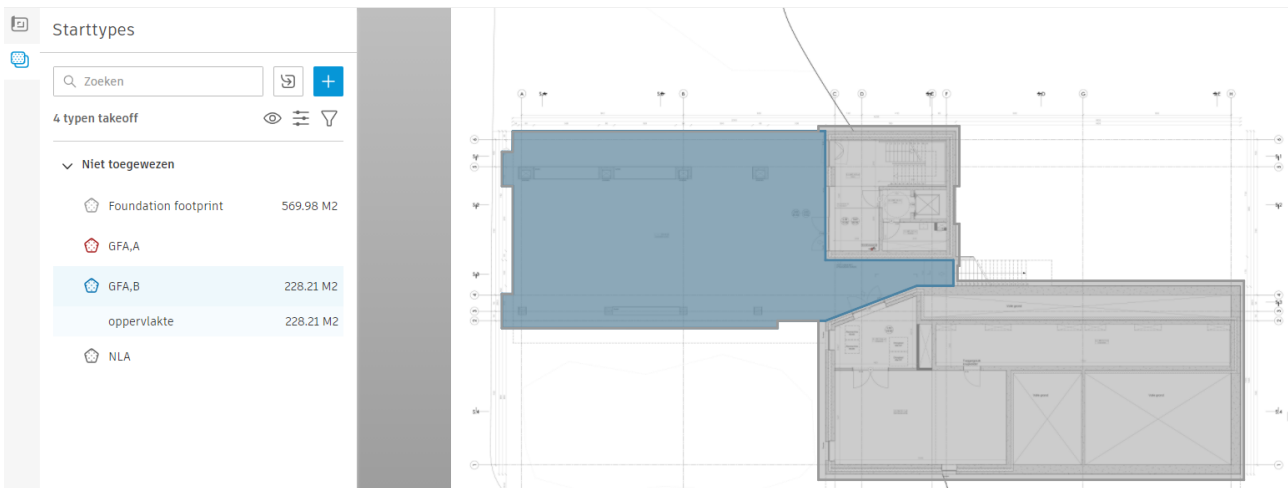
But before we can start working on the "cutouts" for the columns, - these belong to the GFA,A! - we have to remove the "underlayer".
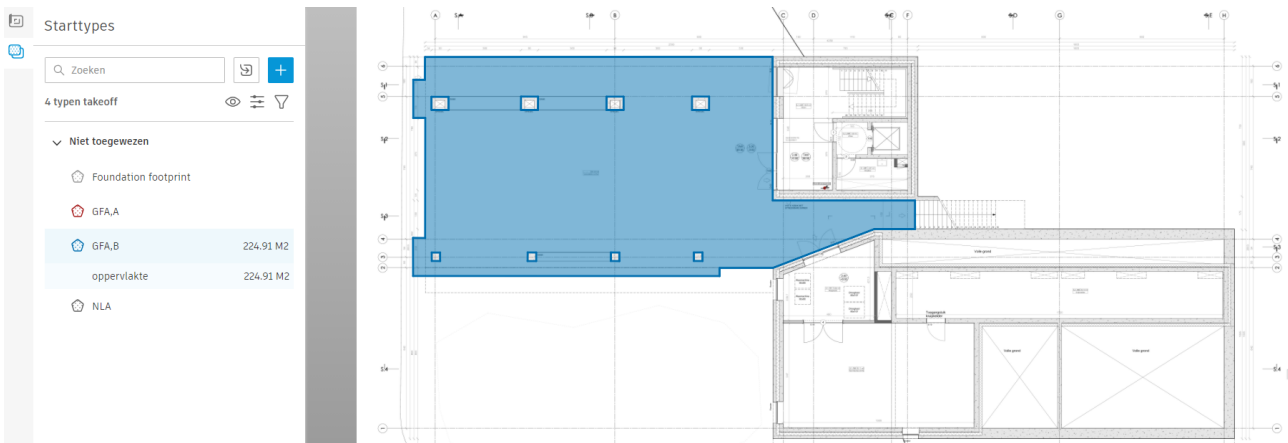
So the GFA,B is 224.91m².
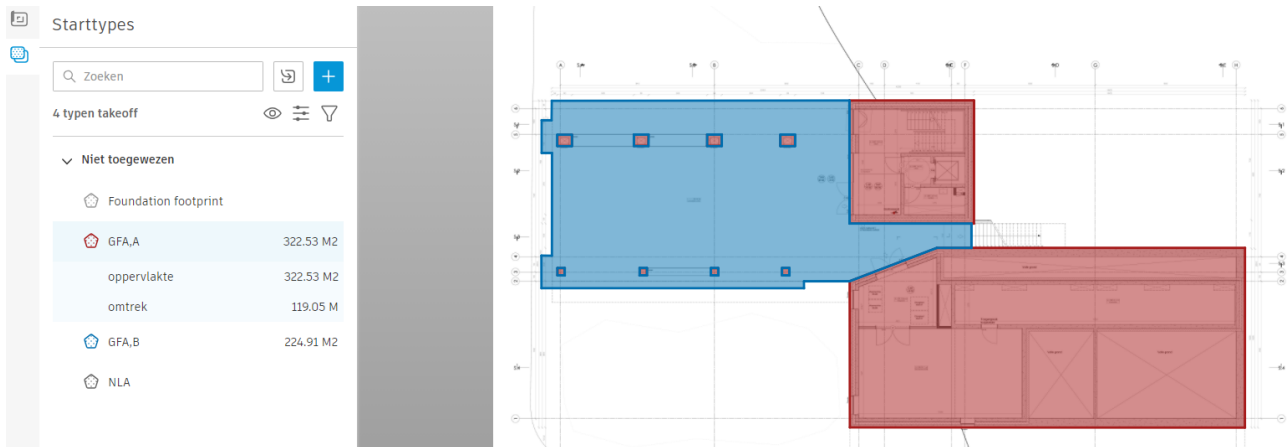
Points of attention:

