ADAPTIVE REUSE OF CAMPUS BUILDINGS TOWARDS STUDENT HOUSING

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ABSTRACT

The focus of this research is dedicated on the TU Delft educational campus buildings CiTG, EWI and TNW from the 1960's and 1970's, who need to be brought up-to-date in order to not become abandoned. With the rising lack in student housing as the foundation, it is to see if these buildings can be a solution with adaptive reuse. The central research question is as follows: How adaptable are campus buildings from the 1960's and 1970's when transforming them to student housing? The adaptability analysis methods used in this research: FLEX4.0, Schmidt & Austin's adaptable architecture and Level(s) 2.3 establish the knowledge about adaptability and its characteristics and gives the three buildings adaptability scores. With EWI as lowest and TNW as highest. The outcome of these three methods are then compared to a research by design element, where the three buildings are via design transformed towards student housing. Based on the spatial characteristics 4 student housing case studies (Röntgenweg, Korvezeestraat, Diemen Zuid and Local+) to verify and compare the outcomes of the analytical methods with the design concepts. The three analythical methods conclude not towards one superior method, where the quick and easy application of Schmidt & Austin's adaptable architecture is combined with the clearly defined indicators and scoring systems of FLEX4.0 and Level(s) 2.3. The inclusion of more indicators, without losing grip of the importance can give the outcome clarity and something to work with. If a certain adaptability score is giving, the specificity of the change in function come into play having serious implications for the outcome of the research. If an adaptable measurement system want to include this change in function, there should be in some way or form an addition. Although the design concept does give a broader result of the adaptability capacities of a building, this does require more time and expertise. Therefore the inclusion of both, where the design gives insight in the change towards the new function and is thereby able to correct the analytical models, can give a broader and completer view of the adaptability of a building.

KEYWORDS: *Building Adaptability, Adaptive reuse, Transformation, Multi-criteria assessment, FLEX4.0, Schmidt & Austin adaptable architecture, Level(s) 2.3, Educational Campus Buildings, Student Dwellings*

I. Introduction

1.1 Problem statement

The vast majority of older Dutch campus buildings from the 1960's and 1970's within the portfolio of the Dutch universities are in dire need of an investment to stay up-to-date, or they will become obsolete and face abandonment (Basisregistratie Adressen en Gebouwen (BAG), 2018)(TU Delft Strategic Framework 2018-2024 [TU Delft], 2018). It is the stricter regulations, higher requirements for energy performance, sustainability reasons and new forms of education that example trends that strongly influence the functional requirements of the buildings (Heijer et al., 2016). The contemporary, and future expected increase in students put the universities and their buildings under even more pressure, but this also directly links to the already severe lack of student housing present in the Netherlands (Kences, Kenniscentrum Studentenhuisvesting, 2022). This all asks for flexibility and adaptability in the campus context in order to quickly encounter the changing demands. But the current strategy is partly to get rid of these expensive and energy inefficient older building within the university's portfolio (Van der Veldt, 2020). Therefore not only excluding their cultural heritage within the build environment and campus area, but also giving away opportunities for these buildings to become part of a sustainable and future proof university. And as the focus of this research, on how these buildings can be the solution for the student housing problem, with the incorporation of adaptive reuse.

1.2 Research Question

Flexibility and adaptability in the campus context can quickly encounter the changing demands. Therefore finding out how adaptable the Dutch campus buildings are and how these can be adapted towards student housing is investigated. To accomplish this, the following research question has been formulated. *How adaptable are campus buildings from the 1960's and 1970's when transforming them to student housing?* To answer this question, five sub-questions are formulated. *1) How can the adaptability of a building be analyzed? 2) How adaptable are the three campus buildings from the TU Delft from the 1960's and 1970's? 3) How does the adaptability from the three campus buildings compare?* The first three questions dedicate towards the adaptability of a campus building, the last 2 questions focus on the adaptation towards student housing and are as follows: *4) What are the spatial characteristics for the student housing? 5) How do the three campus buildings and their adaptability compare when transforming them into student dwellings?*

1.3 Method

The first part brings forward and clarifies three existing adaptability analysis methods. This is done in order to establish a fundament on what adaptability is and how to measure it. These three methods give an indication of the instruments to analyse adaptability. There three methods are then applied on three buildings of the TU Delft campus who were built in the 60's and 70's: buildings 22 (TNW; Applied Physics, 1963), 23 (CiTG; Civil Engineering and Geoscience, 1975) and 36 (EWI; Electro technique, Math and Informatica, 1972) (Basisregistratie Adressen en Gebouwen (BAG), 2018). These buildings are to be taken as a case to be represented for most universities all over the Netherlands, or even abroad with similar building from this construction period. The findings are then compared over their adaptability scores, but also the techniques themselves are to be compared. The outcome of these three methods are then compared to a research by design element, where the three buildings are via design transformed towards student housing. To do this, first the spatial characteristics of different student housing typologies are researched with four different case studies in order to get knowhow on what the campus building have to adapt towards. The obtained information form the cases are then directly used and applied in the design and the outcomes of the design are used to verify and compare the outcomes of the analytical methods with the design concepts.

II. The concept of adaptability

2.1 Adaptability analysis methods

Three multi-criteria assessments are selected that measure the adaptability of a building. These were selected by their differentiating methods and indicators towards the building's spatial and technical characteristics of a building, in order to give a broad spectrum of the multi-criteria assessment tools.

FLEX 4.0 (2016) is the a research project from the Delft University on the investigation of the adaptive capacity of buildings. As result of this research, an instrument has been developed, named FLEX (latest version 4.0) (Geraedts, 2016). This instrument consists of key flexibility performance indicators, these indicators are weighted with different default factors to assess the values from the instrument to determine the flexibility class of buildings (Geraedts, 2016). In total there are 32 flexibility performance indicators who are divided over 5 layers (site, structure, skin, facilities and space) based on the support and infill theory of Habraken. For the readability the 32 indicators are presented in appendix 1. Each flexibility performance indicator is divided into an assessment value between 1 and 4, where 1 means bad and 4 means best. The total and maximum number, thereby giving the highest adaptive capacity, equals 4 times the sum of indicators. Do this over the sum totality of indicators with their appropriated score in order to get the total percentage result.

Robert Schmidt and Simon Austin have in their Adaptable Architecture; theory and practice (2016), constructed a list of 60 building characteristics (CAR's) of adaptability. These have then been subdivided into 12 so-called design strategies (DS)(Schmidt & Austin, 2016). The complete list of the

DS's and CAR's and their meaning and explanation can be found in appendix 2. The assessment of adaptability is as follows. When the building which is to be analysed, possesses all the CAR's within the DS, it is seen as a maximal result of 100%. When the DS has no CAR it possesses from the analysis of the building, this is seen as the minimal result of 0%. Do this over the sum totality of DS's with their appropriated CAR's in order to get the total percentage result.

Level(s) provides a set of indicators and metrics for measuring the performance of buildings along their life cycle, and is developed as a common EU framework of indicators for the sustainability of office and residential buildings (Dodd et al., 2020). In more specificity, the level 2.3 assessment focusses is on the building's spatial and structural design features, mainly the building's structural engineering, internal layouts and technical services (Dodd et al., 2020). Providing an indicator for adaptability in the form of a semi-quantitative assessment of the extent to which the design of a building could facilitate future adaptation to changing occupier needs (Dodd et al., 2020). The level 2.3 assessment consist of 12 indicators, each assessing a specific design aspect and can be seen in appendix 3. The scoring system consist of a 4 point system where, specific per indicator, four options are giving from worst to best. Worst giving 0 points and best giving 3 points. These points are then weighted with a predetermined factor ranging from 1.5 to 4.5. The final adaptability score represents the sum of the weighted scores for each of the design aspects, divided over 100 to get a percentage score.

2.2 TU Delft buildings adaptability score

The adaptability score for method 1 and 3 are mainly based on construction drawings of the TU Delft buildings. These cannot be shared due to their confidentiality and thus only the results of the methos are shown, but the process of method 2 is demonstrated elaborately. Method 1: FLEX 4.0 analysis method, as seen in applied to the TU Delft buildings in appendix 4, 5 and 6. The results of method 1; FLEX 4.0, are displayed in figure 1 and show not only the overall total score of the 32 flexibility performance indicators, but also the score over the 5 layers by Habraken. The overall total score shows little differences between the three buildings, with TNW (building 22) having the highest score of 77% and the EWI (building 36) having the lowest score of 70%.

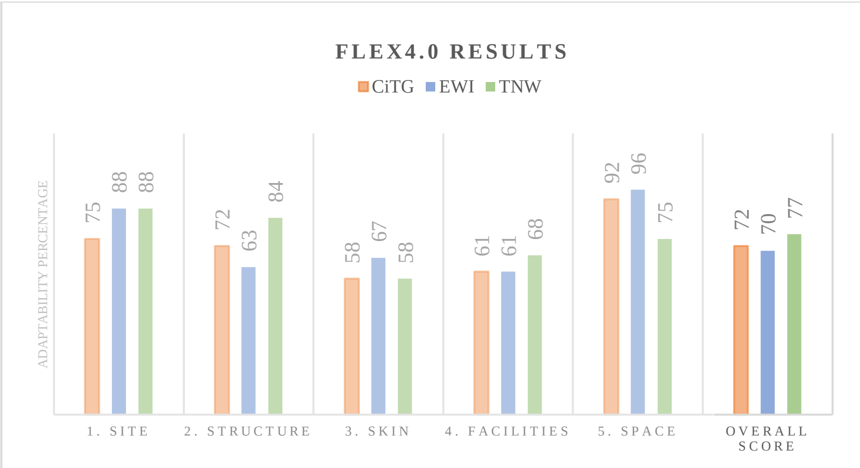


Figure 1: Results FLEX 4.0 from the 3 TU Delft campus buildings (by Author)

The biggest differences can be seen in the layers, where the TNW building scores much lower on the 5th layer of space. The difference here is made through the disconnect ability and removability of the inner walls, as seen by the indicators 28 to 30. Whereas the TNW building consist mostly, and more than the other two buildings of immovable brick interior walls. But what is loses in layer 5 space, it gains in layer 2 'structure' and layer 4 'facilities'. The main difference in layer 2 is made between TNW and EWI because of indicators 6 and 8, considering the layout of horizontal space, and the extension of routings. This has to do with the difference in form of the two buildings, limiting the divide ability over horizontal space. The different corridors/wings of the TNW building make this, and thereby the addition of new routings, more easy than the slim and high form of the EWI building. For the 4th layer of the facilities, the difference is made between the distribution and the ability to control these more and better in the TNW building than the others (indicators 20 and 22). With climate control on unit (room) level and tied services distribution like hot and cold water, electricity, ventilation together on the same places. Finally, the main loss for CiTG (building 23) in the 1st layer of site originates from indicator 1 about the surplus area around the building, where there is less space and thus less adaptable. Method 2: Schmidt, R., & Austin, S. A. Adaptable Architecture: Theory and Practice analysis method, as seen in applied to the TU Delft buildings in appendix 7, 8 and 9. The results of method 2 are displayed in the radar charts in figure 2 where the percentage of CAR's in each DS is visible. The overall total score of the adaptability of the three buildings is as follows: The highest and thereby best score is TNW with 45 from 60 CAR's, equals 75%. Second CiTG 42 from 60 CAR's, equals 70% and the lowest score is from EWI, with 35 from 60 CAR's, equals 58%.

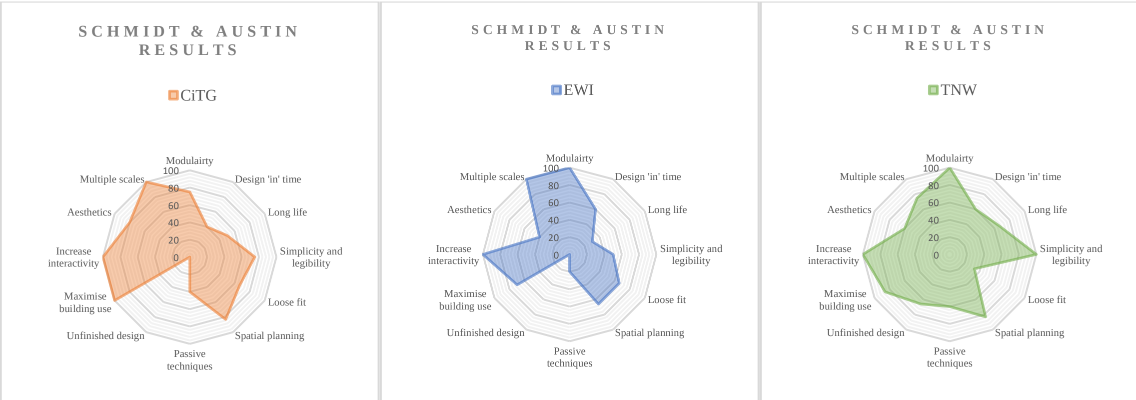


Figure 2: Results Schmidt & Austin from the 3 TU Delft campus buildings (by Author)

The overall adaptability score portrays a big difference between EWI, and the TNW and CiTG buildings, with a difference of at least 12%. This difference is made over almost each DS, where the EWI building scores much lower than the other two, but eye-catching are the 'long life', 'simplicity and legibility' and 'aesthetics' DS's. The main difference in the long life DS is made with CAR's 10 and 13, because EWI makes use of light and easily replaceable interior wall systems. In contrary to the other two buildings have these no capacity for longevity, thus missing out on these two indicators. The difference in the 'aesthetics' DS in spatial quality and history of the interior space (CAR53 and 56), is thereby also affected by this materiality. CAR18 and 19, about the components and construction method of the building to enable change, in the scale of a legible simple and off-site construction systems, which EWI doesn't comply with its poured concrete construction, the difference in the 'simplicity and legibility' is made. Lastly, remarkable is that the TNW is the only building to score in the 'unfinished design' DS (CAR40 and 42). It is the possibility of space to grow into and the user customization of the different labs, that the contrast to the other buildings is made.

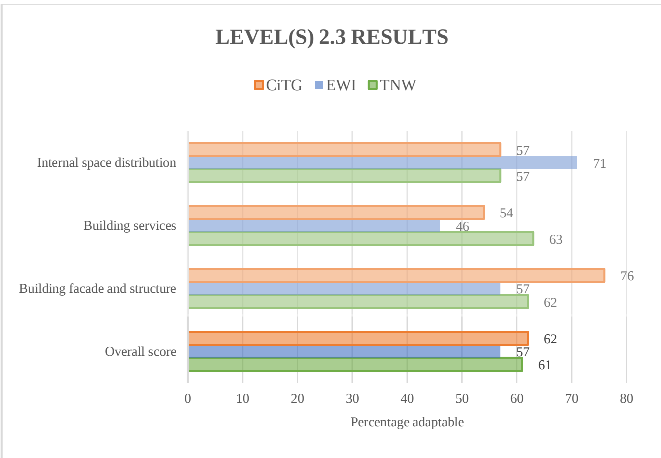


Figure 3: Results Level(s) 2.3 from the 3 TU Delft campus buildings (by Author)

Method 3: Level(s) 2.3 analysis method, as seen in applied to the TU Delft buildings in appendix 10, 11 and 12. The results of method 3 are displayed in figure 3 and show very little difference over the overall score, but 6 and thereby classified as least adaptive. The biggest differences are seen in the design concepts. The movable interior wall system of the EWI scores, partly by the weighting factor of 4.5, makes the difference for the 'interior space distribution' on design aspect 1.3. But EWI loses on aspect 2.5 where the services to sub-division of space isn't as adaptable as the other buildings. In the 'building façade and structure' design aspect 3.2 about the load bearing capacity makes the difference for CiTG towards the other two.

2.3 Adaptability score comparison

In table 1 the results of the percentage adaptability score from the three methods of the three buildings can be seen. The EWI building, although the differences in percentage are sometimes as low as 4%, is in all three methods the building with the lowest score and therefore proclaimed as the building with the lowest capacity to be adapted. The results between the three methods differ in percentage, so shows method 3 generally lower scores, this is due to the weighting factors creating big differences between the maximum and the actual scores, and the fact that this method is originally more specific towards the adaption of more office-like functions (Dodd et al., 2020).

Table 1: Results of the 3 methods from the 3 TU Delft campus buildings (by Author)

	CiTG	EWI	TNW
Method 1	72%	**70%**	77%
Method 2	72%	**58%**	75%
Method 3	62%	**57%**	61%

The differences are the biggest in method 2, this is due to the biggest amount of indicators, 60 compared to 32 and 12. For method 1 all three buildings score high, because this method is more specified for educational buildings and their adaptability towards housing, meaning according to this method all three buildings are suitable for adaption (Geraedts, 2016).

2.4 Analysis method comparison

FLEX4.0 (method 1) and Level(s) 2.3 (method 3) work both with a scoring system that consists of a value/point system of four option ranging from worst (1) to best (4) (Geraedts, 2016)(Dodd et al., 2020). This makes assessing a certain indicator way more concrete and gives the user an indication of what value to investigate, thereby narrowing down the scope of the indicator. This way of assessing can therefore also be applied faster and easier in on-site investigations. Although a simple site visit isn't sufficient for methods 1 and 2 and the dependence on building documents (floorplans, sections, and sometimes even construction details) can complicate, delay or even limit the investigation. The main difference between methods 1 and 3 is the amount of indicators, 32 to 12. Although the weighting system of method 3 does give clarity over what building characteristic is more important than the other, the great differences in weight (from 1.5 to 4.5) can easily influence a score by one simple aspect (3x1.5 relative to 3x4.5), thereby losing the worth of the other(s). This is something that lacks in method 1, where every indicator is worth even, but the reference to the layers to Habraken creates a grounded foundation of adaptability indicators (Geraedts, 2016). Method 2 of Schmidt & Austin leaves the interpretation of the design characteristics to the user him/herself, by not giving a value/point system (Schmidt & Austin, 2016b). The procedure is bases upon a visual/photo analysis of the building and can therefore be analysed using a rather quick site visit, thereby not dependent on building documents. This is helped by the 'it's either present or not' procedure, although this sometimes can be rather vague due to the too broad description of the CAR's. This also put some doubt over the repeatability and the consistency of the outcome of this method, where two different persons could interpret a certain building or characteristic differently, influencing the outcome. But the broad scale of characteristics (60) gives this method a greater opportunity to assess a building in a more complete manner and the subdivision into 12 strategies gives oversight and clarity in the results, also when comparing certain buildings.

These three methods conclude not towards one superior or best method, this could be found somewhere in in the middle where the quick and easy application of method 2 is combined with the clearly defined indicators and scoring systems of methods 1 and 3. The inclusion of more indicators, without losing grip of the importance with for example a weighing system, can give the outcome clarity and something to work with.

III. Adapting towards student housing

3.1 Case study projects

The groundwork for the function it has to adapt to is now researched, in this case student housing. To get a grasp on this typology and its spatial requirements, a case study research is set up. Selected are 4 student housing projects from mainly the Netherlands, and one from Germany in order to stay as close as possible to the Dutch student housing culture and typology. The four cases range from on one side individual studio dwellings that functions on its own (see appendix 13), to a communal dwelling where its shared space is maximised (see appendix 16). The two other cases are combined to show a middle ground between the two and can be seen in appendix 14 and 15.

3.2 Student housing comparison

In this paragraph the results of the comparison are shown. In figure 4, from left (the individual studio dwellings) to right (the maximised shared space) show the analysis. Note that the figures are to scale to one another. Standing out on three of the four cases is the typology of a central corridor with dwellings on both side facing outwards towards the façade of the buildings, thereby being exposed to daylight and natural ventilation by the possibility of openable windows. This also reflects back onto the form of the who building, resulting in mostly a slender layout where the length vastly out ways the width, with a mean width of 14 meters (cases being 16, 14, 14 and 10 meter). The amount of dwellings per floor differ, from left to right with Röntegenweg having 107 dwellings, Diemen Zuid 43 (although 13 on the ground floor plan shown in the figure), Korvezeestraat 18 and Local+ with 3 sleeping units per floor. Further can be seen that, except for Local+, each project has multiple staircases or routings, but the amount of entrances to the building differ. Whereas Röntgenweg and Korvezeestraat have three or more ways of entering the building, Diemen Zuid limits this to only one due to the shared and commercial functions on the ground floor, where the inhabitants have to pass by in order to exit or enter the building.

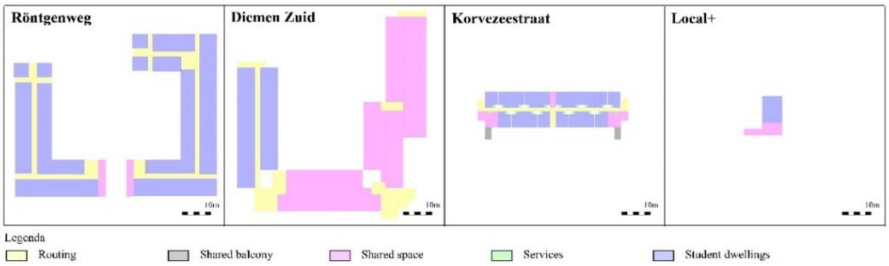


Figure 4: Case study comparison on building scale (by Author)

Zooming in on the unit level, as seen in figure 5 and table 2 showing the individual studios of Röntgenweg and Diemen zuid on scale to the shared Korvezeestraat and Local+. The main difference is in the increasing amount of square meters, not only the living/kitchen aera but also the square meters per person. The creation of shared space by either dividing this over the total numbers of persons using this space, or seeing this space as a necessity per individual unit and thereby adding it to the square meters per individual person, portrays the trend of the increase in amount of square meters per person when the shared space is maximised.

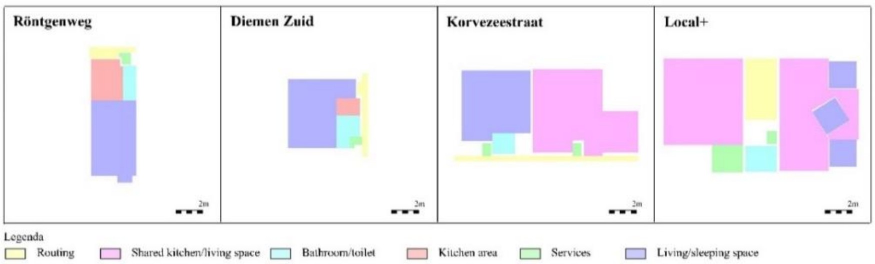


Figure 5: Case study comparison on dwelling scale (by Author)

Table 2: Results and measurements of the case study analysis (by Author)

	Röntgenweg	Diemen Zuid	Korvezeestraat	Local+
Living/kitchen area	24,6 m2	27,2 m2	40 m2	100 m2
Sleeping area	-	-	25,9 m2	4 m2
Bathroom	2,3 m2	3,5 m2	3 m2	5 m2
Persons per house	1	1	9	3
Total m2 per person (when shared m2 is divided over number of persons using)	26,9 m2	30,7 m2	**33,4 m2**	**36,3 m2**
Total m2 per person (when shared m2 is added to m2 over a person)	26,9 m2	30,7 m2	**68,9 m2**	**109 m2**

However, the effects on the services is reversed, with an decrease in square meters of the bathroom (if used by more people) limiting the amount and most importantly the spread and size of the services. With the individual units each having this need, but when these are shared over more persons, these can just be created in a certain central spot. Lastly the Local+ case brings forth the concept that not every sleeping unit has to be tied to the façade of the building, this implies the disconnection from the depth of the building with the sleeping units as seen in the other case study project.

IV. Designing concepts into plan

From the analysis of the four cases, the results have been categorised into three typologies: individual student dwellings (Röntgenweg & Diemen Zuid), shared living student houses (Korvezeestraat) and maximized shared space (Local+). These typologies are in this paragraph applied in design to the three buildings of the TU Delft, delivering 9 building plans total, with the previous cases as a design example (i.e. measurements, typologies, connections, ect.). In figure 6 a selection is seen.

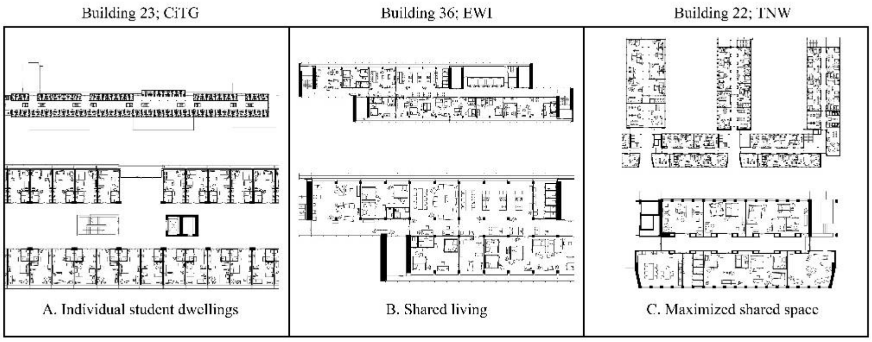


Figure 6: Design plans of student housing cases into the three TU Delft buildings (by Author)

These 3 typologies over the 3 buildings have then been analysed in the same manner in the case studies. It is from these analysis that conclusion are drawn on the ability for these educational TU Delft campus buildings from the 1960's and 1970's to be transformed to the 3 types of student dwelling, thereby giving feedback from design and being able to compare this to the analytical methods as seen in chapter 2. The results of this design and research can be seen in appendix 17, 18 and 19.

The conclusions are as follows: CiTG (building 23) has overall more cons for the transformation into student housing than pros. Although the building features multiple access points, openable windows and leaves the size of the load baring structure more than enough space for change, it is the overall scale, form and dimension of the CiTG building that makes it not fit for the change in function. The too large widths limits the possibility of daylight to enter the building, limiting the daylight demanding function of dwelling. This is mostly seen in appendix 17 at A1 on building scale and in B1 and B2 on house scale, where the in between space of the individual units (which are already over dimensioned) is not suited for functionality. Furthermore limits the scarce amount of (vertical) service zones the possibility for quick and easy adaptation of wet function like toilets, bathrooms and kitchens. In the EWI building (building 36) the pros and cons mostly weigh up on each other. The placement of the (vertical) servicing again leave a lot do desire, making extra plumbing necessary as can be seen in appendix 18 in A2 and A3. And the danger of the lack of daylight in interior central corridors or functions can cause problems, but the overall slender shape of the building lowers the area where this can be a problem. The dimensions of the structure are suitable for the change in function and the multiple access points can create variety, as seen in B1 and C1 in appendix 18. But the main problem with this building is its façade and its lack of openable windows, making the change of function problematic. The pros of TNW building (building 22) out way the cons greatly, the slender building width and the typology of the different wings being connected by corridors makes adaption to the student dwellings possible, as can be seen in appendix 19 A1-C1 and A2-C2. Whereas the individual or shared student dwelling can be places towards the outside, enabling daylight and natural ventilation due to openable windows. The multitude in access points requires no adaption and can be used directly towards the student dwellings. But the main pros of this quick adaption can be seen in appendix 19 A3 and B3 and on greater scale A2-C2, where the (vertical) services are already established at unit level, making the addition of wet functions rather easy. Leading to a great variety of ways to establish this change in function.

V. Conclusion

The designing concept of chapter 4 deem CiTG building not suitable for adaptation towards student housing, whereas the buildings' form and services greatly limit the possibilities of dwelling functionalities. And if it should be adapted, only created mainly options for (maximized) shared amenities. The analytical method 3 did already show the same limitations of the 'internal space distribution' and 'building services' design concepts and methods' 1 'design 'in' time' design strategy lowest score does also clarity some lack of adaptability. Nevertheless portrayed the analytical methods this building as adaptable, being second just short of the most adaptable building. This main difference in outcome is due to the specificity of the student housing function which the building has to be adapted towards. The building may be classified as overall adaptable, but this does not mean for each specific functionality in this case being student housing. The EWI building (building 36) was deemed least adaptable form all three analytical methods, with the main differences in methods 1's structure and facilities layers, method 2's 'spatial planning' and 'simplicity and legibility' design strategies and method 3's 'building services' design concept. All three suggesting low adaptability of the layout, structure and services. This does return in some form in the design concept, whereas specifically for the individual typology of student housing the services does provide problems. But the overall shape and form of the structure is deemed as a good foundation towards shared student housing. This is because the specificity of the student housing, consisting of mostly small repetitive units that fits into the slender form of the building. From the analytical method of analysing adaptability of a building towards student housing, the TNW building (building 22) received the highest scores, suggesting the most adaptable building. This is again seen in the designing concepts. Not only the typology, form and dimensions of the building but also the services make the adaptation towards student housing best possible. This in line with the outcomes of methods 1 and can be seen in the peak of the 4th layer of structure and 5th of facilities. In method 2 this pattern also returns in the score of the 'spatial planning' design strategy. Meaning for the TNW building (36), the analytical methods are confirmed by design and thus can this building be classified as an greatly adaptable building, where all three student housing typologies can be applied or varied through the building.

Adaptability is something that sometimes can and sometimes cannot be analysed using a certain measurement method. If a certain adaptability score is giving, the question then becomes what it is that it's adaptable towards. Here the specificity of the change in function (if necessary) come into play. Thereby the shape, measurements and services (for example) of what it has to adapt towards, are not included in the analytical methods although these can have serious implications for the outcome of the research. As can be seen in the cases of the CiTG and EWI buildings of the TU Delft. The CiTG was analysed to be adaptable, but later designing proved differently for the specific function it has to be changed towards, this case being student housing. The opposite turned out for the EWI building, where later design proved possibilities not seen by the analytical methods. If an adaptable measurement system want to include this change in function, there should be in some way or form an addition where this change is included. Although the design concept does give a broader result of the adaptability capacities of a building, this does require more time and expertise. Therefore the inclusion of both, where the design gives insight in the change towards the new function and is thereby able to correct the analytical models, can give a broader and completer view of the adaptability of a building.

REFERENCES

1. Dodd,N., Donatello,S., & Cordella.M. 2020. *Level(s) indicator 2.3: Design for adaptability and renovation, User manual: overview, instructions and guidance* (publication version 1.0)
2. Schmidt, R., & Austin, S. A. (2016). *Adaptable Architecture: Theory and Practice*. Routledge.
3. Basisregistratie Adressen en Gebouwen (BAG). (2018). Bouwjaar panden [Dataset]. In *Kadaster*. *Rijksinstituut voor Volksgezondheid en Milieu* (RIVM). https://www.atlasleefomgeving.nl/kaarten?config=3ef897de-127f-471a-959b-93b7597de188&gm-x=155604.8558361423&gm-y=462016.56250558776&gm-z=9&gm-b=1544180834512,true,1;1544724925856,true,0.8;&activateOnStart=info&deactivateOnStart=layercollection
4. Geraedts, R. P. (2016). FLEX 4.0: A Practical Instrument to Assess the Adaptive Capacity of Buildings. In *Energy Procedia* (Vol. 96, pp. 568-579) https://doi.org/10.1016/j.egypro.2016.09.102
5. Heijer, A. C., Arkesteijn, M. H., De Jong, P., De Bruyne, E., Meijler, J., & Born, L. (2016). *Campus NL: investeren in de toekomst.*
6. Kences, Kenniscentrum Studentenhuisvesting. (2022, September 7). *Kamertekort onverminderd hoog* - Kences. Kences. https://www.kences.nl/nieuws/kamertekort-onverminderd-hoog/
7. SteenhuisMeurs. (2018). Cultuurhistorisch onderzoek TU Delft. In *Campus and Real Estate TU Delft* (No. 372). https://www.tudelftcampus.nl/nl/campus-development/historie/
8. TU Delft Strategic Framework 2018-2024 [TU Delft]. (2018). *Impact for a better society*. Edauw en Johannissen. https://www.tudelft.nl/over-tu-delft/strategie/tu-delft-strategisch-kader-2018-2024
9. Ministerie van Onderwijs, Cultuur en Wetenschap. (2022, November 30). *Prognose aantal studenten wo. Hoger Onderwijs* | OCW in Cijfers. https://www.ocwincijfers.nl/sectoren/hoger-onderwijs/kengetallen-wetenschappelijk-onderwijs/studenten/prognose-aantal-studenten-wo#:~:text=Het%20geraamde%20aantal%20studenten%20in,2022%2D%2723%20is%20353.500.
10. Stichting Delftse Studenten Huisvesting [SDSH]. (1984). *Informatieboekje van eekelenplantsoen* (1st ed.) [Pdf]. Hofstad Druktechniek bv, Zoetermeer. https://docplayer.nl/23454824-Van-eekelenplantsoen.html
11. Studentenhuisvesting Spoorzone | Leeuwenkamp Architecten. (n.d.). https://www.leeuwenkamp.nl/project/studentenhuisvesting-spoorzone
12. Housing the student (H. Mooij, Interviewer). (2018). *Dash, 10, 46–51*. https://journals.open.tudelft.nl/dash/article/view/4898
13. *Kamer huren in Delft in de Korvezeestraat.* (n.d.). KamerSocial. https://kamersocial.nl/huren/delft/korvezeestraat/601480
14. *Korvezeestraat 480-550*. (n.d.). https://www.duwo.nl/over-duwo/onze-gebouwen/overzicht-gebouwen/complexinformatie/item/65#lg=1&slide=0
15. Kamernet. (2023, January 13). Korvezeestraat - Delft. *Delft Studentenstad*. https://delftstudentenstad.nl/kamers-in-delft/korvezeestraat-delft/2023-01-13
16. Meurers, G. (n.d.). *Team LOCAL+ der FH Aachen überzeugt beim Solar Decathlon | LINEAR*. LINEAR. https://www.linear.eu/de/blog/team-local-der-fh-aachen-ueberzeugt-beim-solar-decathlon-europe-2021/22/
17. Voss, K., Simon, K. (Eds.), n.d. solar decathlon europe 21/22 competition source book. https://doi.org/10.25926/svtg-e916

Appendix

1 FLEX4.0 Analysis method; Method 1

2 Schmidt & Austin analysis method; Method 2

3 Level(s) 2.3 analysis method; Method 3

4 FLEX4.0 Analysis method; Method 1. Applied on building 36; EWI

5 FLEX4.0 Analysis method; Method 1. Applied on building 23; CiTG

6 FLEX4.0 Analysis method; Method 1. Applied on building 22; TNW

7 Schmidt & Austin analysis method; Method 2**.** Applied on building 23; CiTG

8 Schmidt & Austin analysis method; Method 2**.** Applied on building 36; EWI

9 Schmidt & Austin analysis method; Method 2**.** Applied on building 22; TNW

10 Level(s) 2.3 analysis method; Method 3. Applied on building 23; CiTG

11 Level(s) 2.3 analysis method; Method 3. Applied on building 36; EWI

12 Level(s) 2.3 analysis method; Method 3. Applied on building 22; TNW

13 Case study Project: Röntgenweg, Delft

14 Case study Project: Diemen Zuid, Amsterdam

15 Case study Project: Korvezeestraat, Delft

16 Case study Project: Local+

17 Research by design CiTG

18 Research by design EWI

19 Research by design TNW

Appendix 1 FLEX4.0 Analysis method; Method 1

FLEX 4.0: SPECIFICALLY APPLICABLE INDICATORS, PART 1				
LAYER	**SUB-LAYER**	**Flexibility Performance**	**Assessment Values**	**Remarks**
1. SITE		1. **Surplus of site space** Does the site have a surplus of space and is the building located at the centre?	1. No, the site has no surplus of space at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. The site has a surplus space of more than 50% (Best)	The more surplus space on site, the better the building is expandable (horizontal).
		2. **Multifunctional site/location** Is the location capable to support more functions, like offices, living, care and shops?	1. Just one function; suited for offices or living or care or shops (Bad) 2. Two functions (Normal) 3. Three functions (Better) 4. > Three functions; suited for offices, living, care and shops as well (Best)	The more a location around a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.
2. STRUCTURE	Measurement	3. **Available floor space of building** Does the building or the user units have a surplus of the needed usable floor space?	1. No, the building or user units have no surplus of floor space at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. The building has a surplus of floor space of > 50% (Best)	The more surplus space a building/user units have, the more easily a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
		4. **Size of floor buildings** What is the size of the usable floor surface?	1. The usable floor space < 400 m2 (Bad) 2. 400 - 600 m2 (Normal) 3. 600 - 1000 m2 (Better) 4. The usable floor space > 1000 m2 (Best)	The larger the size of the usable floor surface the more easily units in a building can be rearranged or transformed to other functions.
		5. **Measurement system** Have positioning/measurement modulare rules for construction components been used?	1. Rules for modular coordination are not implemented (Bad) 2. <50% implemented (Normal) 3. >50% implemented (better) 4. Rules for modular coordination are > 90% implemented (Best)	The more project independent, demountable and replaceable construction components have been implemented, the more easily a building can be rearranged or transformed to other functions.
		6. **Horizontal zone division/layout** Has use been made of a horizontal zoning system, including intermediate margins?	1. No zoning system of a zoning system without intermediate margins (Bad) 2.Yes, with 10-30% intermediate margins (Normal) 3. Yes, with 30-50% intermediate margins (Better) 4. Yes, with met > 50% intermediate margins	The more margins are used in the zoning system of the building, the more easily a building/units can be rearranged, extended or transformed to other functions.
		7. **Presence of stairs/elevators** Are sufficient stairs/elevators present in the building?	1. Only one decentred located stairs/elevator core is available in the building (Bad) 2. There is one central located stairs/elevator core available in the building (Normal) 3. The building is divided into different wings each with a central stairs/elevator core 4. The building has one central and several decentred stairs/elevator cores per wing	The more stairs/elevators are available in the building the more easily a building/units can be rearranged, rejected, extended or transformed to other functions.
		8. **Extension/reuse of** Is there a possibility to add new stairs/elevators to the building and reusing the existing ones?	1. No stairs/elevators can be added without drastic expensive measures (Bad) 2. A new stairs/elevators core can be accidently added and existing reused (Normal) 3. New stairs/elevators can be limited added and existing ones reused (Better) 4. New stairs/elevators can be easily without drastic expensive measures (Best)	The more stairs/elevators can be added to the building the more easily a building can be rearranged, rejected, extended or transformed to other functions.
	Construction	9. **Surplus of load bearing capacity** How large is the load bearing capacity of the floors in the building?	1. < 3 kN/m2 2. 3 - 3,5 kN/m2 3. 3,5 - 4 kN/m2 4. > 4 kN/m2 and several areas > 8 kN/m2	The larger the load bearing capacity of floors, the easier a building can be rearranged, transformed to other functions, or vertical extended, the better a building can meet to changing user demands.
		10. **Shape of columns** How are the columns in the building shaped?	1. The columns are shaped round and/or have vertical different sizes (Bad) 2. The columns are shaped octagonal (Normal) 3. The columns are shaped rectangular (Better) 4. The columns are shaped square (Best)	The less deviate from a square column, the better a building/units can be rearranged (standardized connection of inner walls).
		11. **Positioning of facilities zones** Are facilities zones and vertical shafts located at central building level and/or local unit level?	1.All facility zones and vertical shafts are only located at central level (Bad) 2. Facility zones/shafts are located at central level and occasionally at local level 3. Facility zones/shafts are located at central level and limited at local level (Better) 4. Facility zones/shafts are located at central level and at local level as well (Best)	The more facility zones/shafts are located at unit level, the easier a building can be rearranged, transformed to other functions.
		12. **Fire resistance main bearing** How many minutes is the fire resistance of the main load bearing construction?	1. The fire resistance of the load bearing construction is 30 minutes (Bad) 2. The fire resistance of the load bearing construction is 60 minutes (Normal) 3. The fire resistance of the load bearing construction is 90 minutes (Better) 4. The fire resistance of the load bearing construction is 120 minutes (Best)	The higher the fire resistance of the load bearing construction, the easier a building can be rearranged/transformed to other functions, the better a building can meet to changing demands.
		13. **Extendible building/units horiz.** Is it possible to expand the building horiz. for new extension to the building/user units?	1. Horizontal extension of building/units is not possible at all (Bad) 2. Horizontal extension of building/units is very limited possible (only at one side) 3. Horizontal extension of building/units is limited possible (at more sides) (Better) 4. Horizontal extension of building/units is easily possible at all sides (Best)	The more a building/unit can be expanded, the easier a building can be rearranged or transformed to other functions or expanded, the better a building can meet the changing user demands.
		14. **Extendible building/units vert.** Is it possible to expand the building vertically, for adding new floors or a new basement?	1. Vertical extension of building/units is not possible at all (Bad) 2. Vertical extension is limited possible; only for a few units in the building (Normal) 3. Vertical extension (added floor or basement) is possible after total rearrangement 4. Vertical extension (new floors/basement & individual user units) is possible (Best)	The more a building/unit can be vertically expanded, the easier a building can be rearranged or transformed to other functions or expanded, the better a building can meet changing user demands.
		15. **Rejectable part of building/unit** Is it possible to reject part of the building for selling/renting to third parties?	1. It is not possible to reject part of building/units (Bad) 2. It is possible to reject 10-30% of the building/units (Normal) 3. It is possible to reject 30-50% of the building units (Better) 4. It is possible to reject >50% of the building/units (Best)	The more (part of) a building/unit can be vertically rejected, the easier a building can be rearranged/transformed to other functions, the better a building can meet changing user demands.
		16. **Insulation between stories/units** How is the thermal and acoustic insulation between the different storeys in the building?	1. Insulation does not meet the current demands for office buildings anymore (Bad) 2. Meets the current demands for office buildings (Normal) 3. Also meets the current demands for housing and care (Better) 4. Meets 10% above the current demand for offices, housing and care (Best)	The better the thermal and acoustic insulation between the different storeys, the easier a building can be rearranged/transformed to other functions, the better a building can meet changing demands.

Figure 1. FLEX4.0 instrument to assess adaptive capacity of buildings part 1/2 (Geraedts, 2016)

FLEX 4.0: SPECIFICALLY APPLICABLE INDICATORS, PART 2				
LAYER	**SUB-LAYER**	**Flexibility Performance**	**Assessment Values**	**Remarks**
3. SKIN	**Facade**	**17. Dismountable facade** To what extend can facade components be dismantled in case of transformation?	1. Facade components can not or hardly be dismantled without demolition (Bad) 2. A small part of the facade components can be dismantled (> 20 < 50%) (Normal) 3. A large part of the facade components can be dismantled (> 50 < 90%) (Better) 4. All facade components are easily dismountable (> 90%) (Best)	The more facade components are easily dismountable, the more easily a building can be rearranged or transformed to other functions.
		18. Location/shape daylight In what way are the facade/daylight openings positioned and shaped?	1. There are large closed surfaces in the facade (Bad) 2. There are small horizontal open surfaces in the facade (Normal) 3. Large open surfaces in the facade, but with different height sizes (Better) 4. Large continuous horiz. open surfaces; connections according to planning grid	The more regular open surfaces in the facade according to the planning grid, the better a building can meet changing demands in functions, quality and finishing of the building.
		19. Insulation of facade How is the thermal and acoustic insulation quality of the facade of the building?	1. Insulation does not meet the current demands for office buildings anymore (Bad) 2. Meets the current demands for office buildings (Normal) 3. Also meets the current demands for housing and care (Better) 4. Meets 10% above the current demand for offices, housing and care (Best)	The better the thermal and acoustic insulation of the facade, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
4. FACILITIES	**Measure & Control**	**20. Measure & control techniques** Is it possible to control/measure facilities on building level as well on user unit level?	1. Control/measurement takes place only at central building level (Bad) 2. On central level and occasionally on unit level (Normal) 3. On central level and limited on unit level (Better) 4. As well central on building level as well completely on unit level (Best)	The more possibilities for measurement and control of the facilities on unit level, the more easily units in a building can be rearranged or transformed to other functions.
	Dimensions	**21. Surplus capacity of facilities** Does the capacity of (the sources of) the facilities have a surplus capacity?	1. The capacities of facilities have no surplus at all (Bad) 2. The capacities of facilities have a surplus of 10-30% (Normal) 3. The capacities of facilities have a surplus of 30-50% (Better) 4. The capacities of facilities have a surplus of > 50% (Best)	The more surplus capacity of the facilities, the easier a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
	Distribution	**22. Distribution facilities** Does the building have a specific distribution facility for hot/cold water, heating, cooling, gas?	1. There is a specific distribution facility for all the different sources (Bad) 2. There is a specific distribution facility for some of the different sources (Normal) 3. There is a specific distribution facility for 2 of the different sources (Better) 4.There is no specific distribution facility one of the different sources (Best)	The less specific distribution equipment facilities have, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
		23. Location sources facilities What is the location of the central facility sources?	1. The facilities sources are located at only one central location in the building (Bad) 2. The facilities sources are located at several locations in the building (Normal) 3. The sources are located at a central location and a decentred location as well. 4. The sources are located at outside the building at city level (district heating)	The more facility sources are localized at decentred level, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
		24. Disconnection of facility Can the components of the facilities be easily disconnected?	1. Facility (parts) can not be disconnected or demounted; 'wet' connections (Bad) 2. Hardly be disconnected, demounted (Normal) 3. Partly be disconnected, demounted (Better) 4. Facility (parts) can be disconnected very easily (completely demountable) (Best)	The more facility parts can be disconnected or demounted, the easier a building can be rearranged/transformed to other functions, the better a building can meet to changing demands.
		25. Accessibility of facility To what extend are facility components good accessible?	1. Hardly or not accessible (components on support level; concreted in) (Bad) 2. Limited accessible (partly on support and infill level) (Normal) 3. Good accessible (a lot of components on infill level) (Better) 4. Very good accessible; most components at infill level; completely demountable	The higher the accessibility of facilities components, the more easily units in a building can be rearranged or transformed to other functions.
		26. Independence of user units In what way are the user units independent related to services as pantry, toilet facilities?	1. No services available at user unit level (Bad) 2. 1 - 2 services available (Normal) 3. 3 - 4 services available (Better) 4. > 4 services available (Best)	The more services are available at unit level, the more independent the units are opposite other units in the building, the more they meet to individual user demands.
5. SPACE	**Functional**	**27. Multifunctional building/Units** Is the building capable to support different functions, like offices, living, care and shops?	1. The building supports only one function (Bad) 2. The building supports 2 functions (Normal) 3. The building supports 3 functions (Better) 4. The building supports > 3 functions (Best)	The more a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.
	Technical	**28. Disconnectable, removable,** To what extend are the user units in a building removable, relocatable?	1. The user units in the building are not removable, relocatable (Bad) 2. The units are only relocatable with drastic expensive measures (Normal) 3. Units are easy relocatable; constructed with demountable components (Better) 4. Easy relocatable; constructed with 2D/3D modules, transportable by road (Best)	The more the units consist of demountable and reusable components, the better the units are relocatable to another location in or outside the building.
		29. Disconnectable, removable, To what extend are inner the walls in the building easily replaceable?	1. Inner walls are not replaceable without drastic/expensive interventions (bad) 2. Inner walls are not replaceable, but good destructible (Normal) 3. Inner walls replaceable by dismantling and rebuilding at another location (Better) 4. Inner walls are easily replaceable without radical/expensive interventions (Best)	The more inner walls can be easily replaced, the more easily a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
		30. Disconnectable connection detail Which detailed construction is applied between the interior walls and support structure and facade?	1. The detailing connection consists of penetrating connections (Bad) 2. The detailing connection consists of wet connections (mortar, sealant, glue) 3. The detailing consists of specific project bound connection elements (Better) 4. The detailing consists of project unbound dismountable connections (Best)	The easier the connection of interior walls can be dismounted, the easier a building can be rearranged or transformed to other functions, the better a building can meet to changing demands.
		31. Possibility of suspended ceilings Is it possible to apply suspended ceilings (-0.20m) and to adapt these to the different user demands?	1. Suspended ceiling results in free floor height of < 2.60 m (Bad) 2. Suspended ceiling results in free floor height of 2.60-2.70m (Normal) 3. Suspended ceiling results in free floor height of 2.70-2.80m (Better) 4. Suspended ceiling results in free floor height of > 2.80m (Best)	The higher the free storey height, the better the building can meet to changing demands concerning functions, facilities, finishing and quality of the building.
		32. Possibility of raised floors Is it possible to apply raised floors and to adapt these to the different user demands?	1. Raised floor results in free floor height of < 2.6 m (bad) 2. Raised floor results in free floor height of 2.60-2.70m (Normal) 3.Raised floor results in free floor height of 2.70-2.80m (Better) 4. Raised floor results in free floor height of > 2.80m (Best)	The higher the free storey height, the better the building can meet to changing demands concerning functions, facilities, finishing and quality of the building.