1. 1. the external staircase including its associated foundation falls under B1G stairs and ramps outdoors and is counted per [p], per floor height.
2. 2. the crawl space is GFA,A as are the other "full-fledged" spaces

The pieces with plain ground between the foundation belong to the NLA and should therefore be measured as "cutouts" in the GFA,A.
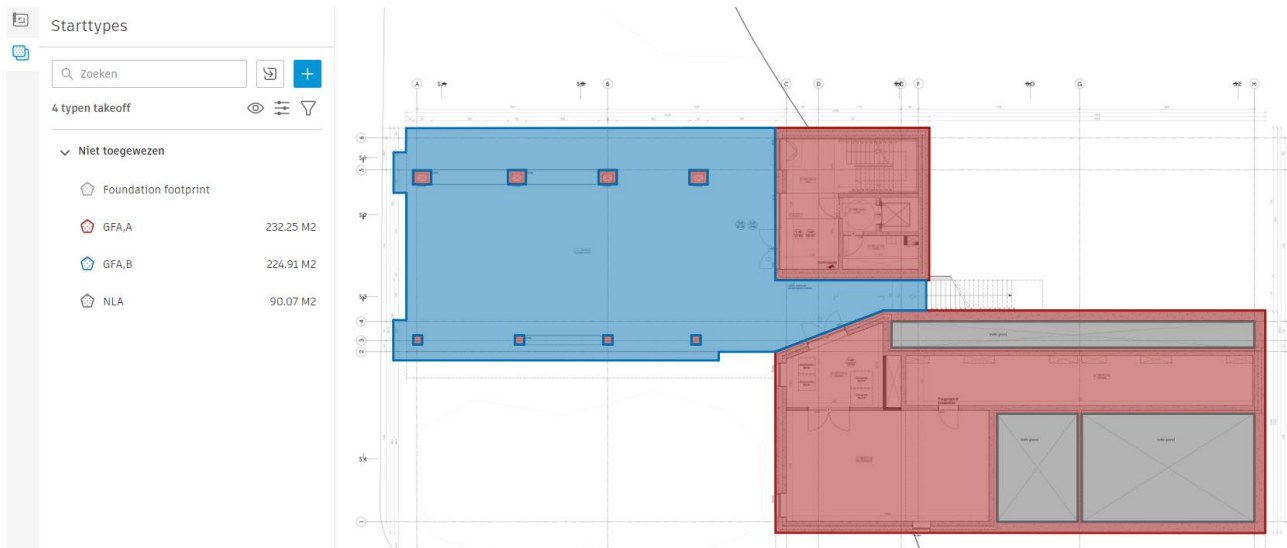
The GFA,A is 232.25m² and the NLA is 90.07m²

The LA of [S]#91 = NLA + GFA,A + GFA,B + GFA,C

$$= 90.07m² + 232.25m² + 224.91m² + 0.00m² = 547.23m²$$

so less than the foundation footprint which makes sense considering foundation footprints typically shoot well beyond the gable line.

Regarding the south façade, we have the following view:

Only the storey [S]#01 follows the rule where the storey height runs from finished floor level to finished floor level:

Geveloppervlakte [S]#01 = 126,54m x (9,81m – 6,68m) = 396,07 m²

For [S]#02, the storey height is the difference between the finished floor level of the relevant storey to the eaves, being: 13.74m - 9.81m = 3.93m

Concerning [S]#00, the storey height is the difference between the finished floor level of the upper storey and the underside of the façade, being:

6.68m - 2.98m = 3.70m

As for [S]#91, the storey height is the difference between the underside of the façade and the finished floor level of the relevant storey, being:

2.98m - (-0.02)m = 3.00m

The associated floor plan is as follows:
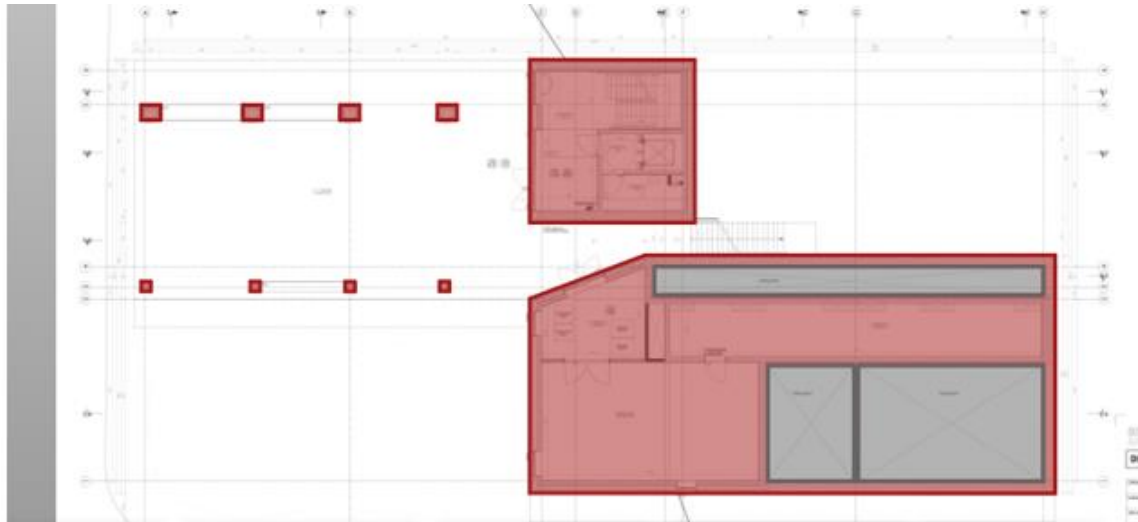
Of the corresponding perimeters, only the 8 columns have the full height:

GFA,A - oppervlakte

	Naam uitvoer	Hoevee… ↑	Eenheid	Gebied (M2)	Perimeter (M)	InnerPerimet…	Document
☐	GFA,A - oppervla…	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	57.49	M2	57.49	30.33	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	171.42	M2	171.42	68.92	85.03	Whitepaper_[S]#91

So here the facade area is: (4x 1.8m + 4x 3.21m) x 3.00m = 60.12m²

GFA,A - oppervlakte

	Naam uitvoer	Hoevee... ↑	Eenheid	Gebied (M2)	Perimeter (M)	InnerPerimet...	Document
☐	GFA,A - oppervla...	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla...	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla...	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla...	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla...	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla...	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla...	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla...	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla...	57.49	M2	57.49	30.33	0	Whitepaper_[S]#91
☐	GFA,A - oppervla...	171.42	M2	171.42	68.92	85.03	Whitepaper_[S]#91

Of the smaller volume, half is fully visible, one side fully buried and one side half buried. I.e. approx. 75% is effective facade area.

We then have 30.33m x 3.00m x 75% = 68.24m²

GFA,A - oppervlakte

	Naam uitvoer	Hoevee… ↑	Eenheid	Gebied (M2)	Perimeter (M)	InnerPerimet…	Document
☐	GFA,A - oppervla…	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.20	M2	0.2	1.8	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	0.63	M2	0.63	3.21	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	57.49	M2	57.49	30.33	0	Whitepaper_[S]#91
☐	GFA,A - oppervla…	171.42	M2	171.42	68.92	85.03	Whitepaper_[S]#91

For the largest volume, over 60% is buried and the facade area is estimated as follows: 68.92m x 3.00m x 40% = 81.70m²

Appendix – overview element clusters

niveau 1: rubriek volgens NEN 2699 dd.2017
niveau 2: clusters volgens NEN 2699 dd 2017 / hoofdindeling NBN EN 15221-4:2006
niveau 3: elementclusters volgens NEN 2699 dd 2017 en NBN EN 15221-4:2006 / B2 aangepast aan tabel 1 NI-SFB 2019