Figure 2. FLEX4.0 instrument to assess adaptive capacity of buildings part 2/2 (Geraedts, 2016)

Appendix 2 Schmidt & Austin analysis method; Method 2

DS1 MODULARITY separation of the physical parts of the building into defined functional entities	CAR1	Reversible	capacity for the construction to be separated into its constituting parts (with minimum if any damage)
	CAR2	Movable Stuff	furniture, equipment or fixtures that can be moved throughout the building freely
	CAR3	Component Accessibility	components within the building are easily accessible; other components are not damaged in the process
	CAR4	Functional Separation	separation of functions into different constituting parts; 1:1 function to component relationship
	Design tactics		DT1–9
	Case studies		A4, A5, A14 and A15

DS2 DESIGN 'IN' TIME capacity of the physical parts to provide options for the users ('in time')	CAR5	Service Zones	separate control/distribution of services among defined areas to allow for increased user control
	CAR6	Configurable Stuff	furniture; equipment, etc. which have multiple states
	CAR7	Multifunctional Components	does not move or change states but can serve multiple functions
	CAR8	Not Precious	often cheap, temporary solutions and can withstand a degree of knockability
	CAR9	'Extra' Components	provisional inclusion of components that go beyond the necessary means of the building to function
	Design tactics		DT1, 10–20
	Case studies		A1, A7, A13 and A14

DS3 LONG LIFE consideration of the physical parts to last a long time	CAR10	Durability	capacity to last a long time; to be knocked around; to resist decay and weather well
	CAR11	Mature Component	a proven component or system that has evolved over time
	CAR12	Efficient Services	reduction in the use and amount of off-site energy or water required
	CAR13	Good Craftsmanship	allows for an increased standard of design and longevity
	CAR14	Overdesign Capacity	components designed beyond the designated capacity to allow for a change in conditions
	CAR15	Readily Available Materials	materials that are produced locally and naturally increasing future accessibility and replaceability
	Design tactics		DT19–34
	Case studies		A2, A8, A9 and A11

DS4 SIMPLICITY and LEGIBILITY use of simplicity and legibility with regards to components and construction methods to enable change to occur more readily	CAR16	Standardised Components	standard off-the-shelf components and/or bulk use of a component designed for the building
	CAR17	Standard Component Locations	components are located in standard locations
	CAR18	Off-site Construction	a higher quality of construction through off-site assembly
	CAR19	Simple Construction Method	simple, legible structural system
	Design tactics		DT1, 5, 24, 30, 34–9
	Case studies		A2, A8, A11 and A15

DS5 LOOSE FIT spatial considerations beyond a minimal standard or that defined by the brief	CAR20	Open Space	a large space that is relatively undisturbed with immovable obstacles (e.g. columns)
	CAR21	Support Space	spaces typically not defined in the brief, but are necessary for functional support
	CAR22	Oversize Space	space that is sized larger than the market standard or functional necessity in plan or section
	Design tactics		DT40–50
	Case studies		A2, A4, A7, A8 and A9

Figure 1. Schmidt & Austin Adaptable Architecture: Theory and Practice instrument to assess adaptive capacity of buildings part 1/3 (Schmidt, et al., 2016)

DS6 SPATIAL PLANNING spatial consideration for the way spaces are laid out; their boundaries, dimensions and relationships to one another	CAR23	Typology Pattern	designed to a typology or standardised use/spatial pattern
	CAR24	Joinable/Divisible Space	space that can be joined or divided to support multiple spatial configurations
	CAR25	Modular Coordination	spatial coordination between systems which have physical consequences
	CAR26	Connect Buildings	capacity to link together or separate buildings
	CAR27	Standard Room Size(s)	a series of rooms that are of all the same size
	CAR28	Spatial Variety	a variety of sized rooms to cater to different uses and sizes of groups
	CAR29	Spatial Ambiguity	blurred boundaries between interior and/or exterior spatial uses through soft boundaries or proximity
	CAR30	Spatial Zones	spatial separation of different types of functional spaces into designated areas
	CAR31	Spatial Proximity	central location or close proximity of related elements
	CAR32	Simple Plan	a geometrically simple plan, deducible into a series of linear/rectangular shapes
	CAR33	Standard Grid	standardised dimensions with few anomalies
	CAR34	Simple Form	straight vertical and horizontal surfaces; few complicated forms such as curved or slanted
	Design tactics		DT14, 51–81
	Case studies		A3, A4, A6, A7, A14 and A15

DS7 PASSIVE TECHNIQUES the building's shape, materiality and orientation provide additional options for heating, cooling and ventilating the building	CAR35	Multiple Ventilation Strategies	capacity to be naturally or mechanically ventilated
	CAR36	Shallow Plan Depth	generally less than 15m in depth
	CAR37	Passive Climate Control	reduced need to mechanically control internal environment
	CAR38	Building Orientation	prevailing direction of the building takes advantage of natural conditions
	CAR39	Good Daylighting	capacity for the majority of the spaces to be daylit
	Design tactics		DT82–94
	Case studies		A2, A8, A11 and A14

DS8 UNFINISHED DESIGN capacity to add to or 'complete' an aspect or layer of the building	CAR40	Space to Grow Into	provisions for additional space (non-existing) to be added horizontally or vertically
	CAR41	Phased	'unfinished' space that requires additional work to make it usable
	CAR42	User Customisation	usable 'finished' space that is designed to be decorated or appropriated by the user
	Design tactics		DT95–104
	Case studies		A3, A6, A10 and A12

DS9 MAXIMISE BUILDING USE increase the timeframe in which the building is used throughout the day, week and year	CAR43	Multifunctional Spaces	space that can be used for multiple uses
	CAR44	Use Differentiation	inclusion of a mixture of uses
	CAR45	Mixed Demographics	services more than a single demographic
	CAR46	Multiple/Mixed Tenure	occupied by multiple tenants that may or may not operate under the same tenure agreement
	CAR47	Shared Ownership	space that is shared by multiple individuals or organisations
	CAR48	Isolatable	space or a wing that can function in separation from the rest of the building
	CAR49	Multiple Access Points	provision of multiple entry points that can serve different uses or users
	Design tactics		DT10–12, 16, 45, 47, 54, 64, 66, 105–16
	Case studies		A1, A5, A6, A7 and A10

Figure 2. Schmidt & Austin Adaptable Architecture: Theory and Practice instrument to assess adaptive capacity of buildings part 2/3 (Schmidt, et al., 2016)

DS10 INCREASE INTERACTIVITY use of physical and visual connections to increase a sense of awareness creating a more legible place	CAR50	Physical Linkage	physical connections between spaces
	CAR51	Visual Linkage	visual connections between interior spaces and interior and exterior spaces
	Design tactics		DT45–6, 106, 117–20
	Case studies		A5, A9, A10, A13 and A15

DS11 AESTHETICS use of the building's image, form and narrative as a way of appealing to the users' and society's appreciation	CAR52	Attitude and Character	use of colour and graphics to provide a level of character to the building
	CAR53	Spatial Quality	a unique spatial character
	CAR54	Building Image	the exterior image offers a level of familiarity or uniqueness
	CAR55	Quirkiness	spatial or physical anomalies that add to the character of the building
	CAR56	Time Interwoven	an historic narrative embedded into the design or through aged material
	Design tactics		DT51, 106, 121–6
	Case studies		A4, A8, A9 and A10

DS12 MULTIPLE SCALES consideration beyond the building to include aspects of the site and surrounding area	CAR57	Good Location	multiple transportation options, a favourable climate and ample density
	CAR58	Contextual	exploits and relates to its surrounding environment
	CAR59	Circulation (neighbourhood)	established physical connections to surrounding area
	CAR60	A Communal Place	a multifunctional, shared space that provides a place for gathering
	Design tactics		DT21, 32, 127–35
	Case studies		A2, A3, A4, A8 and A10

Figure 3. Schmidt & Austin Adaptable Architecture: Theory and Practice instrument to assess adaptive capacity of buildings part 3/3 (Schmidt, et al., 2016)

Appendix 3 Level(s) 2.3 analysis method; Method 3

Adaptability design concept	Specific design aspect to address	How the design aspect can contribute to adaptability	Scoring system	Weighting factor
1. Changes to the internal space distribution	1.1 Column grid spans	Wider column spans will allow for more flexible floor layouts.	Column spacing: - < 5400 mm 0 points - 5400 mm < 8100 mm 1 point - > 8100 mm 2 points - free span 3 points	1.5
	1.2 Façade pattern	Narrower bays will allow for more internal space configurations	Spacing between bays: - 1350 to >1800 mm 0 points - 1350 - 1800 mm 1 point - 1350 - 1800 mm, some bays 900 - 1350 mm 2 points - 900 - 1350 mm, some bays < 900 mm 3 points	1.5
	1.3 Internal wall system	Non-loading bearing internal walls will allow for changes to be made more easily to floor layouts.	- Immovable interior walls, multiple functions 0 points - Immovable interior walls, temporary structures 1 point - Movable interior walls, requires disassembly 2 points - Easily movable interior walls, partition system 3 points	4.5
	1.4 Unit size and access	By ensuring that access/egress is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate size: - > 600 m² 0 points - 400 - 600 m² 1 point - 200 - 400 m² 2 points - < 200 m² 3 points	3.0
2. Changes to the buildings servicing	2.1 Ease of access to service ducts	Access will be improved if services are not embedded in the building structure.	Location of key service ducts: - Embedded in the floor 0 points - Between 2 building layers 1 point - Above one building layer (floor) 2 points - Below one building layer (ceiling) 3 points	1.5
	2.2 Ease of access to plant rooms	Future changes of technical equipment will be facilitated if there is ease of access to plant rooms and equipment.	- Embedded in a sub-basement of the building 0 points - Located in a plant room on the roof or within an accessible patio 1 point - Located in a ground floor plant room with easy external access 2 points - Located external to the building with complete access 3 points	1.5

Figure 1. Level(s) 2.3 instrument to assess adaptive capacity of buildings part 1/2 (Dodd et al., 2020)

	2.3 Longitudinal ducts for service routes	The inclusion of longitudinal ducts will provide flexibility in the location of service points.	- Connection grid in 1 direction 0 points - Cable duct in 1 direction 1 point - Connection grid in 2 directions 2 points - Cable duct in 2 directions 3 points	1.5
	2.4 Higher ceilings for service routes	The use of greater ceiling heights will provide more flexibility in the routing of services.	Internal height (floor surface to ceiling surface): - < 3000 mm 0 points - 3000-3500 mm 1 point - 3500-4000 mm 2 points - > 4000 mm 3 points	4.5
	2.5 Services to sub-divisions	By ensuring that individual servicing for sanitary facilities is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate sub-division size that can be serviced: - > 600 m² 0 points - 400 - 600 m² 1 point - 200 - 400 m² 2 points - < 200 m² 3 points	3.0
3. Changes to the buildings' façade and structure	3.1 Non-load bearing facades	Non-load bearing facades will allow for changes to be made more easily to both internal layouts and external elements.	- Bearing facade with bearing obstacles 0 points - Bearing facade, no bearing obstacles 1 point - Non-bearing facade, bearing obstacles 2 points - Non-bearing facade, no bearing obstacles 3 points *Note: Examples of obstacles include bearing interior walls, columns, elevator shafts or installation ducts.*	4.5
	3.2 Future-proofing of load bearing capacity	The incorporation of redundant load bearing capacity will support potential future changes in the building's façade and uses.	Variable capacity: - 1,75 kN/m² 0 points - 2,50 kN/m² 1 point - 4,00 kN/m² 2 points - 5,00 kN/m² 3 points	4.5
	3.3 Structural design to support future expansion	Structural designs that have the vertical strength to support additional storeys will allow for future expansion of the floor area.	Capacity to add storeys: - 1 storey 0 points - 2 storey 1 point - 3 storeys 2 points - 4 or more storeys 3 points	1.5

Figure 2. Level(s) 2.3 instrument to assess adaptive capacity of buildings part 2/2 (Dodd et al., 2020)

Appendix 4 FLEX4.0 Analysis method; Method 1. Applied on building 36; EWI

FLEX 4.0: SPECIFICALLY APPLICABLE INDICATORS, PART 1				
LAYER	**SUB-LAYER**	**Flexibility Performance**	**Assessment Values**	**Remarks**
1. SITE 7/12		**1. Surplus of site space** Does the site have a surplus of space and is the building located at the centre?	1. No, the site has no surplus of space at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. The site has a surplus space of more than 50% (Best)	The more surplus space on site, the better the building is expandable (horizontal).
		2. Multifunctional site/location Is the location capable to support more functions, like offices, living, care and shops?	1. Just one function; suited for offices or living or care or shops (Bad) 2. Two functions (Normal) 3. Three functions (Better) 4. > Three functions; suited for offices, living, care and shops as well (Best)	The more a location around a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.
2. STRUCTURE 35/56	Measurement 13/24	**3. Available floor space of building** Does the building or the user units have a surplus of the needed usable floor space?	1. No, the building or user units have no surplus of floor space at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. The building has a surplus of floor space of > 50% (Best)	The more surplus space a building/user units have, the more easily a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
		4. Size of floor buildings What is the size of the usable floor surface?	1. The usable floor space < 400 m2 (Bad) 2. 400 - 600 m2 (Normal) 3. 600 - 1000 m2 (Better) 4. The usable floor space > 1000 m2 (Best)	The larger the size of the usable floor surface the more easily units in a building can be rearranged or transformed to other functions.
		5. Measurement system Have positioning/measurement modulare rules for construction components been used?	1. Rules for modular coordination are not implemented (Bad) 2. <50% implemented (Normal) 3. >50% implemented (better) 4. Rules for modular coordination are > 90% implemented (Best)	The more project independent, demountable and replaceable construction components have been implemented, the more easily a building can be rearranged or transformed to other functions.
		6. Horizontal zone division/layout Has use been made of a horizontal zoning system, including intermediate margins?	1. No zoning system of a zoning system without intermediate margins (Bad) 2.Yes, with 10-30% intermediate margins (Normal) 3. Yes, with 30-50% intermediate margins (Better) 4. Yes, with met > 50% intermediate margins	The more margins are used in the zoning system of the building, the more easily a building/units can be rearranged, extended or transformed to other functions.
		7. Presence of stairs/elevators Are sufficient stairs/elevators present in the building?	1. Only one decentred located stairs/elevator core is available in the building (Bad) 2. There is one central located stairs/elevator core available in the building (Normal) 3. The building is divided into different wings each with a central stairs/elevator core 4. The building has one central and several decentred stairs/elevator cores per wing	The more stairs/elevators are available in the building the more easily a building/units can be rearranged, rejected, extended or transformed to other functions.
		8. Extension/reuse of Is there a possibility to add new stairs/elevators to the building and reusing the existing ones?	1. No stairs/elevators can be added without drastic expensive measures (Bad) 2. A new stairs/elevators core can be accidently added and existing reused (Normal) 3. New stairs/elevators can be limited added and existing ones reused (Better) 4. New stairs/elevators can be easily without drastic expensive measures (Best)	The more stairs/elevators can be added to the building the more easily a building can be rearranged, rejected, extended or transformed to other functions.
	Construction 22/32	**9. Surplus of load bearing capacity** How large is the load bearing capacity of the floors in the building?	1. < 3 kN/m2 2. 3 - 3,5 kN/m2 3. 3,5 - 4 kN/m2 4. > 4 kN/m2 and several areas > 8 kN/m2	The larger the load bearing capacity of floors, the easier a building can be rearranged, transformed to other functions, or vertical extended, the better a building can meet to changing user demands.
		10. Shape of columns How are the columns in the building shaped?	1. The columns are shaped round and/or have vertical different sizes (Bad) 2. The columns are shaped octagonal (Normal) 3. The columns are shaped rectangular (Better) 4. The columns are shaped square (Best)	The less deviate from a square column, the better a building/units can be rearranged (standardized connection of inner walls).
		11. Positioning of facilities zones Are facilities zones and vertical shafts located at central building level and/or local unit level?	1.All facility zones and vertical shafts are only located at central level (Bad) 2. Facility zones/shafts are located at central level and occasionally at local level 3. Facility zones/shafts are located at central level and limited at local level (Better) 4. Facility zones/shafts are located at central level and at local level as well (Best)	The more facility zones/shafts are located at unit level, the easier a building can be rearranged, transformed to other functions.
		12. Fire resistance main bearing How many minutes is the fire resistance of the main load bearing construction?	1. The fire resistance of the load bearing construction is 30 minutes (Bad) 2. The fire resistance of the load bearing construction is 60 minutes (Normal) 3. The fire resistance of the load bearing construction is 90 minutes (Better) 4. The fire resistance of the load bearing construction is 120 minutes (Best)	The higher the fire resistance of the load bearing construction, the easier a building can be rearranged/transformed to other functions, the better a building can meet to changing demands.
		13. Extendible building/units horiz. Is it possible to expand the building horiz. for new extension to the building/user units?	1. Horizontal extension of building/units is not possible at all (Bad) 2. Horizontal extension of building/units is very limited possible (only at one side) 3. Horizontal extension of building/units is limited possible (at more sides) (Better) 4. Horizontal extension of building/units is easily possible at all sides (Best)	The more a building/unit can be expanded, the easier a building can be rearranged or transformed to other functions or expanded, the better a building can meet the changing user demands.
		14. Extendible building/units vert. Is it possible to expand the building vertically, for adding new floors or a new basement?	1. Vertical extension of building/units is not possible at all (Bad) 2. Vertical extension is limited possible; only for a few units in the building (Normal) 3. Vertical extension (added floor or basement) is possible after total rearrangement 4. Vertical extension (new floors/basement & individual user units) is possible (Best)	The more a building/unit can be vertically expanded, the easier a building can be rearranged or transformed to other functions or expanded, the better a building can meet changing user demands.
		15. Rejectable part of building/unit Is it possible to reject part of the building for selling/renting to third parties?	1. It is not possible to reject part of building/units (Bad) 2. It is possible to reject 10-30% of the building/units (Normal) 3. It is possible to reject 30-50% of the building units (Better) 4. It is possible to reject >50% of the building/units (Best)	The more (part of) a building/unit can be vertically rejected, the easier a building can be rearranged/transformed to other functions, the better a building can meet changing user demands.
		16. Insulation between stories/units How is the thermal and acoustic insulation between the different storeys in the building?	1. Insulation does not meet the current demands for office buildings anymore (Bad) 2. Meets the current demands for office buildings (Normal) 3. Also meets the current demands for housing and care (Better) 4. Meets 10% above the current demand for offices, housing and care (Best)	The better the thermal and acoustic insulation between the different storeys, the easier a building can be rearranged/transformed to other functions, the better a building can meet changing demands.

Figure 1. FLEX4.0 assessment on building 36 (EWI) part 1/2 (Geraedts, 2016) (by Author)

FLEX 4.0: SPECIFICALLY APPLICABLE INDICATORS, PART 2				
LAYER	SUB-LAYER	Flexibility Performance	Assessment Values	Remarks
3. SKIN 8/12	Facade	17. Dismountable facade To what extend can facade components be dismantled in case of transformation?	1. Facade components can not or hardly be dismantled without demolition (Bad) 2. A small part of the facade components can be dismantled (> 20 < 50%) (Normal) 3. A large part of the facade components can be dismantled (> 50 < 90%) (Better) 4. All facade components are easily dismountable (> 90%) (Best)	The more facade components are easily dismountable, the more easily a building can be rearranged or transformed to other functions.
		18. Location/shape daylight In what way are the facade/daylight openings positioned and shaped?	1. There are large closed surfaces in the facade (Bad) 2. There are small horizontal open surfaces in the facade (Normal) 3. Large open surfaces in the facade, but with different height sizes (Better) 4. Large continuous horiz. open surfaces; connections according to planning grid	The more regular open surfaces in the facade according to the planning grid, the better a building can meet changing demands in functions, quality and finishing of the building.
		19. Insulation of facade How is the thermal and acoustic insulation quality of the facade of the building?	1. Insulation does not meet the current demands for office buildings anymore (Bad) 2. Meets the current demands for office buildings (Normal) 3. Also meets the current demands for housing and care (Better) 4. Meets 10% above the current demand for offices, housing and care (Best)	The better the thermal and acoustic insulation of the facade, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
4. FACILITIES 17/28	Measure & Control	20. Measure & control techniques Is it possible to control/measure facilities on building level as well on user unit level?	1. Control/measurement takes place only at central building level (Bad) 2. On central level and occasionally on unit level (Normal) 3. On central level and limited on unit level (Better) 4. As well central on building level as well completely on unit level (Best)	The more possibilities for measurement and control of the facilities on unit level, the more easily units in a building can be rearranged or transformed to other functions.
	Dimensions	21. Surplus capacity of facilities Does the capacity of (the sources of) the facilities have a surplus capacity?	1. The capacities of facilities have no surplus at all (Bad) 2. The capacities of facilities have a surplus of 10-30% (Normal) 3. The capacities of facilities have a surplus of 30-50% (Better) 4. The capacities of facilities have a surplus of > 50% (Best)	The more surplus capacity of the facilities, the easier a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
	Distribution	22. Distribution facilities Does the building have a specific distribution facility for hot/cold water, heating, cooling, gas?	1. There is a specific distribution facility for all the different sources (Bad) 2. There is a specific distribution facility for some of the different sources (Normal) 3. There is a specific distribution facility for 2 of the different sources (Better) 4.There is no specific distribution facility one of the different sources (Best)	The less specific distribution equipment facilities have, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
		23. Location sources facilities What is the location of the central facility sources?	1. The facilities sources are located at only one central location in the building (Bad) 2. The facilities sources are located at several locations in the building (Normal) 3. The sources are located at a central location and a decentred location as well. 4. The sources are located at outside the building at city level (district heating)	The more facility sources are localized at decentred level, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
		24. Disconnection of facility Can the components of the facilities be easily disconnected?	1. Facility (parts) can not be disconnected or demounted; 'wet' connections (Bad) 2. Hardly be disconnected, demounted (Normal) 3. Partly be disconnected, demounted (Better) 4. Facility (parts) can be disconnected very easily (completely demountable) (Best)	The more facility parts can be disconnected or demounted, the easier a building can be rearranged/transformed to other functions, the better a building can meet to changing demands.
		25. Accessibility of facility To what extend are facility components good accessible?	1. Hardly or not accessible (components on support level; concreted in) (Bad) 2. Limited accessible (partly on support and infill level) (Normal) 3. Good accessible (a lot of components on infill level) (Better) 4. Very good accessible; most components at infill level; completely demountable	The higher the accessibility of facilities components, the more easily units in a building can be rearranged or transformed to other functions.
		26. Independence of user units In what way are the user units independent related to services as pantry, toilet facilities?	1. No services available at user unit level (Bad) 2. 1 - 2 services available (Normal) 3. 3 - 4 services available (Better) 4. > 4 services available (Best)	The more services are available at unit level, the more independent the units are opposite other units in the building, the more they meet to individual user demands.
5. SPACE 23/24	Functional	27. Multifunctional building/Units Is the building capable to support different functions, like offices, living, care and shops?	1. The building supports only one function (Bad) 2. The building supports 2 functions (Normal) 3. The building supports 3 functions (Better) 4. The building supports > 3 functions (Best)	The more a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.
	Technical	28. Disconnectable, removable, To what extend are the user units in a building removable, relocatable?	1. The user units in the building are not removable, relocatable (Bad) 2. The units are only relocatable with drastic expensive measures (Normal) 3. Units are easy relocatable; constructed with demountable components (Better) 4. Easy relocatable; constructed with 2D/3D modules, transportable by road (Best)	The more the units consist of demountable and reusable components, the better the units are relocatable to another location in or outside the building.
		29. Disconnectable, removable, To what extend are inner the walls in the building easily replaceable?	1. Inner walls are not replaceable without drastic/expensive interventions (bad) 2. Inner walls are not replaceable, but good destructible (Normal) 3. Inner walls replaceable by dismantling and rebuilding at another location (Better) 4. Inner walls are easily replaceable without radical/expensive interventions (Best)	The more inner walls can be easily replaced, the more easily a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
		30. Disconnectable connection detail Which detailed construction is applied between the interior walls and support structure and facade?	1. The detailing connection consists of penetrating connections (Bad) 2. The detailing connection consists of wet connections (mortar, sealant, glue) 3. The detailing consists of specific project bound connection elements (Better) 4. The detailing consists of project unbound dismountable connections (Best)	The easier the connection of interior walls can be dismounted, the easier a building can be rearranged or transformed to other functions, the better a building can meet to changing demands.
		31. Possibility of suspended ceilings Is it possible to apply suspended ceilings (-0.20m) and to adapt these to the different user demands?	1. Suspended ceiling results in free floor height of < 2.60 m (Bad) 2. Suspended ceiling results in free floor height of 2.60-2.70m (Normal) 3. Suspended ceiling results in free floor height of 2.70-2.80m (Better) 4. Suspended ceiling results in free floor height of > 2.80m (Best)	The higher the free storey height, the better the building can meet to changing demands concerning functions, facilities, finishing and quality of the building.
		32. Possibility of raised floors Is it possible to apply raised floors and to adapt these to the different user demands?	1. Raised floor results in free floor height of < 2.6 m (bad) 2. Raised floor results in free floor height of 2.60-2.70m (Normal) 3.Raised floor results in free floor height of 2.70-2.80m (Better) 4. Raised floor results in free floor height of > 2.80m (Best)	The higher the free storey height, the better the building can meet to changing demands concerning functions, facilities, finishing and quality of the building.

Figure 2. FLEX4.0 assessment on building 36 (EWI) part 2/2 (Geraedts, 2016) (by Author)

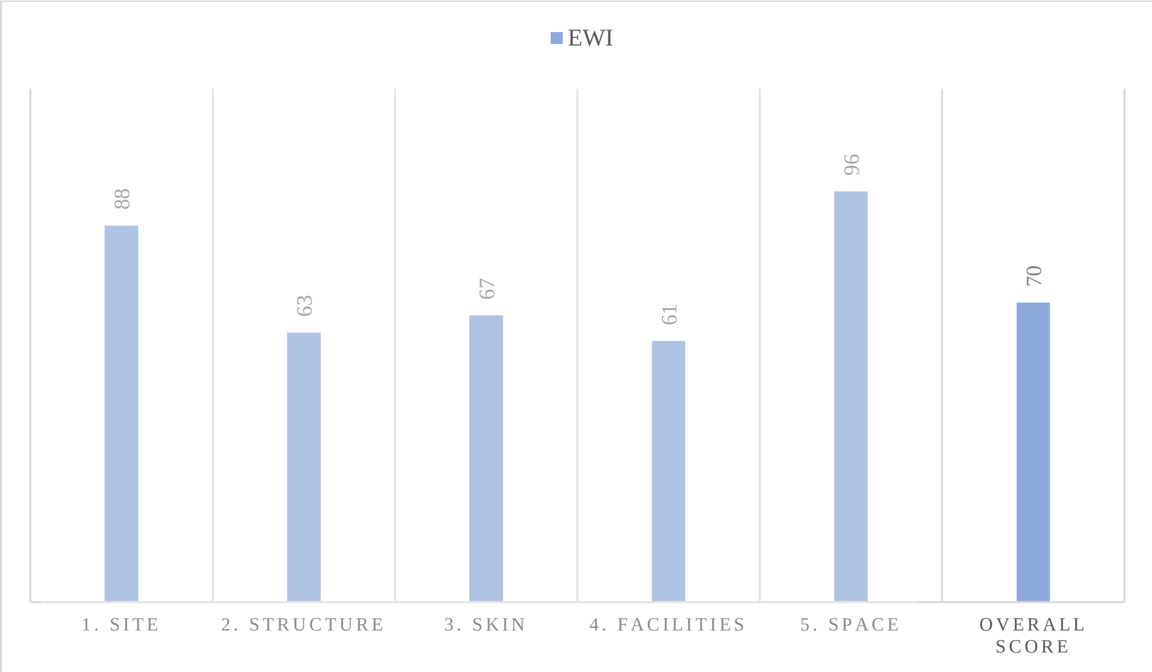


Figure 3. FLEX4.0 assessment results on building 36 (EWI) (by Author)

Appendix 5 FLEX4.0 Analysis method; Method 1. Applied on building 23; CiTG

FLEX 4.0: SPECIFICALLY APPLICABLE INDICATORS, PART 1				
LAYER	**SUB-LAYER**	**Flexibility Performance**	**Assessment Values**	**Remarks**
1. SITE 6/8		**1. Surplus of site space** Does the site have a surplus of space and is the building located at the centre?	1. No, the site has no surplus of space at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. The site has a surplus space of more than 50% (Best)	The more surplus space on site, the better the building is expandable (horizontal).
		2. Multifunctional site/location Is the location capable to support more functions, like offices, living, care and shops?	1. Just one function; suited for offices or living or care or shops (Bad) 2. Two functions (Normal) 3. Three functions (Better) 4. > Three functions; suited for offices, living, care and shops as well (Best)	The more a location around a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.
2. STRUCTURE 40/56	**Measurement** 15/24	**3. Available floor space of building** Does the building or the user units have a surplus of the needed usable floor space?	1. No, the building or user units have no surplus of floor space at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. The building has a surplus of floor space of > 50% (Best)	The more surplus space a building/user units have, the more easily a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
		4. Size of floor buildings What is the size of the usable floor surface?	1. The usable floor space < 400 m2 (Bad) 2. 400 - 600 m2 (Normal) 3. 600 - 1000 m2 (Better) 4. The usable floor space > 1000 m2 (Best)	The larger the size of the usable floor surface the more easily units in a building can be rearranged or transformed to other functions.
		5. Measurement system Have positioning/measurement modulare rules for construction components been used?	1. Rules for modular coordination are not implemented (Bad) 2. <50% implemented (Normal) 3. >50% implemented (better) 4. Rules for modular coordination are > 90% implemented (Best)	The more project independent, demountable and replaceable construction components have been implemented, the more easily a building can be rearranged or transformed to other functions.
		6. Horizontal zone division/layout Has use been made of a horizontal zoning system, including intermediate margins?	1. No zoning system of a zoning system without intermediate margins (Bad) 2.Yes, with 10-30% intermediate margins (Normal) 3. Yes, with 30-50% intermediate margins (Better) 4. Yes, with met > 50% intermediate margins	The more margins are used in the zoning system of the building, the more easily a building/units can be rearranged, extended or transformed to other functions.
		7. Presence of stairs/elevators Are sufficient stairs/elevators present in the building?	1. Only one decentred located stairs/elevator core is available in the building (Bad) 2. There is one central located stairs/elevator core available in the building (Normal) 3. The building is divided into different wings each with a central stairs/elevator core 4. The building has one central and several decentred stairs/elevator cores per wing	The more stairs/elevators are available in the building the more easily a building/units can be rearranged, rejected, extended or transformed to other functions.
		8. Extension/reuse of Is there a possibility to add new stairs/elevators to the building and reusing the existing ones?	1. No stairs/elevators can be added without drastic expensive measures (Bad) 2. A new stairs/elevators core can be accidently added and existing reused (Normal) 3. New stairs/elevators can be limited added and existing ones reused (Better) 4. New stairs/elevators can be easily without drastic expensive measures (Best)	The more stairs/elevators can be added to the building the more easily a building can be rearranged, rejected, extended or transformed to other functions.
	Construction 25/32	**9. Surplus of load bearing capacity** How large is the load bearing capacity of the floors in the building?	1. < 3 kN/m2 2. 3 - 3,5 kN/m2 3. 3,5 - 4 kN/m2 4. > 4 kN/m2 and several areas > 8 kN/m2	The larger the load bearing capacity of floors, the easier a building can be rearranged, transformed to other functions, or vertical extended, the better a building can meet to changing user demands.
		10. Shape of columns How are the columns in the building shaped?	1. The columns are shaped round and/or have vertical different sizes (Bad) 2. The columns are shaped octagonal (Normal) 3. The columns are shaped rectangular (Better) 4. The columns are shaped square (Best)	The less deviate from a square column, the better a building/units can be rearranged (standardized connection of inner walls).
		11. Positioning of facilities zones Are facilities zones and vertical shafts located at central building level and/or local unit level?	1.All facility zones and vertical shafts are only located at central level (Bad) 2. Facility zones/shafts are located at central level and occasionally at local level 3. Facility zones/shafts are located at central level and limited at local level (Better) 4. Facility zones/shafts are located at central level and at local level as well (Best)	The more facility zones/shafts are located at unit level, the easier a building can be rearranged, transformed to other functions.
		12. Fire resistance main bearing How many minutes is the fire resistance of the main load bearing construction?	1. The fire resistance of the load bearing construction is 30 minutes (Bad) 2. The fire resistance of the load bearing construction is 60 minutes (Normal) 3. The fire resistance of the load bearing construction is 90 minutes (Better) 4. The fire resistance of the load bearing construction is 120 minutes (Best)	The higher the fire resistance of the load bearing construction, the easier a building can be rearranged/transformed to other functions, the better a building can meet to changing demands.
		13. Extendible building/units horiz. Is it possible to expand the building horiz. for new extension to the building/user units?	1. Horizontal extension of building/units is not possible at all (Bad) 2. Horizontal extension of building/units is very limited possible (only at one side) 3. Horizontal extension of building/units is limited possible (at more sides) (Better) 4. Horizontal extension of building/units is easily possible at all sides (Best)	The more a building/unit can be expanded, the easier a building can be rearranged or transformed to other functions or expanded, the better a building can meet the changing user demands.
		14. Extendible building/units vert. Is it possible to expand the building vertically, for adding new floors or a new basement?	1. Vertical extension of building/units is not possible at all (Bad) 2. Vertical extension is limited possible; only for a few units in the building (Normal) 3. Vertical extension (added floor or basement) is possible after total rearrangement 4. Vertical extension (new floors/basement & individual user units) is possible (Best)	The more a building/unit can be vertically expanded, the easier a building can be rearranged or transformed to other functions or expanded, the better a building can meet changing user demands.
		15. Rejectable part of building/unit Is it possible to reject part of the building for selling/renting to third parties?	1. It is not possible to reject part of building/units (Bad) 2. It is possible to reject 10-30% of the building/units (Normal) 3. It is possible to reject 30-50% of the building units (Better) 4. It is possible to reject >50% of the building/units (Best)	The more (part of) a building/unit can be vertically rejected, the easier a building can be rearranged/transformed to other functions, the better a building can meet changing user demands.
		16. Insulation between stories/units How is the thermal and acoustic insulation between the different storeys in the building?	1. Insulation does not meet the current demands for office buildings anymore (Bad) 2. Meets the current demands for office buildings (Normal) 3. Also meets the current demands for housing and care (Better) 4. Meets 10% above the current demand for offices, housing and care (Best)	The better the thermal and acoustic insulation between the different storeys, the easier a building can be rearranged/transformed to other functions, the better a building can meet changing demands.

Figure 1. FLEX4.0 assessment on building 23 (CiTG) part 1/2 (Geraedts, 2016) (by Author)

FLEX 4.0: SPECIFICALLY APPLICABLE INDICATORS, PART 2				
LAYER	**SUB-LAYER**	**Flexibility Performance**	**Assessment Values**	**Remarks**
3. SKIN 7/12	**Facade**	**17. Dismountable facade** To what extend can facade components be dismantled in case of transformation?	1. Facade components can not or hardly be dismantled without demolition (Bad) 2. A small part of the facade components can be dismantled (> 20 < 50%) (Normal) 3. A large part of the facade components can be dismantled (> 50 < 90%) (Better) 4. All facade components are easily dismountable (> 90%) (Best)	The more facade components are easily dismountable, the more easily a building can be rearranged or transformed to other functions.
		18. Location/shape daylight In what way are the facade/daylight openings positioned and shaped?	1. There are large closed surfaces in the facade (Bad) 2. There are small horizontal open surfaces in the facade (Normal) 3. Large open surfaces in the facade, but with different height sizes (Better) 4. Large continuous horiz. open surfaces; connections according to planning grid	The more regular open surfaces in the facade according to the planning grid, the better a building can meet changing demands in functions, quality and finishing of the building.
		19. Insulation of facade How is the thermal and acoustic insulation quality of the facade of the building?	1. Insulation does not meet the current demands for office buildings anymore (Bad) 2. Meets the current demands for office buildings (Normal) 3. Also meets the current demands for housing and care (Better) 4. Meets 10% above the current demand for offices, housing and care (Best)	The better the thermal and acoustic insulation of the facade, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
4. FACILITIES 17/28	**Measure & Control**	**20. Measure & control techniques** Is it possible to control/measure facilities on building level as well on user unit level?	1. Control/measurement takes place only at central building level (Bad) 2. On central level and occasionally on unit level (Normal) 3. On central level and limited on unit level (Better) 4. As well central on building level as well completely on unit level (Best)	The more possibilities for measurement and control of the facilities on unit level, the more easily units in a building can be rearranged or transformed to other functions.
	Dimensions	**21. Surplus capacity of facilities** Does the capacity of (the sources of) the facilities have a surplus capacity?	1. The capacities of facilities have no surplus at all (Bad) 2. The capacities of facilities have a surplus of 10-30% (Normal) 3. The capacities of facilities have a surplus of 30-50% (Better) 4. The capacities of facilities have a surplus of > 50% (Best)	The more surplus capacity of the facilities, the easier a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
	Distribution	**22. Distribution facilities** Does the building have a specific distribution facility for hot/cold water, heating, cooling, gas?	1. There is a specific distribution facility for all the different sources (Bad) 2. There is a specific distribution facility for some of the different sources (Normal) 3. There is a specific distribution facility for 2 of the different sources (Better) 4.There is no specific distribution facility one of the different sources (Best)	The less specific distribution equipment facilities have, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
		23. Location sources facilities What is the location of the central facility sources?	1. The facilities sources are located at only one central location in the building (Bad) 2. The facilities sources are located at several locations in the building (Normal) 3. The sources are located at a central location and a decentred location as well. 4. The sources are located at outside the building at city level (district heating)	The more facility sources are localized at decentred level, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
		24. Disconnection of facility Can the components of the facilities be easily disconnected?	1. Facility (parts) can not be disconnected or demounted; 'wet' connections (Bad) 2. Hardly be disconnected, demounted (Normal) 3. Partly be disconnected, demounted (Better) 4. Facility (parts) can be disconnected very easily (completely demountable) (Best)	The more facility parts can be disconnected or demounted, the easier a building can be rearranged/transformed to other functions, the better a building can meet to changing demands.
		25. Accessibility of facility To what extend are facility components good accessible?	1. Hardly or not accessible (components on support level; concreted in) (Bad) 2. Limited accessible (partly on support and infill level) (Normal) 3. Good accessible (a lot of components on infill level) (Better) 4. Very good accessible; most components at infill level; completely demountable	The higher the accessibility of facilities components, the more easily units in a building can be rearranged or transformed to other functions.
		26. Independence of user units In what way are the user units independent related to services as pantry, toilet facilities?	1. No services available at user unit level (Bad) 2. 1 - 2 services available (Normal) 3. 3 - 4 services available (Better) 4. > 4 services available (Best)	The more services are available at unit level, the more independent the units are opposite other units in the building, the more they meet to individual user demands.
5. SPACE 22/24	**Functional**	**27. Multifunctional building/Units** Is the building capable to support different functions, like offices, living, care and shops?	1. The building supports only one function (Bad) 2. The building supports 2 functions (Normal) 3. The building supports 3 functions (Better) 4. The building supports > 3 functions (Best)	The more a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.
	Technical	**28. Disconnectable, removable,** To what extend are the user units in a building removable, relocatable?	1. The user units in the building are not removable, relocatable (Bad) 2. The units are only relocatable with drastic expensive measures (Normal) 3. Units are easy relocatable; constructed with demountable components (Better) 4. Easy relocatable; constructed with 2D/3D modules, transportable by road (Best)	The more the units consist of demountable and reusable components, the better the units are relocatable to another location in or outside the building.
		29. Disconnectable, removable, To what extend are inner the walls in the building easily replaceable?	1. Inner walls are not replaceable without drastic/expensive interventions (bad) 2. Inner walls are not replaceable, but good destructible (Normal) 3. Inner walls replaceable by dismantling and rebuilding at another location (Better) 4. Inner walls are easily replaceable without radical/expensive interventions (Best)	The more inner walls can be easily replaced, the more easily a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
		30. Disconnectable connection detail Which detailed construction is applied between the interior walls and support structure and facade?	1. The detailing connection consists of penetrating connections (Bad) 2. The detailing connection consists of wet connections (mortar, sealant, glue) 3. The detailing consists of specific project bound connection elements (Better) 4. The detailing consists of project unbound dismountable connections (Best)	The easier the connection of interior walls can be dismounted, the easier a building can be rearranged or transformed to other functions, the better a building can meet to changing demands.
		31. Possibility of suspended ceilings Is it possible to apply suspended ceilings (-0.20m) and to adapt these to the different user demands?	1. Suspended ceiling results in free floor height of < 2.60 m (Bad) 2. Suspended ceiling results in free floor height of 2.60-2.70m (Normal) 3. Suspended ceiling results in free floor height of 2.70-2.80m (Better) 4. Suspended ceiling results in free floor height of > 2.80m (Best)	The higher the free storey height, the better the building can meet to changing demands concerning functions, facilities, finishing and quality of the building.
		32. Possibility of raised floors Is it possible to apply raised floors and to adapt these to the different user demands?	1. Raised floor results in free floor height of < 2.6 m (bad) 2. Raised floor results in free floor height of 2.60-2.70m (Normal) 3.Raised floor results in free floor height of 2.70-2.80m (Better) 4. Raised floor results in free floor height of > 2.80m (Best)	The higher the free storey height, the better the building can meet to changing demands concerning functions, facilities, finishing and quality of the building.

Figure 2. FLEX4.0 assessment on building 23 (CiTG) part 2/2 (Geraedts, 2016) (by Author)

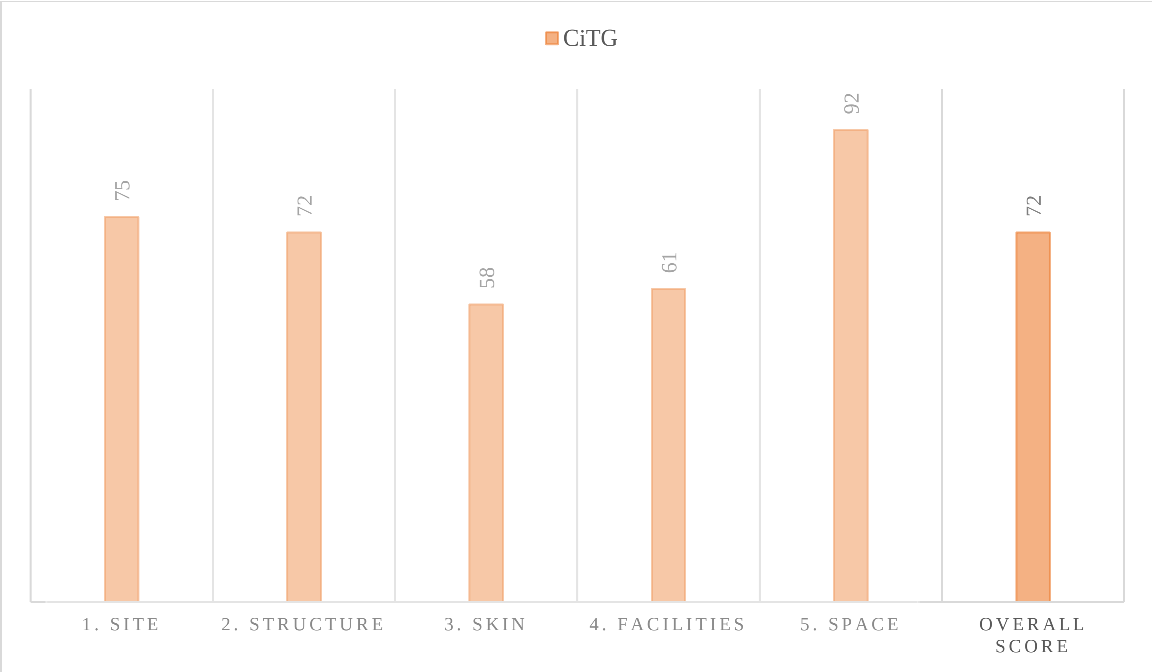


Figure 3. FLEX4.0 assessment results on building 23 (CiTG) (by Author)

Appendix 6 FLEX4.0 Analysis method; Method 1. Applied on building 22; TNW

FLEX 4.0: SPECIFICALLY APPLICABLE INDICATORS, PART 1				
LAYER	**SUB-LAYER**	**Flexibility Performance**	**Assessment Values**	**Remarks**
1. SITE 17/28		**1. Surplus of site space** Does the site have a surplus of space and is the building located at the centre?	1. No, the site has no surplus of space at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. The site has a surplus space of more than 50% (Best)	The more surplus space on site, the better the building is expandable (horizontal).
		2. Multifunctional site/location Is the location capable to support more functions, like offices, living, care and shops?	1. Just one function; suited for offices or living or care or shops (Bad) 2. Two functions (Normal) 3. Three functions (Better) 4. > Three functions; suited for offices, living, care and shops as well (Best)	The more a location around a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.
2. STRUCTURE 47/56	**Measurement** 19/24	**3. Available floor space of building** Does the building or the user units have a surplus of the needed usable floor space?	1. No, the building or user units have no surplus of floor space at all (Bad) 2. 10-30% surplus (Normal) 3. 30-50% surplus (Better) 4. The building has a surplus of floor space of > 50% (Best)	The more surplus space a building/user units have, the more easily a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
		4. Size of floor buildings What is the size of the usable floor surface?	1. The usable floor space < 400 m2 (Bad) 2. 400 - 600 m2 (Normal) 3. 600 - 1000 m2 (Better) 4. The usable floor space > 1000 m2 (Best)	The larger the size of the usable floor surface the more easily units in a building can be rearranged or transformed to other functions.
		5. Measurement system Have positioning/measurement modulare rules for construction components been used?	1. Rules for modular coordination are not implemented (Bad) 2. <50% implemented (Normal) 3. >50% implemented (better) 4. Rules for modular coordination are > 90% implemented (Best)	The more project independent, demountable and replaceable construction components have been implemented, the more easily a building can be rearranged or transformed to other functions.
		6. Horizontal zone division/layout Has use been made of a horizontal zoning system, including intermediate margins?	1. No zoning system of a zoning system without intermediate margins (Bad) 2.Yes, with 10-30% intermediate margins (Normal) 3. Yes, with 30-50% intermediate margins (Better) 4. Yes, with met > 50% intermediate margins	The more margins are used in the zoning system of the building, the more easily a building/units can be rearranged, extended or transformed to other functions.
		7. Presence of stairs/elevators Are sufficient stairs/elevators present in the building?	1. Only one decentred located stairs/elevator core is available in the building (Bad) 2. There is one central located stairs/elevator core available in the building (Normal) 3. The building is divided into different wings each with a central stairs/elevator core 4. The building has one central and several decentred stairs/elevator cores per wing	The more stairs/elevators are available in the building the more easily a building/units can be rearranged, rejected, extended or transformed to other functions.
		8. Extension/reuse of Is there a possibility to add new stairs/elevators to the building and reusing the existing ones?	1. No stairs/elevators can be added without drastic expensive measures (Bad) 2. A new stairs/elevators core can be accidently added and existing reused (Normal) 3. New stairs/elevators can be limited added and existing ones reused (Better) 4. New stairs/elevators can be easily without drastic expensive measures (Best)	The more stairs/elevators can be added to the building the more easily a building can be rearranged, rejected, extended or transformed to other functions.
	Construction 28/32	**9. Surplus of load bearing capacity** How large is the load bearing capacity of the floors in the building?	1. < 3 kN/m2 2. 3 - 3,5 kN/m2 3. 3,5 - 4 kN/m2 4. > 4 kN/m2 and several areas > 8 kN/m2	The larger the load bearing capacity of floors, the easier a building can be rearranged, transformed to other functions, or vertical extended, the better a building can meet to changing user demands.
		10. Shape of columns How are the columns in the building shaped?	1. The columns are shaped round and/or have vertical different sizes (Bad) 2. The columns are shaped octagonal (Normal) 3. The columns are shaped rectangular (Better) 4. The columns are shaped square (Best)	The less deviate from a square column, the better a building/units can be rearranged (standardized connection of inner walls).
		11. Positioning of facilities zones Are facilities zones and vertical shafts located at central building level and/or local unit level?	1.All facility zones and vertical shafts are only located at central level (Bad) 2. Facility zones/shafts are located at central level and occasionally at local level 3. Facility zones/shafts are located at central level and limited at local level (Better) 4. Facility zones/shafts are located at central level and at local level as well (Best)	The more facility zones/shafts are located at unit level, the easier a building can be rearranged, transformed to other functions.
		12. Fire resistance main bearing How many minutes is the fire resistance of the main load bearing construction?	1. The fire resistance of the load bearing construction is 30 minutes (Bad) 2. The fire resistance of the load bearing construction is 60 minutes (Normal) 3. The fire resistance of the load bearing construction is 90 minutes (Better) 4. The fire resistance of the load bearing construction is 120 minutes (Best)	The higher the fire resistance of the load bearing construction, the easier a building can be rearranged/transformed to other functions, the better a building can meet to changing demands.
		13. Extendible building/units horiz. Is it possible to expand the building horiz. for new extension to the building/user units?	1. Horizontal extension of building/units is not possible at all (Bad) 2. Horizontal extension of building/units is very limited possible (only at one side) 3. Horizontal extension of building/units is limited possible (at more sides) (Better) 4. Horizontal extension of building/units is easily possible at all sides (Best)	The more a building/unit can be expanded, the easier a building can be rearranged or transformed to other functions or expanded, the better a building can meet the changing user demands.
		14. Extendible building/units vert. Is it possible to expand the building vertically, for adding new floors or a new basement?	1. Vertical extension of building/units is not possible at all (Bad) 2. Vertical extension is limited possible; only for a few units in the building (Normal) 3. Vertical extension (added floor or basement) is possible after total rearrangement 4. Vertical extension (new floors/basement & individual user units) is possible (Best)	The more a building/unit can be vertically expanded, the easier a building can be rearranged or transformed to other functions or expanded, the better a building can meet changing user demands.
		15. Rejectable part of building/unit Is it possible to reject part of the building for selling/renting to third parties?	1. It is not possible to reject part of building/units (Bad) 2. It is possible to reject 10-30% of the building/units (Normal) 3. It is possible to reject 30-50% of the building units (Better) 4. It is possible to reject >50% of the building/units (Best)	The more (part of) a building/unit can be vertically rejected, the easier a building can be rearranged/transformed to other functions, the better a building can meet changing user demands.
		16. Insulation between stories/units How is the thermal and acoustic insulation between the different storeys in the building?	1. Insulation does not meet the current demands for office buildings anymore (Bad) 2. Meets the current demands for office buildings (Normal) 3. Also meets the current demands for housing and care (Better) 4. Meets 10% above the current demand for offices, housing and care (Best)	The better the thermal and acoustic insulation between the different storeys, the easier a building can be rearranged/transformed to other functions, the better a building can meet changing demands.

Figure 1. FLEX4.0 assessment on building 22 (TNW) part 1/2 (Geraedts, 2016) (by Author)