object code	omschrijving object	EH	relatie tot development code / toelichting
B	**INITIËLE BOUWKOSTEN**	**m²**	**Σ level area, opgesplitst per [E] entity**
B1	**Bouwkundige werken**	m²	Σ level area, opgesplitst per [E] entity
B1A	Fundering	m²	Building footprint + m² level area buiten building footprint van bouwlaag geheel onder de grond en bedekt met aarde opgesplitst per [E] entiteit
B1B	Skelet	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B1C	Dakafbouw/dakafwerking	m²	m² roof area (according to slope, no projection) = Σ hoev B1C(37)+(47), opgesplitst per [E] entity
B1D	Gevelafbouw/gevelafwerking	m²	m² facade area (according to slope, no projection) = Σ hoev B1D(31)+(41), opgesplitst per [E] entity
B1E	Binnenwandafbouw/binnenwandafwerking	m²	Σ gross floor area, type A, opgesplitst per [E] entity en per [Z] zone
B1F1	Vloerafbouw/vloerafwerking binnen	m²	Σ gross floor area, type A, opgesplitst per [E] entity en per [Z] zone
B1F2	Vloeren buiten	m²	Σ gross floor area, type B+C, opgesplitst per [E] entity en per [Z] zone
B1G1	Trappen en hellingbanen binnen	st, [S]	per stuk per bouwlaag, opgesplitst per [E] entity en per [Z] zone
B1G2	Trappen en hellingbanen buiten	st, [S]	per stuk per bouwlaag, opgesplitst per [E] entity en per [Z] zone
B1H1	Plafonds binnen	m²	Σ gross floor area, type A, opgesplitst per [E] entity en per [Z] zone
B1H2	Plafonds buiten	m²	Σ gross floor area, type B, opgesplitst per [E] entity en per [Z] zone
B2	**Technische installaties**	m²	Σ level area, opgesplitst per [E] entity
B2A1	Technieken fluïda: vloeistof- en gasinstallaties - standaard	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B2A2	Technieken fluïda: vloeistof- en gasinstallaties - bijzonder	tp	
B2B1	Technieken fluïda: klimaatinstallaties - standaard	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B2B2	Technieken fluïda: klimaatinstallaties - bijzonder	tp	
B2C1	Technieken fluïda: brandbestrijding - standaard	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B2C2	Technieken fluïda: brandbestrijding - bijzonder	tp	
B2D1	Technieken elektro: centrale voorzieningen - standaard	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B2D2	Technieken elektro: centrale voorzieningen - bijzonder	tp	
B2E1	Technieken elektro: energievoorziening gebruikersaansluitingen en	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B2E2	Technieken elektro: energievoorziening gebruikersaansluitingen en	tp	
B2F1	Technieken elektro: communicatie en beveiliging - standaard	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B2F2	Technieken elektro: communicatie en beveiliging - bijzonder	tp	
B2G1	Transport - standaard	st, [S]	per stuk per bouwlaag, opgesplitst per [E] entity
B2G2	Transport - bijzonder	tp	
B2H	Meet-en regelinstallaties en gebouwbeheersysteem	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B3	**Vaste inrichtingen en voorzieningen**	m²	Σ level area, opgesplitst per [E] entity
B3(71)	Vaste verkeersvoorzieningen	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B3(72)	Vaste gebruikersvoorzieningen	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B3(73)	Vaste keukenvoorzieningen	st	per geheel met onderscheid tussen volwaardige keuken, kitchnette en koffiehoek (incl. toestellen) opgesplitst per [E] entity en per [Z] zone
B3(74)	Vaste sanitairvoorzieningen	st	per toestel (incl. kraanwerk en toebehoren) opgesplitst per [E] entity en per [Z] zone
B3(75)	Vaste onderhoudsvoorzieningen	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B3(76)	Vaste opslagvoorzieningen	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B3(77)	Vaste voorzieningen voor speciale activiteiten	m²	Σ gross floor area type A, opgesplitst per [E] entity en per [Z] zone
B4	**Terrein**	m²	external area - communal & private
B4A	Terrein Grondvoorzieningen	m²	external area - communal & private
B4B	Terrein Opstallen (gebouwtjes, overkappingen enz.)	m²	related m² external area - communal & private = hoev B4B(90.2)
B4C	Terrein Omheining en afwerking	m²	related m² external area - communal & private = hoev B4C(90.4)
B4D	Technische nstallaties voor het terrein	m²	external area - communal & private
B4E	Terreininrichting	m²	external area - communal & private
B5	**Algemene uitvoeringskosten**	%	supplement t.o.v. productiekosten B1 tem B4
B5A	Plaatsbeschrijving en staat van vergelijking	tp	
B5B	Algemene bouw(plaats)kosten	%	supplement t.o.v. productiekosten (B1 tem B4)
B5C	Coördinatiekosten nevenaannemers	%	supplement t.o.v. productiekosten (B1 tem B4)
B5D	Algemene kosten (bouwbedrijf)	%	supplement t.o.v. productiekosten (B1 tem B4) - ter info t.b.v. verrekeningen nieuwe posten
B5E	Winst en risico (bouwbedrijf)	%	supplement t.o.v. productiekosten (B1 tem B4) - ter info t.b.v. verrekeningen nieuwe posten
B5F	As built dossier	tp	
B5G	Opleiding personeel technische installaties	tp	

Appendix – BBW article list versus element clusters

See Excel in appendix.

Table of content