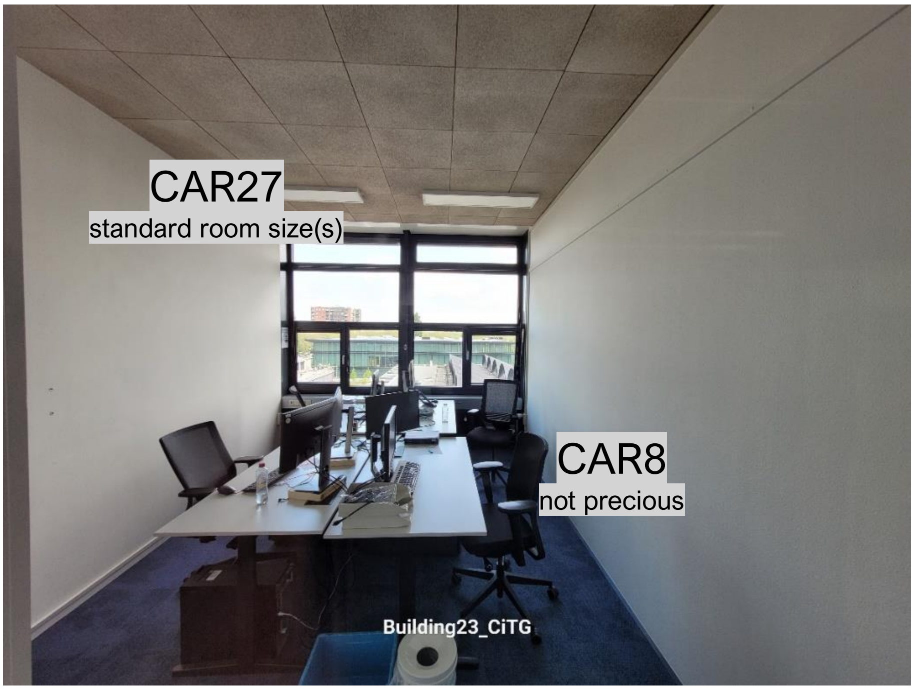
FLEX 4.0: SPECIFICALLY APPLICABLE INDICATORS, PART 2				
LAYER	**SUB-LAYER**	**Flexibility Performance**	**Assessment Values**	**Remarks**
3. SKIN	**Facade**	**17. Dismountable facade** To what extend can facade components be dismantled in case of transformation?	1. Facade components can not or hardly be dismantled without demolition (Bad) 2. A small part of the facade components can be dismantled (> 20 < 50%) (Normal) 3. A large part of the facade components can be dismantled (> 50 < 90%) (Better) 4. All facade components are easily dismountable (> 90%) (Best)	The more facade components are easily dismountable, the more easily a building can be rearranged or transformed to other functions.
7/12		**18. Location/shape daylight** In what way are the facade/daylight openings positioned and shaped?	1. There are large closed surfaces in the facade (Bad) 2. There are small horizontal open surfaces in the facade (Normal) 3. Large open surfaces in the facade, but with different height sizes (Better) 4. Large continuous horiz. open surfaces; connections according to planning grid	The more regular open surfaces in the facade according to the planning grid, the better a building can meet changing demands in functions, quality and finishing of the building.
		19. Insulation of facade How is the thermal and acoustic insulation quality of the facade of the building?	1. Insulation does not meet the current demands for office buildings anymore (Bad) 2. Meets the current demands for office buildings (Normal) 3. Also meets the current demands for housing and care (Better) 4. Meets 10% above the current demand for offices, housing and care (Best)	The better the thermal and acoustic insulation of the facade, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
4. FACILITIES	**Measure & Control**	**20. Measure & control techniques** Is it possible to control/measure facilities on building level as well on user unit level?	1. Control/measurement takes place only at central building level (Bad) 2. On central level and occasionally on unit level (Normal) 3. On central level and limited on unit level (Better) 4. As well central on building level as well completely on unit level (Best)	The more possibilities for measurement and control of the facilities on unit level, the more easily units in a building can be rearranged or transformed to other functions.
	Dimensions	**21. Surplus capacity of facilities** Does the capacity of (the sources of) the facilities have a surplus capacity?	1. The capacities of facilities have no surplus at all (Bad) 2. The capacities of facilities have a surplus of 10-30% (Normal) 3. The capacities of facilities have a surplus of 30-50% (Better) 4. The capacities of facilities have a surplus of > 50% (Best)	The more surplus capacity of the facilities, the easier a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
	Distribution	**22. Distribution facilities** Does the building have a specific distribution facility for hot/cold water, heating, cooling, gas?	1. There is a specific distribution facility for all the different sources (Bad) 2. There is a specific distribution facility for some of the different sources (Normal) 3. There is a specific distribution facility for 2 of the different sources (Better) 4.There is no specific distribution facility one of the different sources (Best)	The less specific distribution equipment facilities have, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
19/28		**23. Location sources facilities** What is the location of the central facility sources?	1. The facilities sources are located at only one central location in the building (Bad) 2. The facilities sources are located at several locations in the building (Normal) 3. The sources are located at a central location and a decentred location as well. 4. The sources are located at outside the building at city level (district heating)	The more facility sources are localized at decentred level, the easier a building can be rearranged or transformed to other functions, the better a building can meet the changing user demands.
		24. Disconnection of facility Can the components of the facilities be easily disconnected?	1. Facility (parts) can not be disconnected or demounted; 'wet' connections (Bad) 2. Hardly be disconnected, demounted (Normal) 3. Partly be disconnected, demounted (Better) 4. Facility (parts) can be disconnected very easily (completely demountable) (Best)	The more facility parts can be disconnected or demounted, the easier a building can be rearranged/transformed to other functions, the better a building can meet to changing demands.
		25. Accessibility of facility To what extend are facility components good accessible?	1. Hardly or not accessible (components on support level; concreted in) (Bad) 2. Limited accessible (partly on support and infill level) (Normal) 3. Good accessible (a lot of components on infill level) (Better) 4. Very good accessible; most components at infill level; completely demountable	The higher the accessibility of facilities components, the more easily units in a building can be rearranged or transformed to other functions.
		26. Independence of user units In what way are the user units independent related to services as pantry, toilet facilities?	1. No services available at user unit level (Bad) 2. 1 - 2 services available (Normal) 3. 3 - 4 services available (Better) 4. > 4 services available (Best)	The more services are available at unit level, the more independent the units are opposite other units in the building, the more they meet to individual user demands.
5. SPACE	**Functional**	**27. Multifunctional building/Units** Is the building capable to support different functions, like offices, living, care and shops?	1. The building supports only one function (Bad) 2. The building supports 2 functions (Normal) 3. The building supports 3 functions (Better) 4. The building supports > 3 functions (Best)	The more a building supports more different functions of the building, the more easily a building can be rearranged or transformed to other functions.
	Technical	**28. Disconnectable, removable,** To what extend are the user units in a building removable, relocatable?	1. The user units in the building are not removable, relocatable (Bad) 2. The units are only relocatable with drastic expensive measures (Normal) 3. Units are easy relocatable; constructed with demountable components (Better) 4. Easy relocatable; constructed with 2D/3D modules, transportable by road (Best)	The more the units consist of demountable and reusable components, the better the units are relocatable to another location in or outside the building.
		29. Disconnectable, removable, To what extend are inner the walls in the building easily replaceable?	1. Inner walls are not replaceable without drastic/expensive interventions (bad) 2. Inner walls are not replaceable, but good destructible (Normal) 3. Inner walls replaceable by dismantling and rebuilding at another location (Better) 4. Inner walls are easily replaceable without radical/expensive interventions (Best)	The more inner walls can be easily replaced, the more easily a building can be rearranged or transformed to other functions, the better a building can meet to changing user demands.
18/24		**30. Disconnectable connection detail** Which detailed construction is applied between the interior walls and support structure and facade?	1. The detailing connection consists of penetrating connections (Bad) 2. The detailing connection consists of wet connections (mortar, sealant, glue) 3. The detailing consists of specific project bound connection elements (Better) 4. The detailing consists of project unbound dismountable connections (Best)	The easier the connection of interior walls can be dismounted, the easier a building can be rearranged or transformed to other functions, the better a building can meet to changing demands.
		31. Possibility of suspended ceilings Is it possible to apply suspended ceilings (-0.20m) and to adapt these to the different user demands?	1. Suspended ceiling results in free floor height of < 2.60 m (Bad) 2. Suspended ceiling results in free floor height of 2.60-2.70m (Normal) 3. Suspended ceiling results in free floor height of 2.70-2.80m (Better) 4. Suspended ceiling results in free floor height of > 2.80m (Best)	The higher the free storey height, the better the building can meet to changing demands concerning functions, facilities, finishing and quality of the building.
		32. Possibility of raised floors Is it possible to apply raised floors and to adapt these to the different user demands?	1. Raised floor results in free floor height of < 2.6 m (bad) 2. Raised floor results in free floor height of 2.60-2.70m (Normal) 3.Raised floor results in free floor height of 2.70-2.80m (Better) 4. Raised floor results in free floor height of > 2.80m (Best)	The higher the free storey height, the better the building can meet to changing demands concerning functions, facilities, finishing and quality of the building.

Figure 2. FLEX4.0 assessment on building 22 (TNW) part 2/2 (Geraedts, 2016) (by Author)

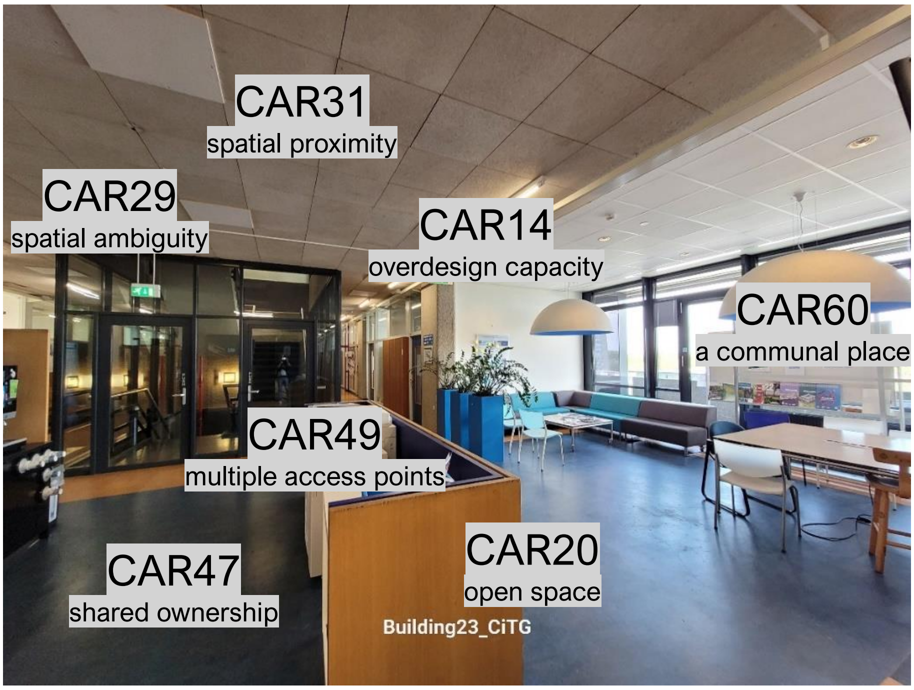
Figure 3. FLEX4.0 assessment results on building 22 (TNW) (by Author)

Appendix 7 Schmidt & Austin analysis method; Method 2**.** Applied on building 23; CiTG

Within the figure above, the interior area of the CiTG building is seen. The typology pattern (CAR23) of the space plan becomes clear, the simple plan (CAR32) where office spaces on the both sides of the building area placed, creates an opportunity for the mixed tenure (CAR65) within the building. With the physical linkage (CAR50) of the long corridors and the shared communal spaces.

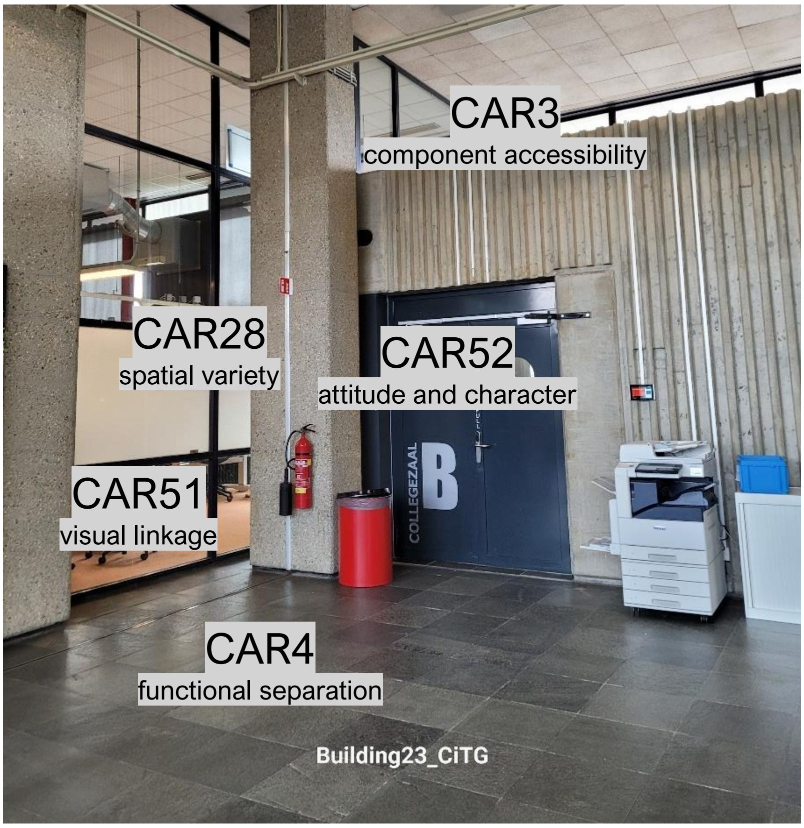


The office spaces, as seen depicted in the figure above, are created with standard room sizes (CAR27), and filled in with not precious (CAR8) furniture. Creating a loose fit interior space where rooms and functions can be easily retrofitted.

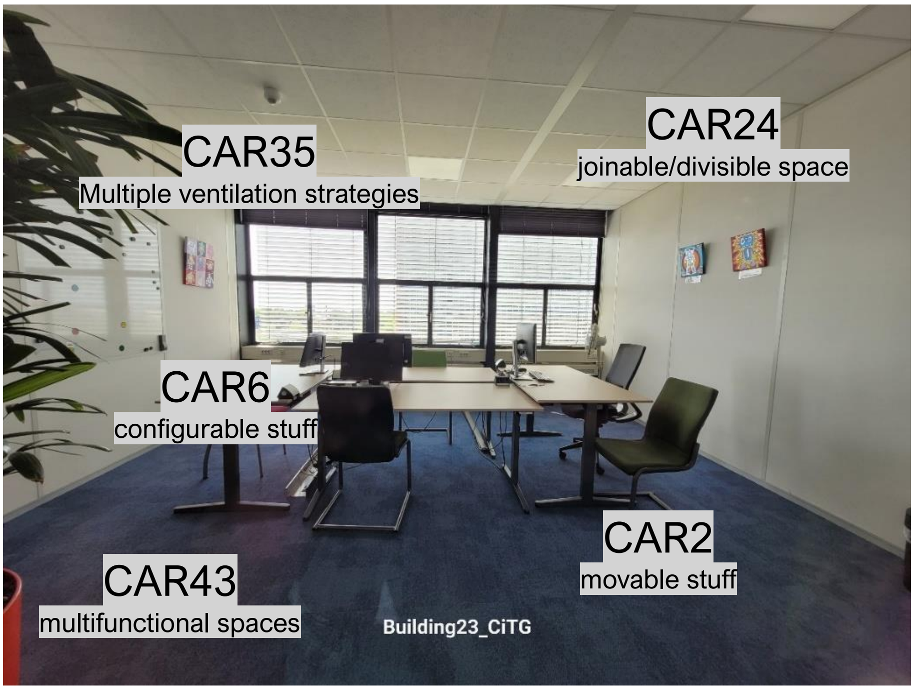


The office spaces and corridors connect to the multiple open communal places (CAR20)(CAR60). These spaces are shared in ownership (CAR47) whereas multiple people and functions can share this space. These communal places are linked to the multiple access points (CAR49) directly, creating the spatial proximity (CAR31). The staircases are made of glass in order to blur the boundaries (CAR29) between the different floors. These open spaces also serve as overdesign capacity space (CAR14), they can later be turned into different functions due to the not yet filled in way of designing this space.

The building itself stand upon the TU Delft campus (CAR57) and is therefore connected to multiple transport connections (CAR59), and the building makes by its raised floors (or empty ground floor as seen in the figure above) a connection to the context (CAR58). But this space also shows the construction of the building and the materiality. The use of concrete creates the capacity to last, resist decay and can weather well (CAR10). And the use of concrete columns and beams betrays the simple construction method (CAR19).



Back on the interior to the building, the attitude and character (CAR52) of the building form the outside also shows on the inside, making use of the same materiality. This rigid materiality of concrete makes for the component accessibility (CAR3) as seen in the figure above. The functional separation (CAR4) within the buildings construction creates spatial variety (CAR28) that the educational function desires. And the visual linkage (CAR51) still makes the building function and feel as a whole.



On the higher floors of the building, smaller multifunctional spaces (CAR43) (as seen in the figure above), are located. These spaces are filled with configurable and movable stuff (CAR6)(CAR2) like tables and chairs. The possibility for opening windows creates therefore multiple ventilation strategies

(CAR35) that can be adjusted by the users. These spaces can be joined together and divided (CAR24) again into larger or smaller spaces, as the interior walls are not tied to the construction of the building.

Within the corridors the standardised components (CAR16), here in the form of ceiling-panels and repetitive window/door frames, can be seen in the figure above. These spaces can be used by a mixed demographic (CAR45), like students, docents and scientist. The corridors can also be made isolate (CAR48) from the whole of the building, by the implementation of doors.

Within the corridors the different materiality of the interior is also made visible. First off the quirkiness (CAR55) of the column being out of line from the interior wall shows, as it also stands out due to the difference in materiality from the construction and the infill (CAR17). Thanks to the good craftmanship (CAR13) of the old wooden interior walls, the history of the building is interwoven into the look and feel (CAR56). The different entrances for the different office-like spaces create opportunities for the differentiation in use of these spaces (CAR44).

Within the over dimensioned first floor of the building (CAR22), the entrance of good daylighting (CAR39) becomes clear. This daylight gives the simple rectangular form (CAR34) its spatial quality (CAR53) and creates a spatial zone (CAR30) where people can come together.

Results

CiTG 42 from 60 CAR’s, equals 70%

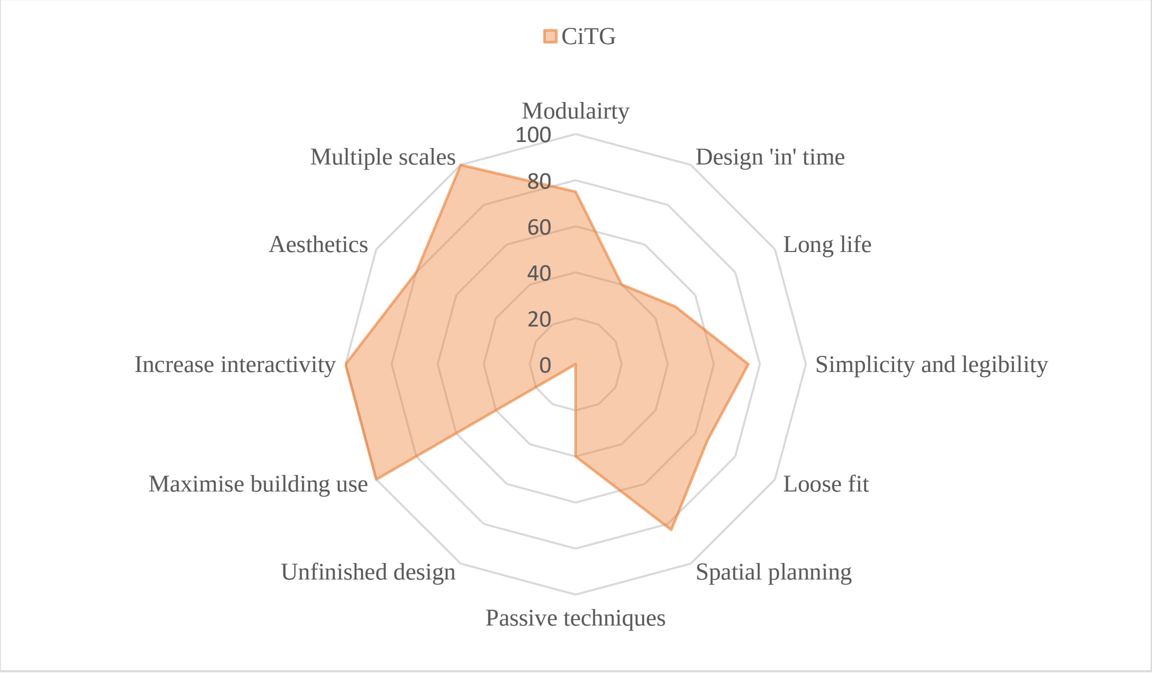
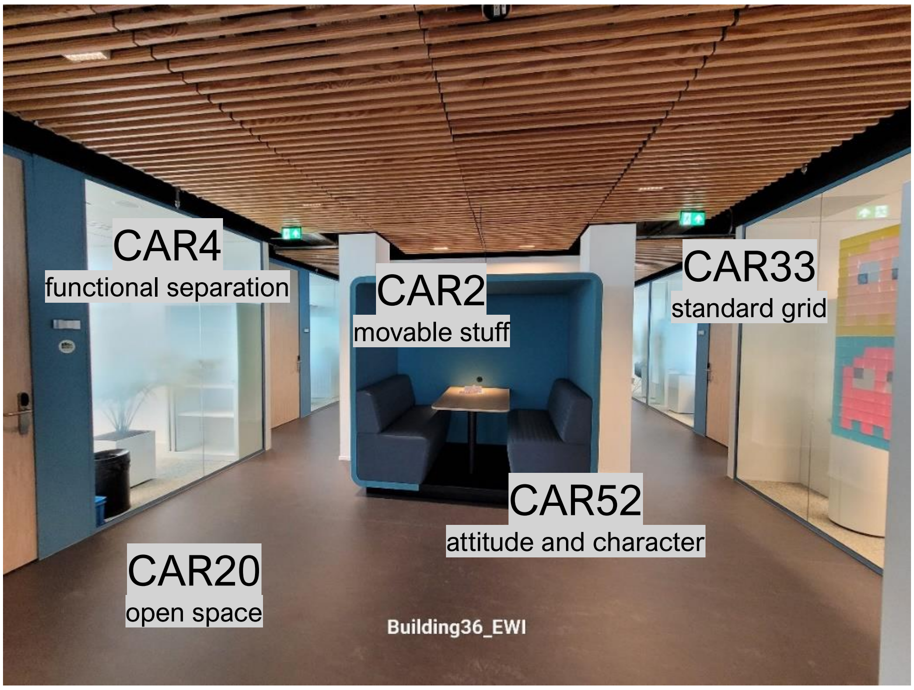
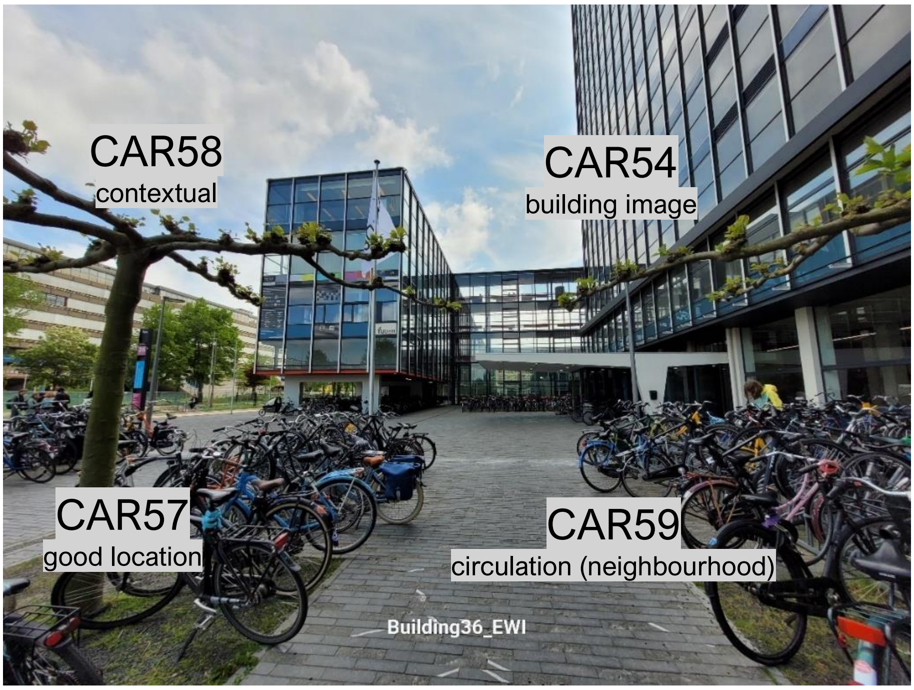


Figure 1. Schmidt & Austin assessment results on building 23 (CiTG) (by Author)

Appendix 8 Schmidt & Austin analysis method; Method 2**.** Applied on building 36; EWI

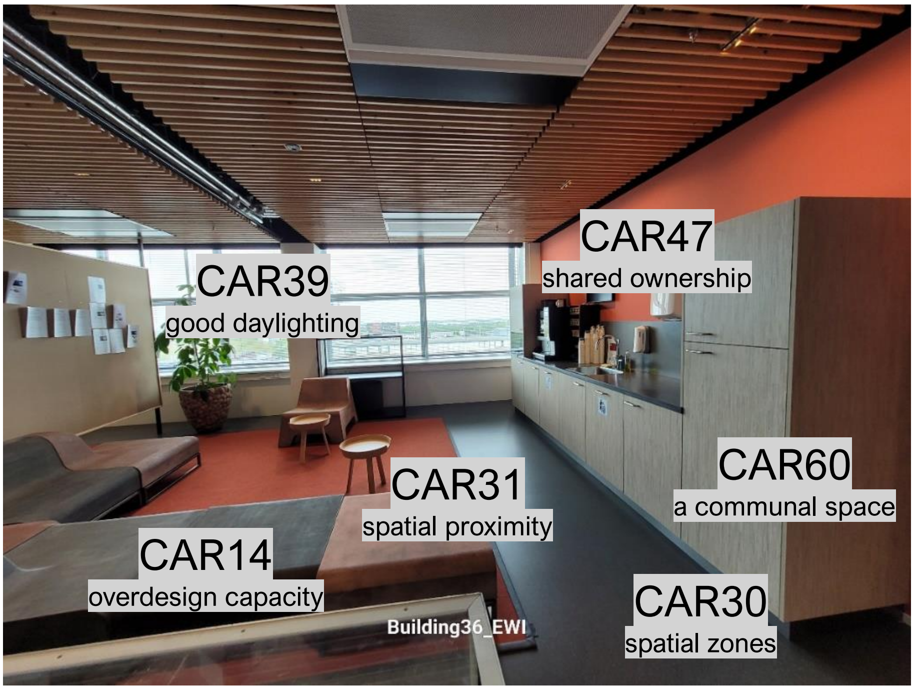


The standard grid (CAR33) of the building becomes clear due to the repetitive columns and the infill of interior wall systems, creating this functional separation (CAR4). Within the open space (CAR20) between the infill the use of movable stuff (CAR2), here in the form of a seating area, is depicted above. The constant materiality and the use of colour give the interior of the building attitude and character (CAR52)

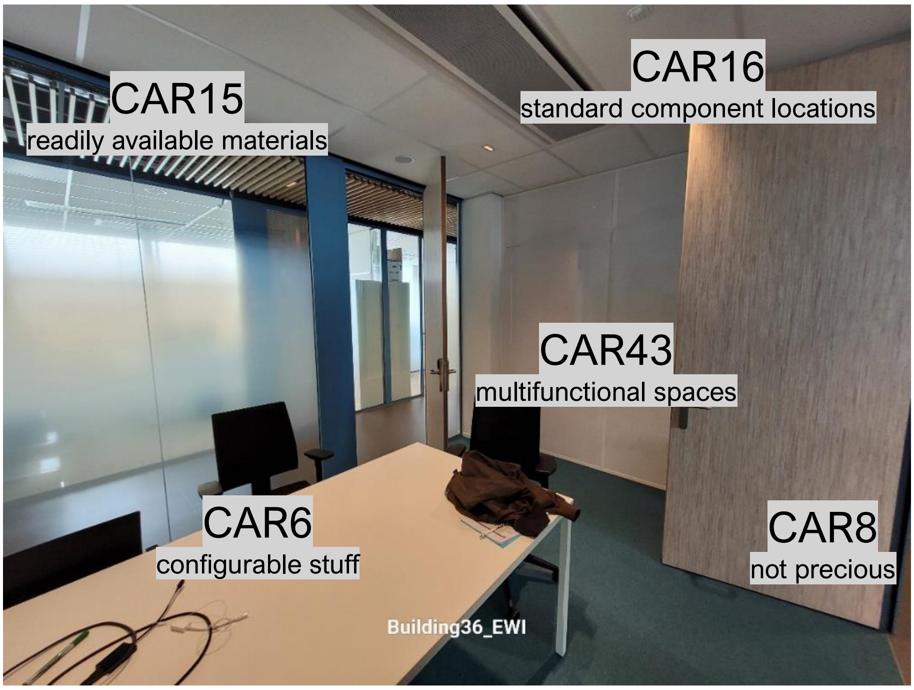


The outside of the building, as seen in the figure above, creates a strong building image (CAR54) onto the context of the TU Delft campus area (CAR57), thanks to its materiality and use of colour. Therefore the building poses itself onto the location (CAR58) and establishes a physical connection to the surrounding area (CAR59).

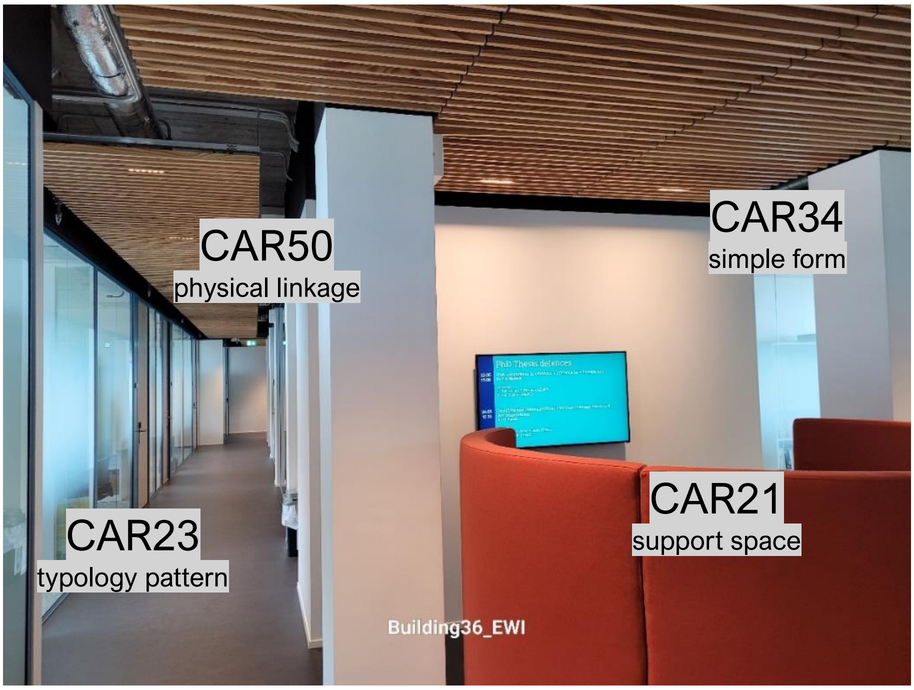
The interior building systems, here in the figure above focused on the interior walls, is made reversible (CAR1) due to the use of a flexible wall components. This creates a multitude of standard room sizes (CAR27), establishing a simple plan (CAR32), which can therefore be used by a mixture of tenures (CAR46). But still due to the wall systems, leaving room for the interior of the building to flexible as by joining or dividing spaces (CAR24).



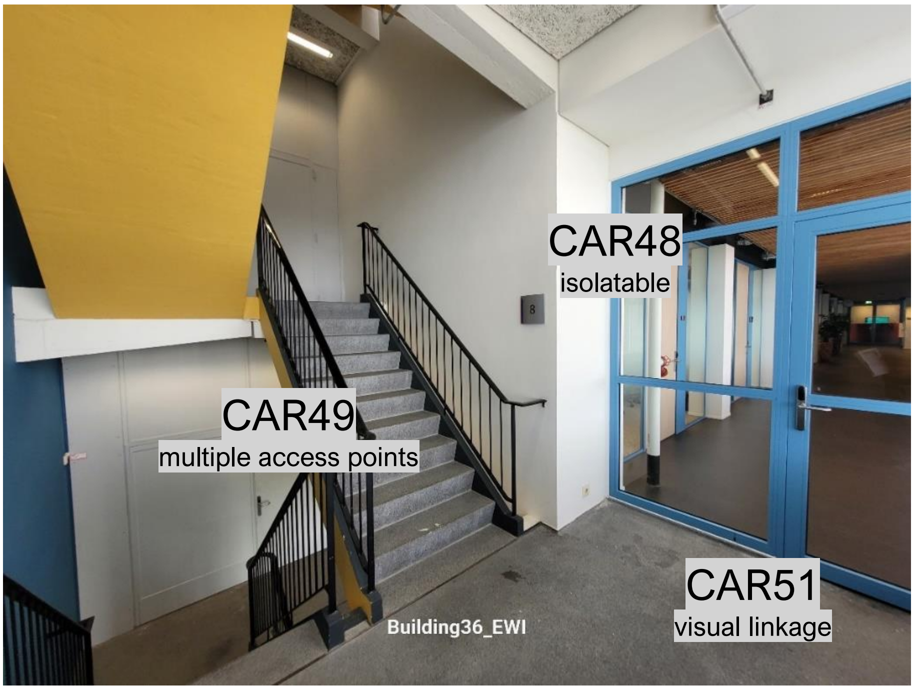
Within the interior of the building, central parts of the floorplan (CAR31) create room for a communal space (CAR60). Here, the shared ownership (CAR47) of this space, together with the entry of good daylighting (CAR39), create a spot for people to come together and meet. In the case that this type of space is not needed, with the use of flexible interior wall systems this space can become another function, therefore creating overdesign capacity for the building (CAR14)



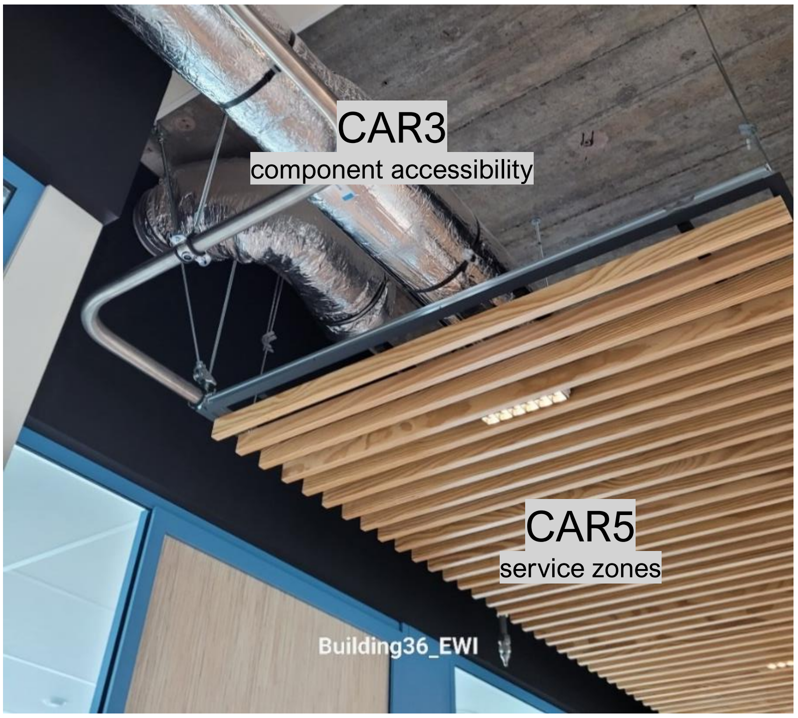
Within the interior spaces, with the use of readily available materials (CAR15) such as the wall-panels or ceiling-panels (CAR16), often not precious (CAR8) materials, different multifunctional spaces (CAR43) are created on the different floors. And the implementation of configurable stuff (CAR6), such as a simple table and a few chairs as seen in the figure above, create the multifunctionality by simplicity.



The typological pattern (CAR23) of the interior of the building can be seen in the figure above, with the multifunctional spaces in the centre of the space plan (left of the figure). The use of an orthogonal system (only rectangles and 90 degrees angels) creates the simple forms (CAR34) of the plan. With physical linkage (CAR50) of long corridors, and on these corridors support space (CAR21), in the figure above as seen as a small meeting place with a seating area and tv.



The corridors meet on the ends with the staircases, on both end of the longitudinal formed building (CAR49). On the figure above, one of these staircases is depicted. The floors themselves are isolatable (CAR48) by the use of doors within the passageways. But the visual linkage (CAR51) between the routing and the floors themselves is made by the use of glass.



The last figure displays the separate service zones (CAR5), creating component accessibility (CAR3) of the building services.

Results

EWI 35 from 60 CAR’s, equals 58%

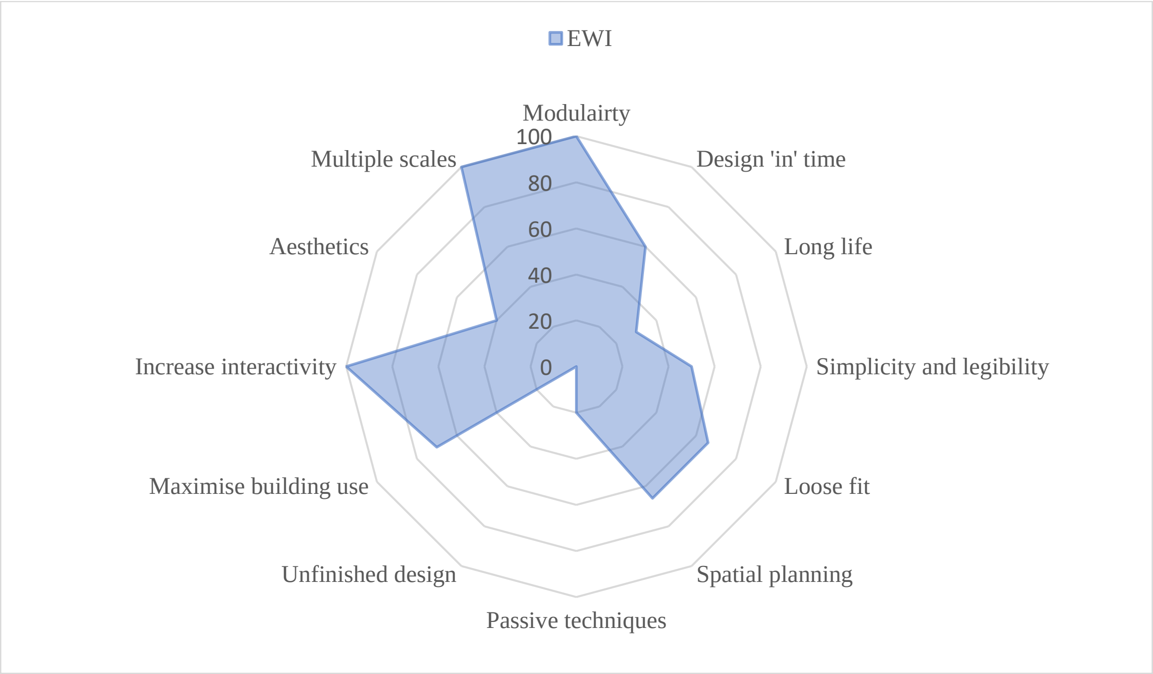
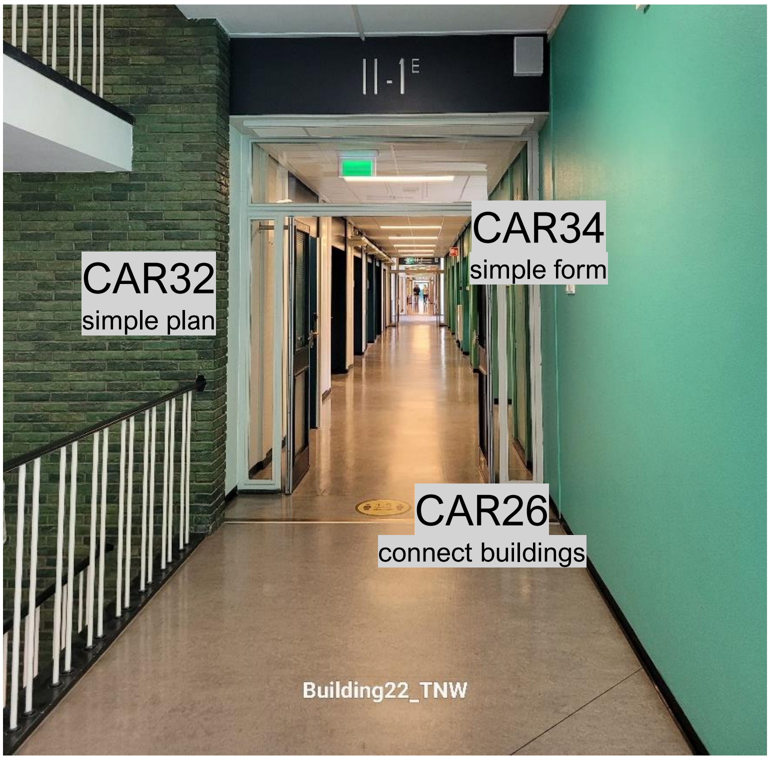


Figure 1. Schmidt & Austin assessment results on building 36 (EWI) (by Author)

Appendix 9 Schmidt & Austin analysis method; Method 2**.** Applied on building 22; TNW

Form the outside of the TNW building (building 22) the construction of the façade becomes visible, as seen in the figure above. It is build up from premanufactured concrete parts (CAR18), as dictated by the joins. Hereby is stating that these parts are able to be (at least partially) reversible (CAR1). The materiality of the façade creates an unique building image (CAR54) on the TU Delft campus.

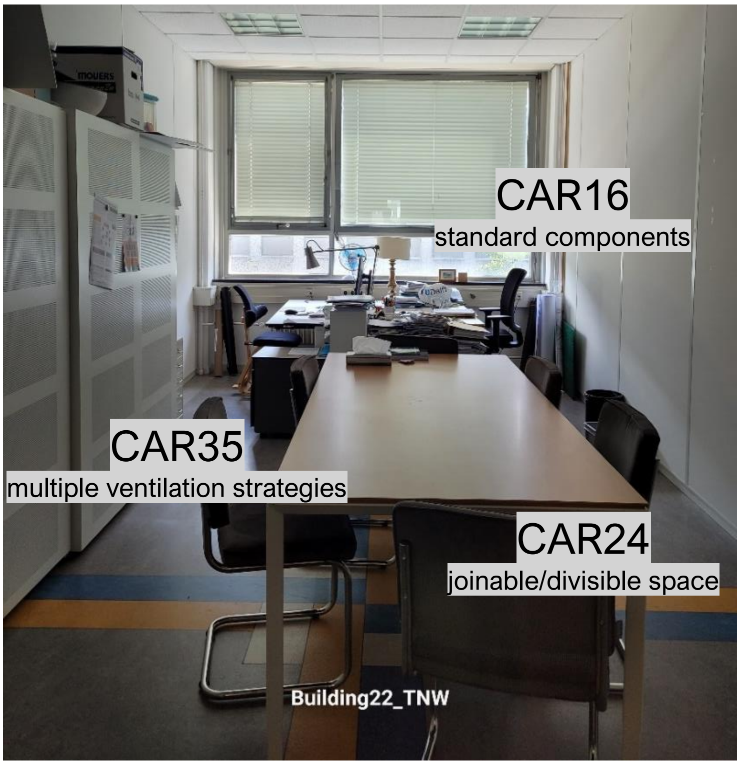
The direct contact with the campus surroundings create a good location (CAR57) with multiple opportunities. The visual linkage (CAR51) from the building, with the implementation of open glass corridors, combines the building and its context together (CAR58), as seen in the figure above.



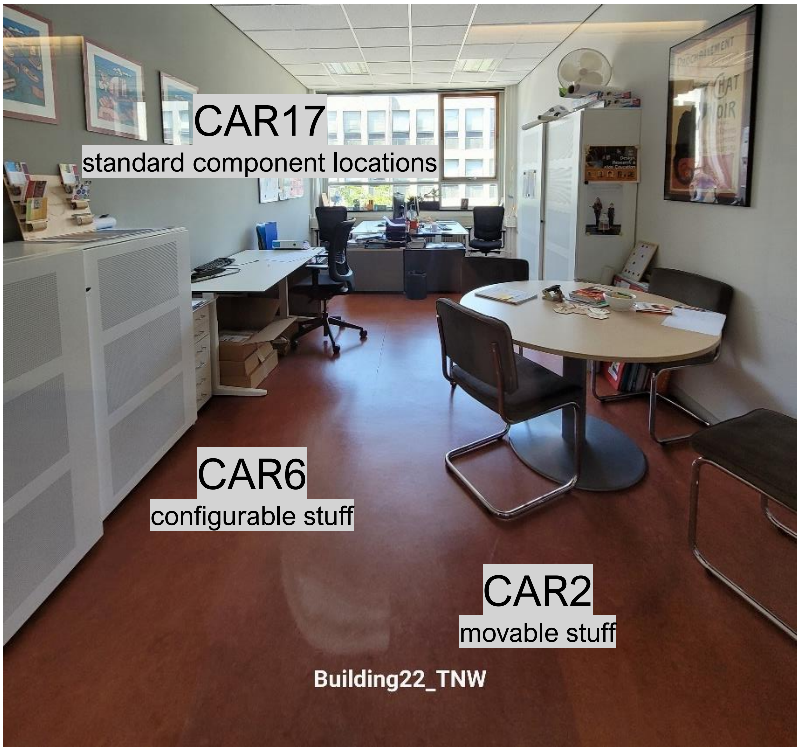
The first image (see figure above) of the interior of the TNW building, show the structure. The building is made up of different parts, wings, which connect together with these long central corridors, with rooms, offices or study places on both sides (CAR34). This repetitive and simple plan (CAR32) allows the building to connect or separate the different wings (CAR26) over time depending on the use.

The corridors of the different wings come together in the central spaces (CAR31), as seen in the figure above, and open up into more open space (CAR20). In this place the stairs and corridors connect, creating physical linkage (CAR50) between the routings and create an opportunity for meetings (CAR60) by implementing multifunctional furniture (CAR43). The durability of the interior (CAR10) speaks through the original stair balustrade, which blurs the boundaries between floors (CAR29) by revealing the verticality. The construction method (CAR19) of the building is shown through the circular pilar in the room.

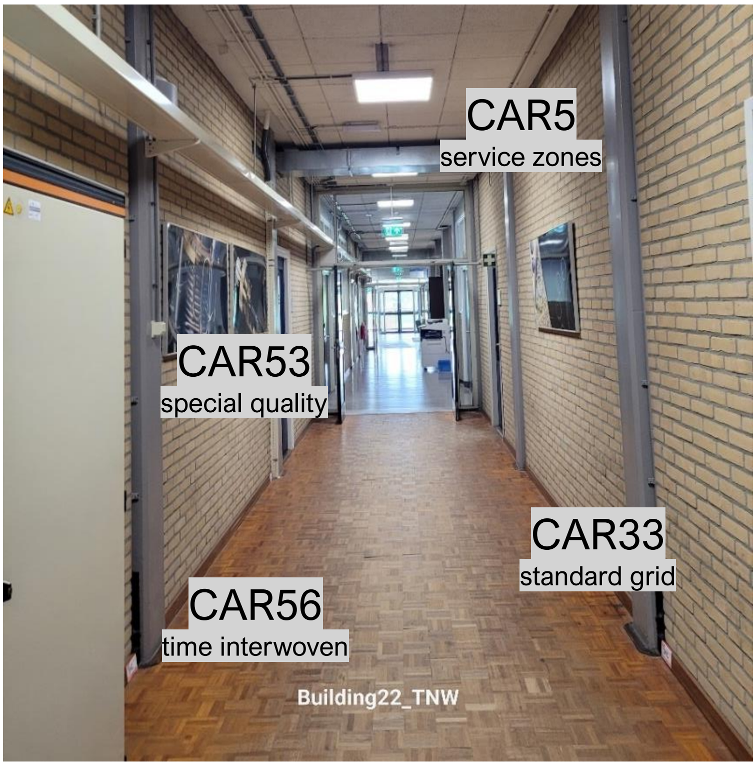
Within the corridors, each an individual spatial zone (CAR30) which can be secluded from the main areas, the materiality of the interior becomes clear. Here in the figure above, the use of readily available materials (CAR15), such as ceiling panels, wooden interior walls and premanufactured door- and doorframes, becomes visible. The functional separation from the corridors into the rooms itself can also be spotted above (CAR4).



Within the rooms themselves, the use of standards components (CAR16), here in the form of interior walls, is seen in the figure above. This creates joinable or divisible spaces (CAR24), because these materials can be removed or added easily. The figure also shows the multiple ventilation strategies (CAR35), whereas the windows can be opened, this on top of the mechanical ventilation.

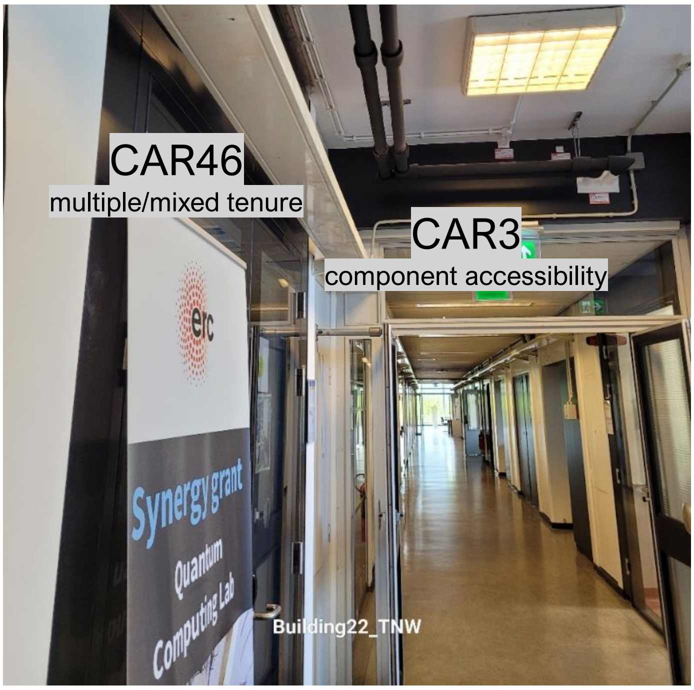


In another room, further on in the building, similarities can be seen (CAR17). But the use of movable furniture (CAR2) different configurations can be made with the stuff (CAR6) in order to create variety with the same basic furniture.

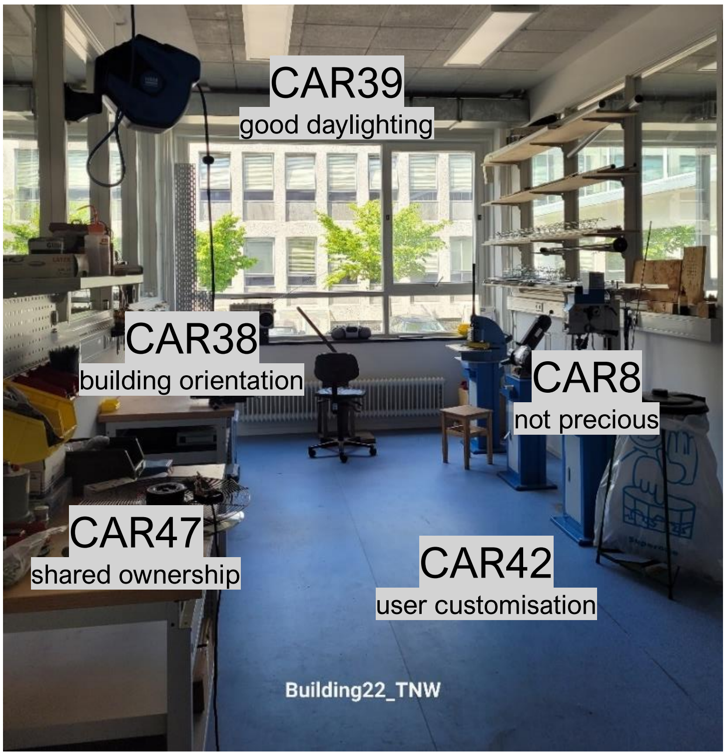


The different corridors (CAR53), here another in the figure above, constantly show the standard grid (CAR33) of the building by revealing the columns on both sides of the corridor. The materiality of this specific corridor shows the history of the materiality (CAR56), with the old wooden floor and the exposed brick, whereas in some corridors the materiality is more modernised. Because of the high ceilings, there is room for services (CAR5).

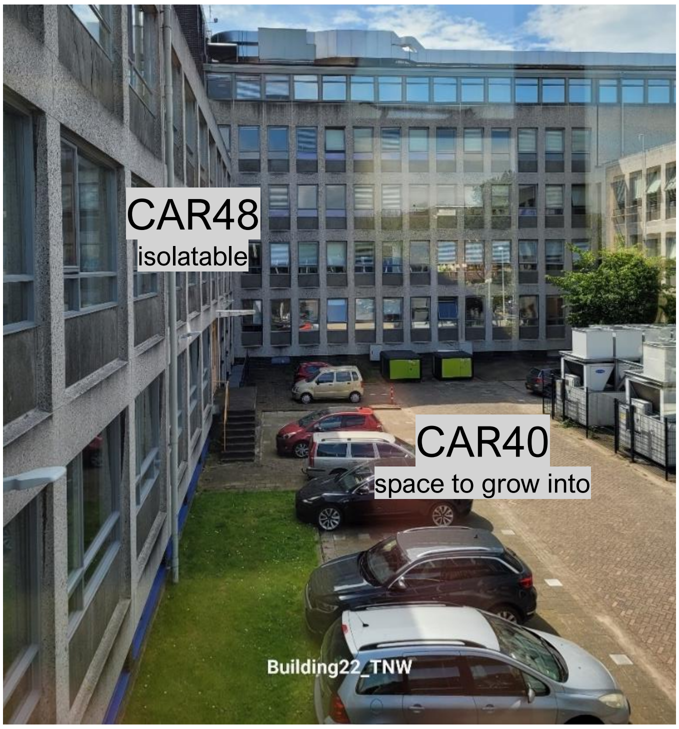
The typology pattern (CAR23) was, and is again in the image above, established by the central corridors with rooms on both sides, facing the façade of the building. These rooms are of standard size (CAR27) and therefore create differentation in use (CAR44) and demographics (CAR45). As the figure above shows, the different corridors with different functions as portrayed by the sign. To close off the beginning of the hallway, the old and origional doors still hold up (CAR11), portraying longevity by good craftmanship (CAR13).



An example of the mixed tenures (CAR46) within the different wings and corridors of the building can be seen in the figure above, where different external companies collaborate within the university campus building. The exposed component accessibility (CAR3) makes adjusting or moving in easy.



Within the laboratory spaces in the applied science building (figure above), the customisation (CAR42) of the rooms can be seen. Whereas the space is highly customised for the different experiments where with shared ownership (CAR47) and not precious materiality (CAR8) different experiments can be executed. Due to the buildings orientation (CAR38) the entry of daylight (CAR39) has the capacity to light the space up.



An outside view from shows the different wings of the building, as stated before which can be isolated from each other (CAR48). But this figure also reveals the courtyard like space, where there is enough room for the building to grow into (CAR40) when later expansion is required.

Results

TNW 45 from 60 CAR’s, equals 75%

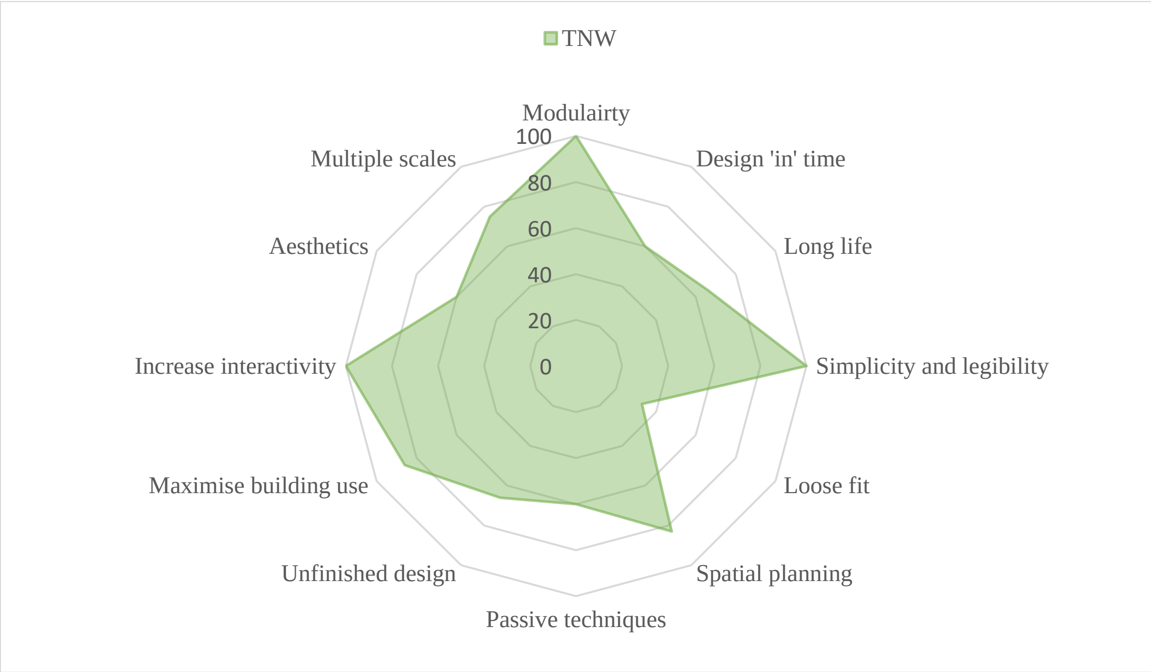


Figure 1. Schmidt & Austin assessment results on building 22 (TNW) (by Author)

Appendix 10 Level(s) 2.3 analysis method; Method 3. Applied on building 23; CiTG

Adaptability design concept	Specific design aspect to address	How the design aspect can contribute to adaptability	Scoring system	Weighting factor
1. Changes to the internal space distribution	1.1 Column grid spans	Wider column spans will allow for more flexible floor layouts.	Column spacing: - < 5400 mm 0 points - 5400 mm < 8100 mm 1 point - > 8100 mm 2 points - free span 3 points	1.5
	1.2 Façade pattern	Narrower bays will allow for more internal space configurations	Spacing between bays: - 1350 to >1800 mm 0 points - 1350 - 1800 mm 1 point - 1350 - 1800 mm, some bays 900 - 1350 mm 2 points - 900 - 1350 mm, some bays < 900 mm 3 points	1.5
	1.3 Internal wall system	Non-loading bearing internal walls will allow for changes to be made more easily to floor layouts.	- Immovable interior walls, multiple functions 0 points - Immovable interior walls, temporary structures 1 point - Movable interior walls, requires disassembly 2 points - Easily movable interior walls, partition system 3 points	4.5
	1.4 Unit size and access	By ensuring that access/egress is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate size: - > 600 m² 0 points - 400 - 600 m² 1 point - 200 - 400 m² 2 points - < 200 m² 3 points	3.0
2. Changes to the buildings servicing	2.1 Ease of access to service ducts	Access will be improved if services are not embedded in the building structure.	Location of key service ducts: - Embedded in the floor 0 points - Between 2 building layers 1 point - Above one building layer (floor) 2 points - Below one building layer (ceiling) 3 points	1.5
	2.2 Ease of access to plant rooms	Future changes of technical equipment will be facilitated if there is ease of access to plant rooms and equipment.	- Embedded in a sub-basement of the building 0 points - Located in a plant room on the roof or within an accessible patio 1 point - Located in a ground floor plant room with easy external access 2 points - Located external to the building with complete access 3 points	1.5

Figure 1. Level(s) 2.3 assessment on building 22 (TNW) part 1/2 (Dodd et al., 2020) (by Author)

	2.3 Longitudinal ducts for service routes	The inclusion of longitudinal ducts will provide flexibility in the location of service points.	- Connection grid in 1 direction 0 points - Cable duct in 1 direction 1 point - Connection grid in 2 directions 2 points - Cable duct in 2 directions 3 points	1.5
	2.4 Higher ceilings for service routes	The use of greater ceiling heights will provide more flexibility in the routing of services.	Internal height (floor surface to ceiling surface): - < 3000 mm 0 points - 3000-3500 mm 1 point - 3500-4000 mm 2 points - > 4000 mm 3 points	4.5
	2.5 Services to sub-divisions	By ensuring that individual servicing for sanitary facilities is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate sub-division size that can be serviced: - > 600 m² 0 points - 400 - 600 m² 1 point - 200 - 400 m² 2 points - < 200 m² 3 points	3.0
3. Changes to the buildings' façade and structure	3.1 Non-load bearing facades	Non-load bearing facades will allow for changes to be made more easily to both internal layouts and external elements.	- Bearing facade with bearing obstacles 0 points - Bearing facade, no bearing obstacles 1 point - Non-bearing facade, bearing obstacles 2 points - Non-bearing facade, no bearing obstacles 3 points *Note: Examples of obstacles include bearing interior walls, columns, elevator shafts or installation ducts.*	4.5
	3.2 Future-proofing of load bearing capacity	The incorporation of redundant load bearing capacity will support potential future changes in the building's façade and uses.	Variable capacity: - 1,75 kN/m² 0 points - 2,50 kN/m² 1 point - 4,00 kN/m² 2 points - 5,00 kN/m² 3 points	4.5
	3.3 Structural design to support future expansion	Structural designs that have the vertical strength to support additional storeys will allow for future expansion of the floor area.	Capacity to add storeys: - 1 storey 0 points - 2 storey 1 point - 3 storeys 2 points - 4 or more storeys 3 points	1.5

Figure 2. Level(s) 2.3 assessment on building 22 (TNW) part 2/2 (Dodd et al., 2020) (by Author)

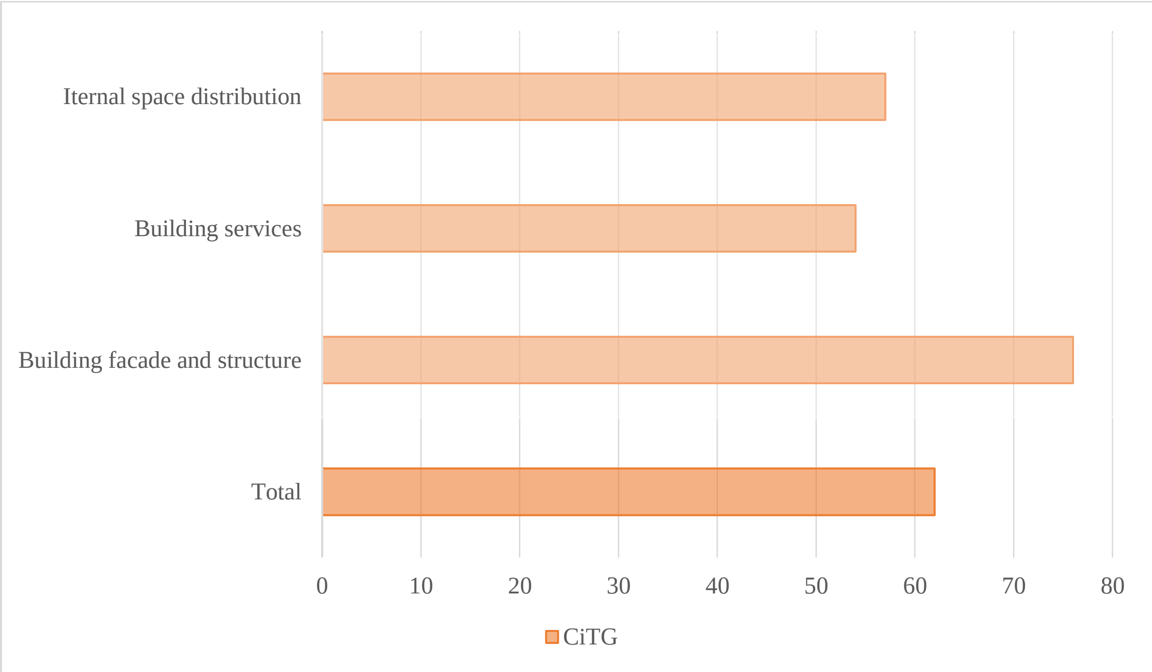


Figure 3. Level(s) 2.3 assessment results on building 22 (TNW) (by Author)

Appendix 11 Level(s) 2.3 analysis method; Method 3. Applied on building 36; EWI

Adaptability design concept	Specific design aspect to address	How the design aspect can contribute to adaptability	Scoring system	Weighting factor
1. Changes to the internal space distribution 13,5/31,5	1.1 Column grid spans	Wider column spans will allow for more flexible floor layouts.	Column spacing: - < 5400 mm 0 points - 5400 mm < 8100 mm 1 point - > 8100 mm 2 points - free span 3 points	1.5
	1.2 Façade pattern	Narrower bays will allow for more internal space configurations	Spacing between bays: - 1350 to >1800 mm 0 points - 1350 - 1800 mm 1 point - 1350 - 1800 mm, some bays 900 - 1350 mm 2 points - 900 - 1350 mm, some bays < 900 mm 3 points	1.5
	1.3 Internal wall system	Non-loading bearing internal walls will allow for changes to be made more easily to floor layouts.	- Immovable interior walls, multiple functions 0 points - Immovable interior walls, temporary structures 1 point - Movable interior walls, requires disassembly 2 points - Easily movable interior walls, partition system 3 points	4.5
	1.4 Unit size and access	By ensuring that access/egress is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate size: - > 600 m² 0 points - 400 - 600 m² 1 point - 200 - 400 m² 2 points - < 200 m² 3 points	3.0
2. Changes to the buildings servicing	2.1 Ease of access to service ducts	Access will be improved if services are not embedded in the building structure.	Location of key service ducts: - Embedded in the floor 0 points - Between 2 building layers 1 point - Above one building layer (floor) 2 points - Below one building layer (ceiling) 3 points	1.5
	2.2 Ease of access to plant rooms	Future changes of technical equipment will be facilitated if there is ease of access to plant rooms and equipment.	- Embedded in a sub-basement of the building 0 points - Located in a plant room on the roof or within an accessible patio 1 point - Located in a ground floor plant room with easy external access 2 points - Located external to the building with complete access 3 points	1.5

Figure 1. Level(s) 2.3 assessment on building 36 (EWI) part 1/2 (Dodd et al., 2020) (by Author)

16,5/36	2.3 Longitudinal ducts for service routes	The inclusion of longitudinal ducts will provide flexibility in the location of service points.	- Connection grid in 1 direction 0 points - Cable duct in 1 direction 1 point - Connection grid in 2 directions 2 points - Cable duct in 2 directions 3 points	1.5
	2.4 Higher ceilings for service routes	The use of greater ceiling heights will provide more flexibility in the routing of services.	Internal height (floor surface to ceiling surface): - < 3000 mm 0 points - 3000-3500 mm 1 point - 3500-4000 mm 2 points - > 4000 mm 3 points	4.5
	2.5 Services to sub-divisions	By ensuring that individual servicing for sanitary facilities is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate sub-division size that can be serviced: - > 600 m² 0 points - 400 - 600 m² 1 point - 200 - 400 m² 2 points - < 200 m² 3 points	3.0
3. Changes to the buildings' façade and structure 18/31,5	3.1 Non-load bearing facades	Non-load bearing facades will allow for changes to be made more easily to both internal layouts and external elements.	- Bearing facade with bearing obstacles 0 points - Bearing facade, no bearing obstacles 1 point - Non-bearing facade, bearing obstacles 2 points - Non-bearing facade, no bearing obstacles 3 points *Note: Examples of obstacles include bearing interior walls, columns, elevator shafts or installation ducts.*	4.5
	3.2 Future-proofing of load bearing capacity	The incorporation of redundant load bearing capacity will support potential future changes in the building's façade and uses.	Variable capacity: - 1,75 kN/m² 0 points - 2,50 kN/m² 1 point - 4,00 kN/m² 2 points - 5,00 kN/m² 3 points	4.5
	3.3 Structural design to support future expansion	Structural designs that have the vertical strength to support additional storeys will allow for future expansion of the floor area.	Capacity to add storeys: - 1 storey 0 points - 2 storey 1 point - 3 storeys 2 points - 4 or more storeys 3 points	1.5

Figure 2. Level(s) 2.3 assessment on building 36 (EWI) part 2/2 (Dodd et al., 2020) (by Author)

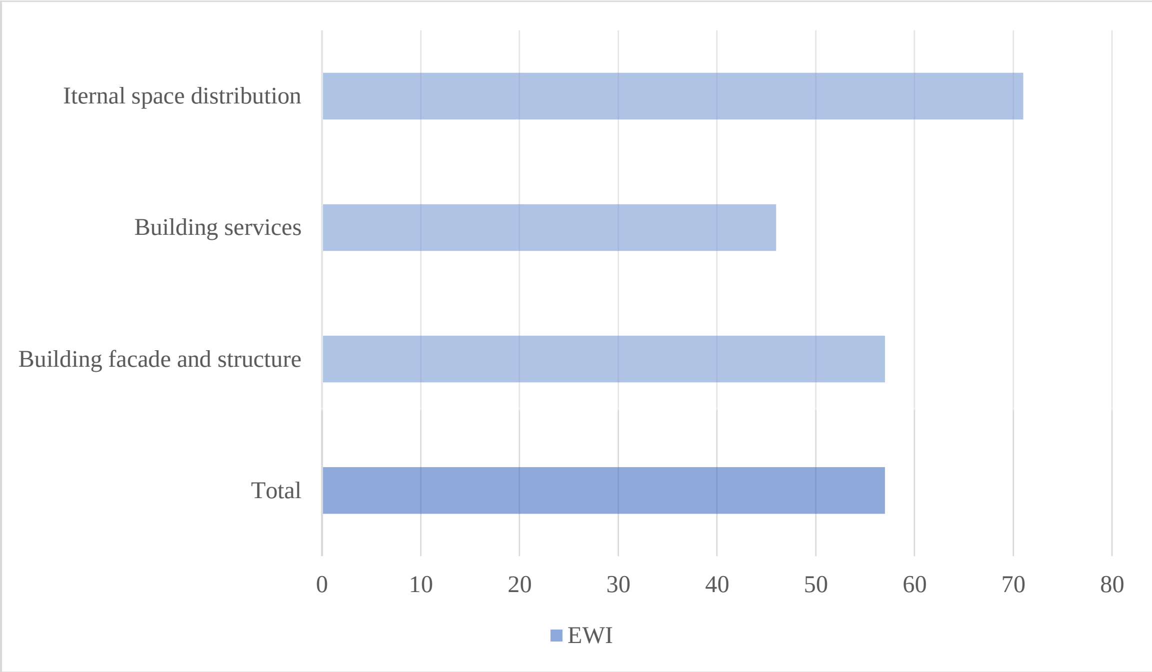


Figure 3. Level(s) 2.3 assessment results on building 36 (EWI) (by Author)

Appendix 12 Level(s) 2.3 analysis method; Method 3. Applied on building 22; TNW

Adaptability design concept	Specific design aspect to address	How the design aspect can contribute to adaptability	Scoring system	Weighting factor
1. Changes to the internal space distribution	1.1 Column grid spans	Wider column spans will allow for more flexible floor layouts.	Column spacing: - < 5400 mm 0 points - 5400 mm < 8100 mm 1 point - > 8100 mm 2 points - free span 3 points	1.5
	1.2 Façade pattern	Narrower bays will allow for more internal space configurations	Spacing between bays: - 1350 to >1800 mm 0 points - 1350 - 1800 mm 1 point - 1350 - 1800 mm, some bays 900 - 1350 mm 2 points - 900 - 1350 mm, some bays < 900 mm 3 points	1.5
	1.3 Internal wall system	Non-loading bearing internal walls will allow for changes to be made more easily to floor layouts.	- Immovable interior walls, multiple functions 0 points - Immovable interior walls, temporary structures 1 point - Movable interior walls, requires disassembly 2 points - Easily movable interior walls, partition system 3 points	4.5
	1.4 Unit size and access	By ensuring that access/egress is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate size: - > 600 m² 0 points - 400 - 600 m² 1 point - 200 - 400 m² 2 points - < 200 m² 3 points	3.0
2. Changes to the buildings servicing	2.1 Ease of access to service ducts	Access will be improved if services are not embedded in the building structure.	Location of key service ducts: - Embedded in the floor 0 points - Between 2 building layers 1 point - Above one building layer (floor) 2 points - Below one building layer (ceiling) 3 points	1.5
	2.2 Ease of access to plant rooms	Future changes of technical equipment will be facilitated if there is ease of access to plant rooms and equipment.	- Embedded in a sub-basement of the building 0 points - Located in a plant room on the roof or within an accessible patio 1 point - Located in a ground floor plant room with easy external access 2 points - Located external to the building with complete access 3 points	1.5

Figure 1. Level(s) 2.3 assessment on building 22 (TNW) part 1/2 (Dodd et al., 2020) (by Author)

	2.3 Longitudinal ducts for service routes	The inclusion of longitudinal ducts will provide flexibility in the location of service points.	- Connection grid in 1 direction 0 points - Cable duct in 1 direction 1 point - Connection grid in 2 directions 2 points - Cable duct in 2 directions 3 points	1.5
	2.4 Higher ceilings for service routes	The use of greater ceiling heights will provide more flexibility in the routing of services.	Internal height (floor surface to ceiling surface): - < 3000 mm 0 points - 3000-3500 mm 1 point - 3500-4000 mm 2 points - > 4000 mm 3 points	4.5
	2.5 Services to sub-divisions	By ensuring that individual servicing for sanitary facilities is possible for sub-divisions of the spaces, this will provide more sub-letting options.	Weighted average unit/floor plate sub-division size that can be serviced: - > 600 m² 0 points - 400 - 600 m² 1 point - 200 - 400 m² 2 points - < 200 m² 3 points	3.0
3. Changes to the buildings' façade and structure	3.1 Non-load bearing facades	Non-load bearing facades will allow for changes to be made more easily to both internal layouts and external elements.	- Bearing facade with bearing obstacles 0 points - Bearing facade, no bearing obstacles 1 point - Non-bearing facade, bearing obstacles 2 points - Non-bearing facade, no bearing obstacles 3 points *Note: Examples of obstacles include bearing interior walls, columns, elevator shafts or installation ducts.*	4.5
	3.2 Future-proofing of load bearing capacity	The incorporation of redundant load bearing capacity will support potential future changes in the building's façade and uses.	Variable capacity: - 1,75 kN/m² 0 points - 2,50 kN/m² 1 point - 4,00 kN/m² 2 points - 5,00 kN/m² 3 points	4.5
	3.3 Structural design to support future expansion	Structural designs that have the vertical strength to support additional storeys will allow for future expansion of the floor area.	Capacity to add storeys: - 1 storey 0 points - 2 storey 1 point - 3 storeys 2 points - 4 or more storeys 3 points	1.5

Figure 2. Level(s) 2.3 assessment on building 22 (TNW) part 2/2 (Dodd et al., 2020) (by Author)

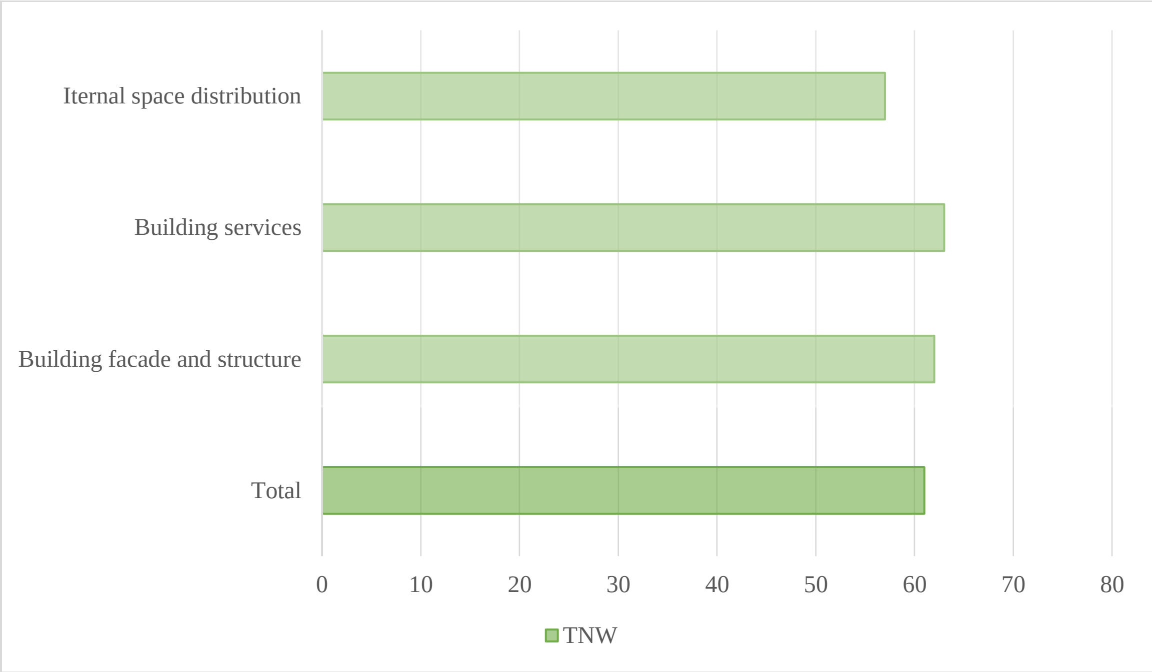


Figure 3. Level(s) 2.3 assessment results on building 22 (TNW) (by Author)

Appendix 13 Case study Project: Röntgenweg, Delft

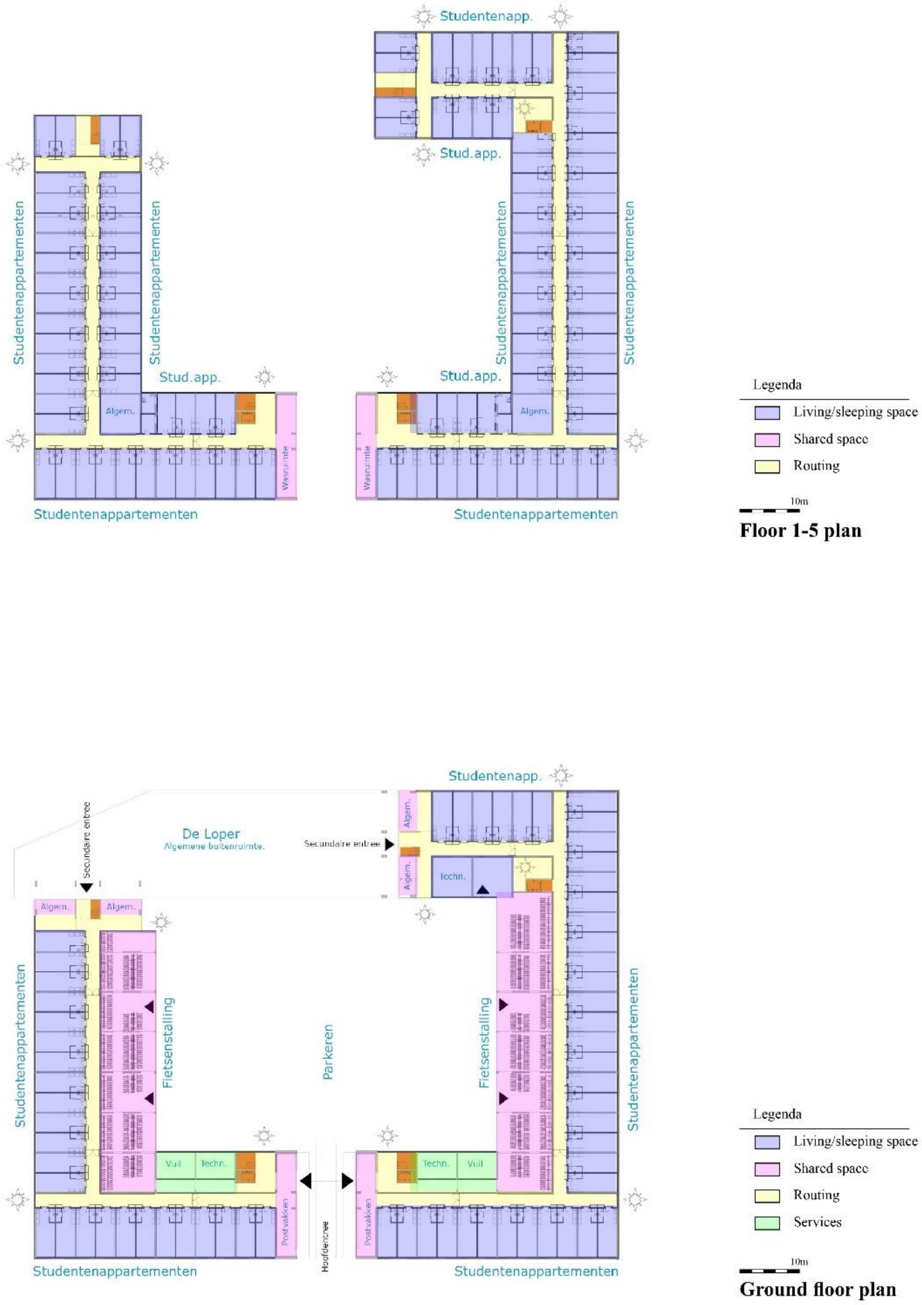


Figure 1. Röntgenweg case study analysis project building scale floor plans (Studentenhuisvesting Spoorzone | Leeuwenkamp Architecten, n.d.)

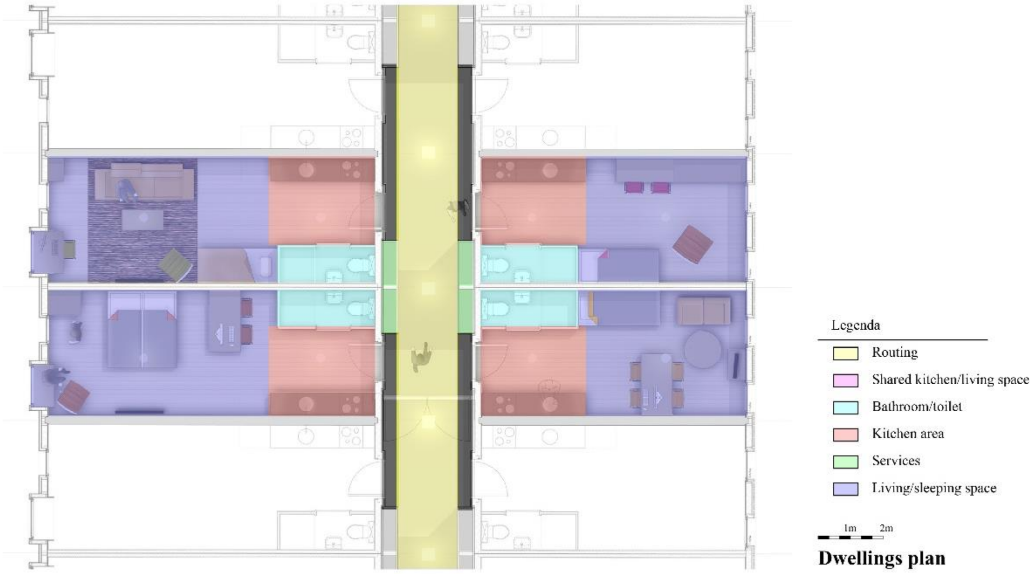


Figure 2. Röntgenweg case study analysis dwellings plans (Studentenhuisvesting Spoorzone | Leeuwenkamp Architecten, n.d.)

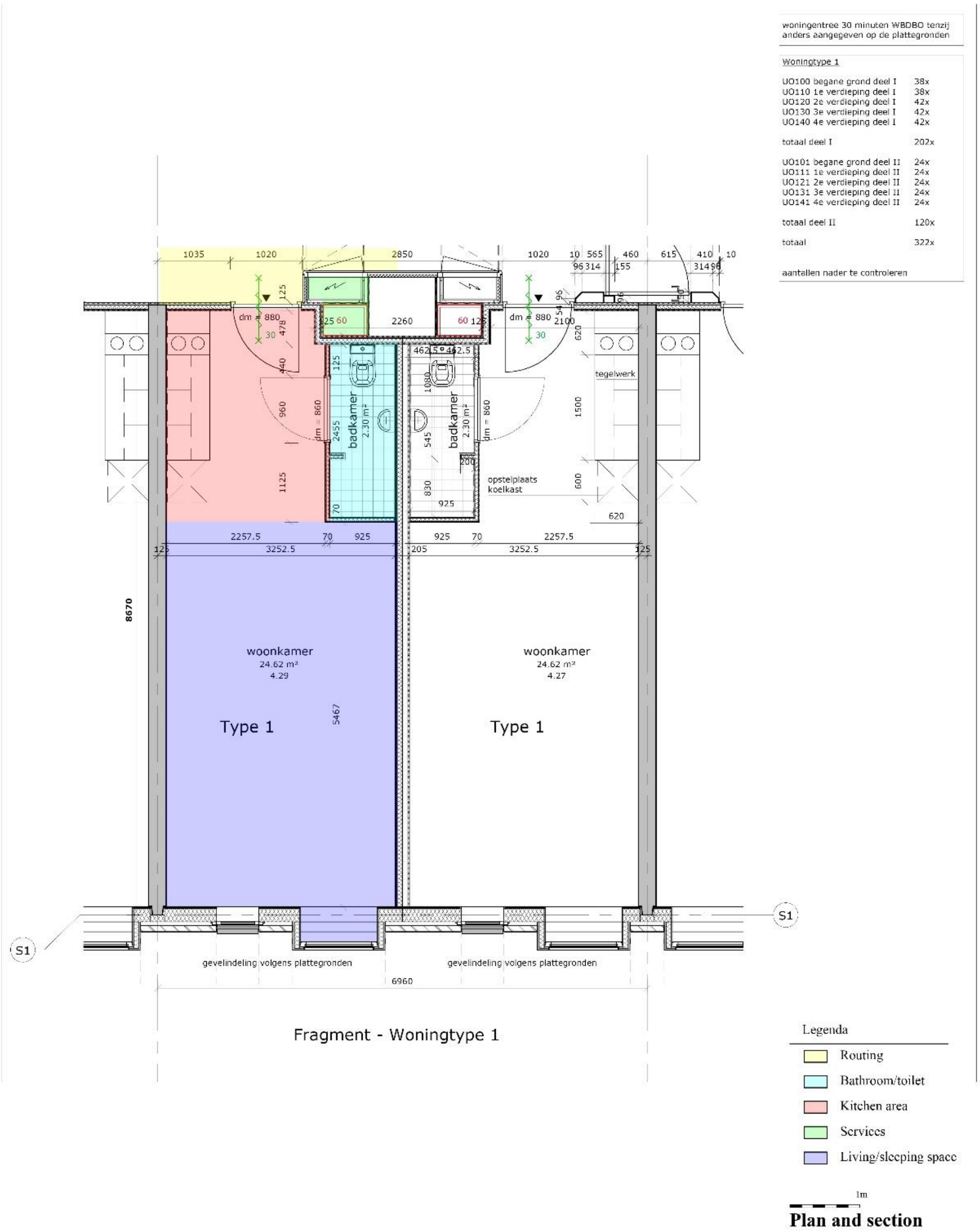


Figure 3. Röntgenweg case study analysis detailed dwellings plans (Studentenhuisvesting Spoorzone | Leeuwenkamp Architecten, n.d.)

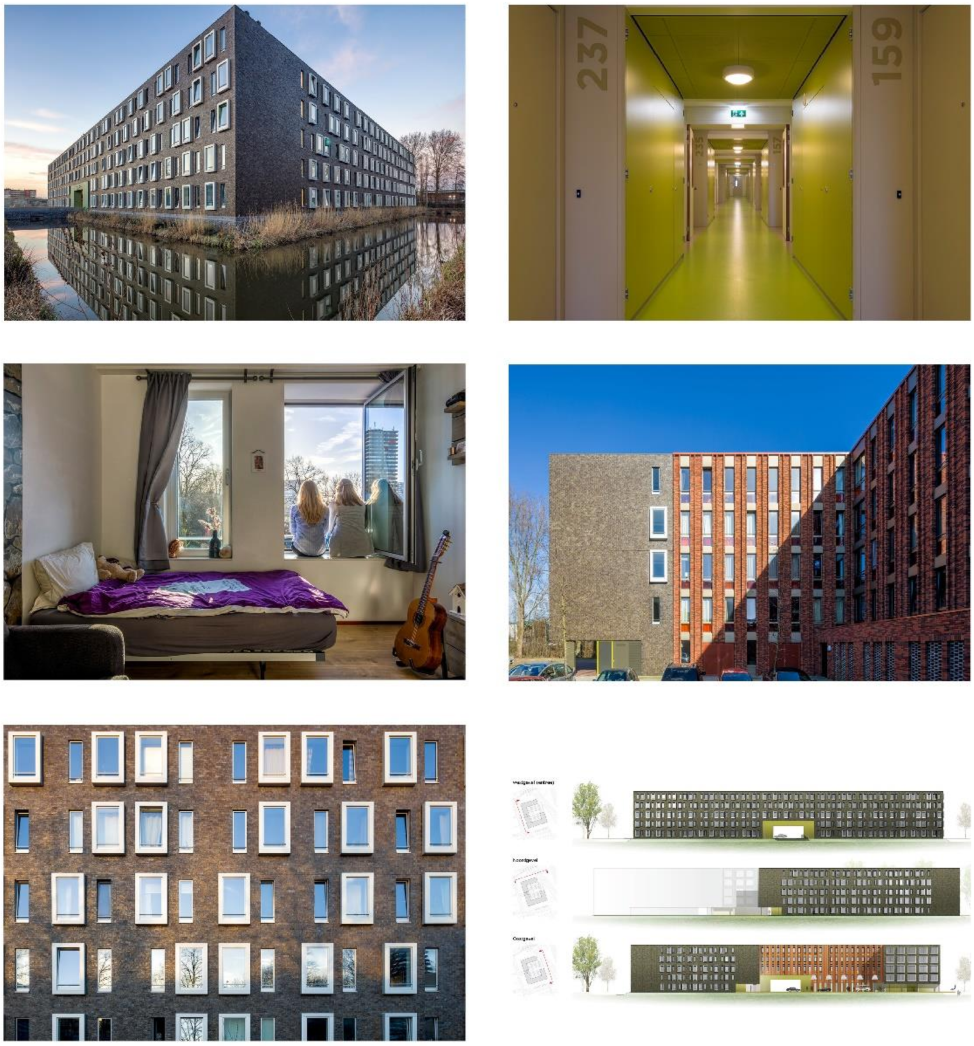


Figure 4. Six picture of the Röntgenweg case study project (Studentenhuisvesting Spoorzone | Leeuwenkamp Architecten, n.d.)

Appendix 14 Case study Project: Diemen Zuid, Amsterdam

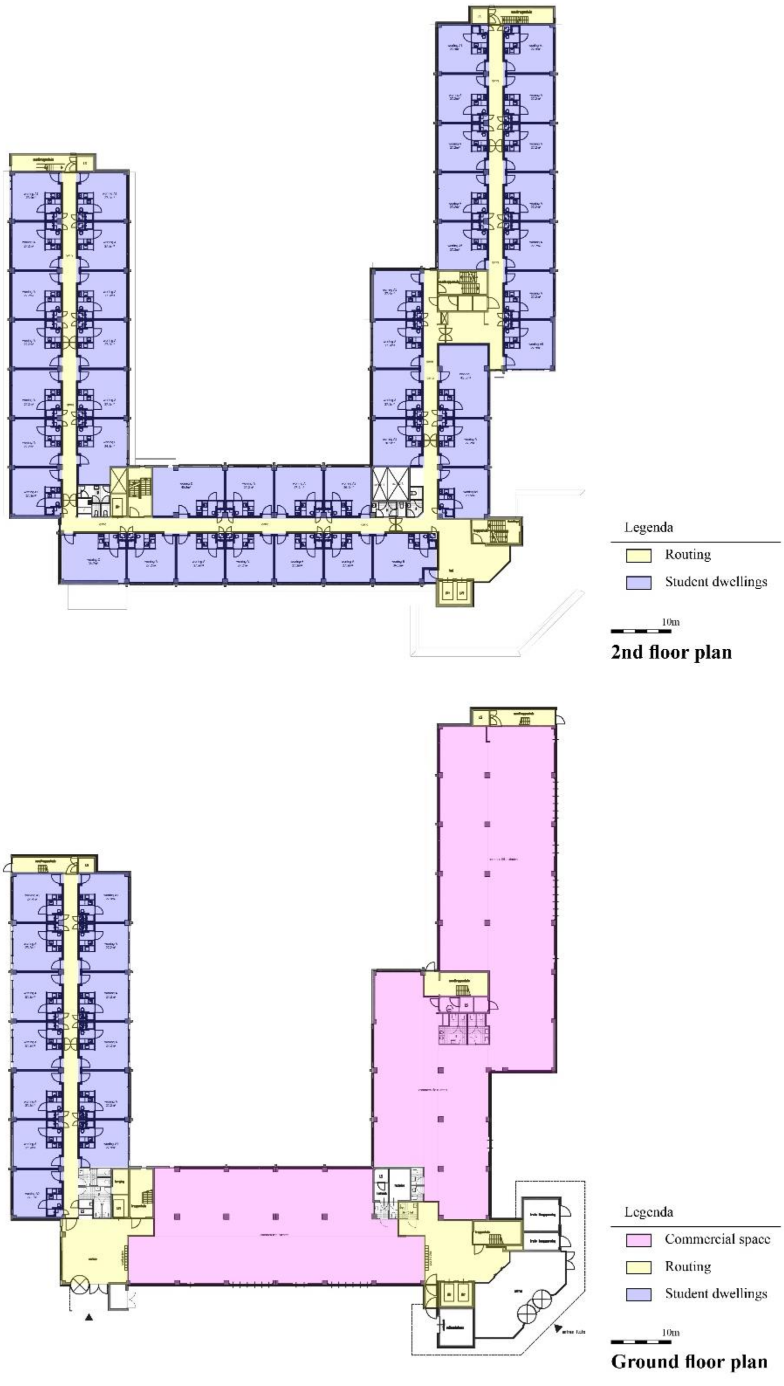
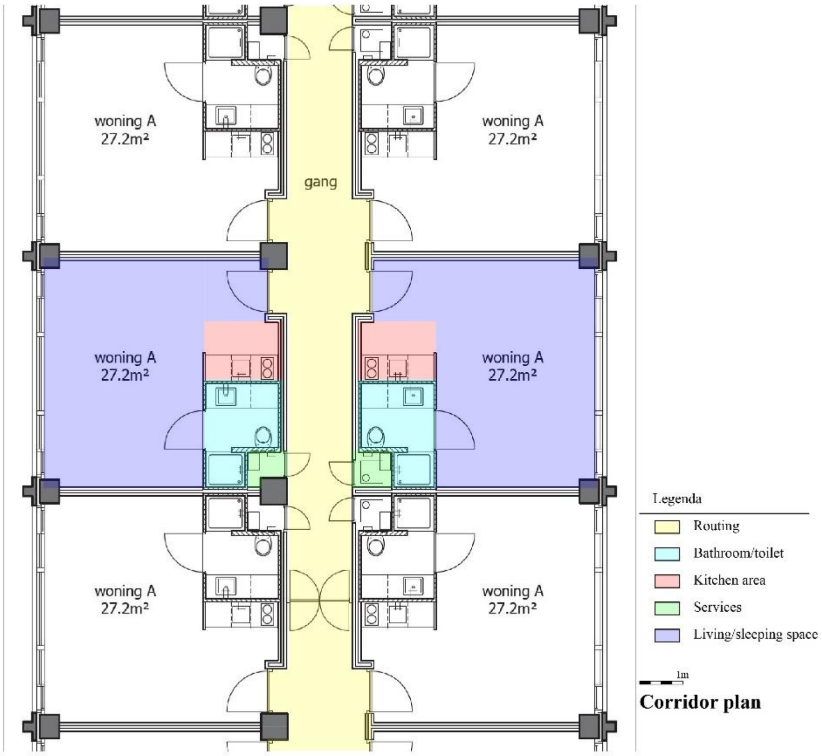


Figure 1. Diemen Zuid case study analysis project building scale floor plans ("Housing the Student," 2018)



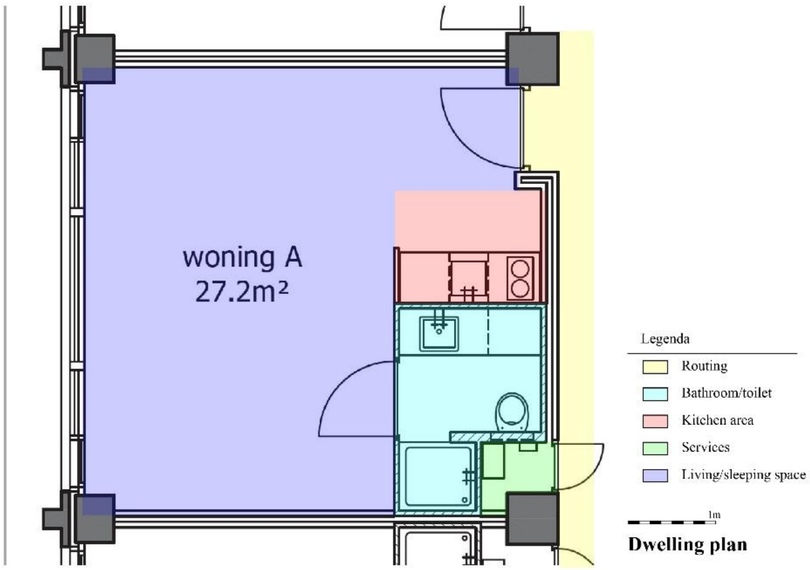
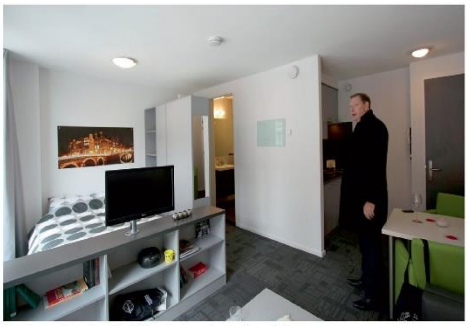


Figure 2. Diemen Zuid case study analysis project plans ("Housing the Student," 2018)

1. Shared outdoor space



2. Interior individual student dwelling

3. Grand Café Berlin

4. Corridor on a floor

5. Fitness centre, looking onto the wine bar

6. Louffe Coffee & campus laundromat

7. Hospitality desk and local police station

8. The Graduates hairdresser

Figure 3. Eight picture of the Diemen Zuid case study project ("Housing the Student," 2018)

Appendix 15 Case study Project: Korvezeestraat, Delft

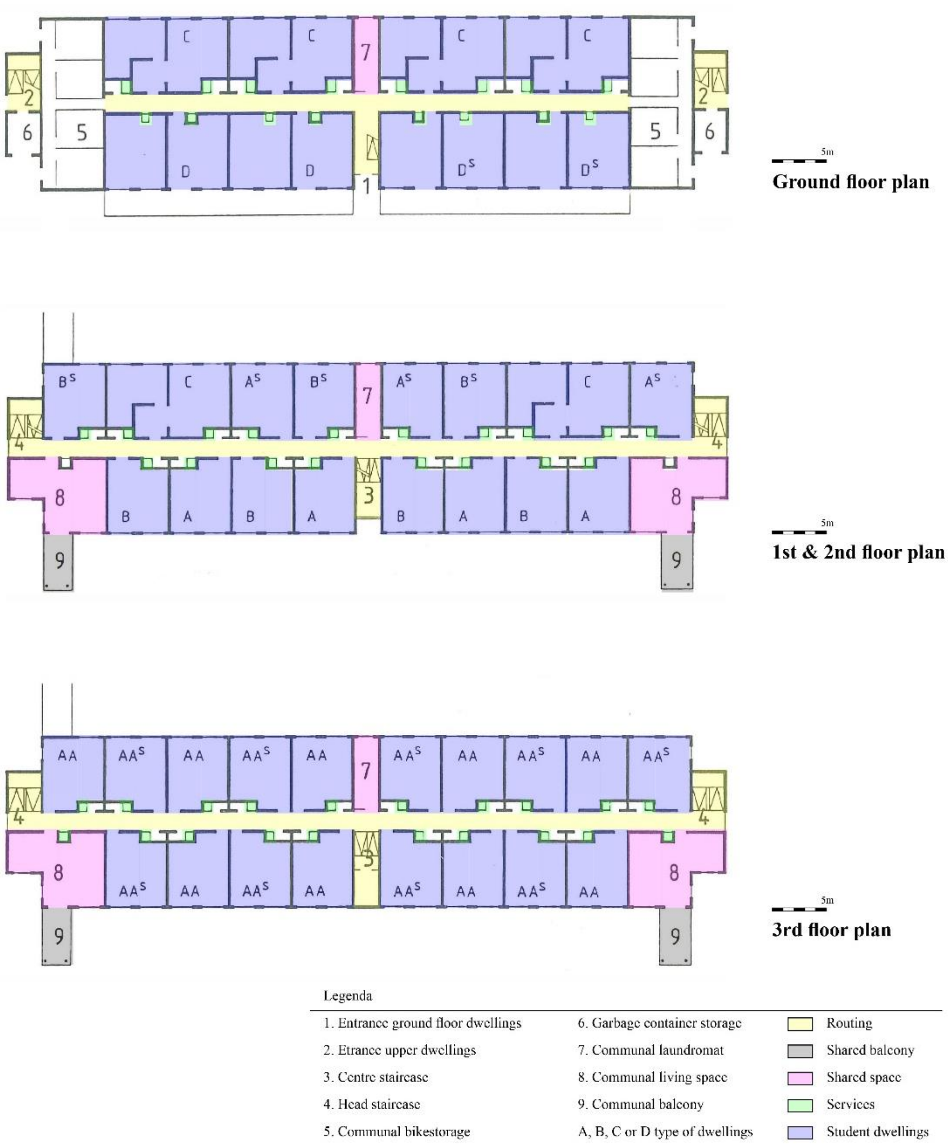


Figure 1. Korvezeestraat case study analysis project building scale floor plans (Stichting Delftse Studenten Huisvesting [SDSH], 1984)

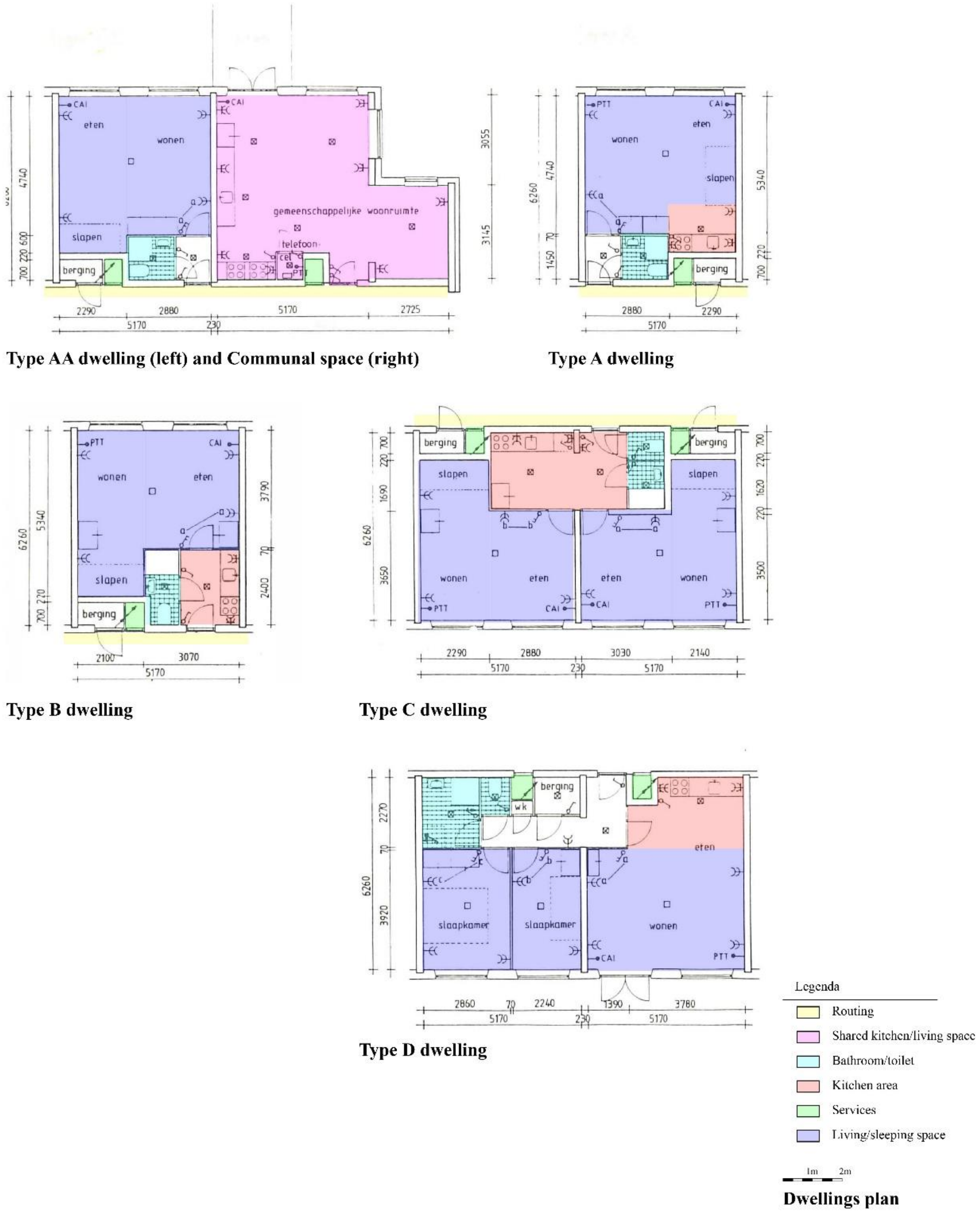


Figure 2. Korvezeestraat case study analysis dwelling plans (Stichting Delftse Studenten Huisvesting [SDSH], 1984)


1. Shared outdoor space


2. Interior individual student dwelling C


3. Shared living/kitchen space


4. Interior individual student dwelling AA


5. Shared laundry room

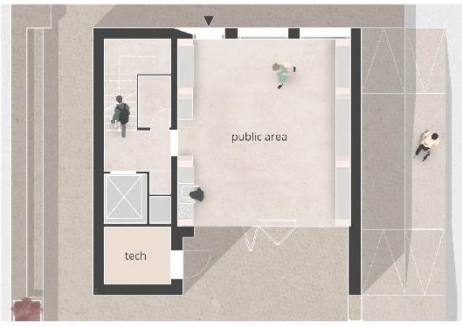

6. Inner corridor


7. Shared outdoor space

Figure 3. Seven picture of the Korvezeestraat case study project (Kamernet, 2023)(Korvezeestraat 480-550, n.d.)

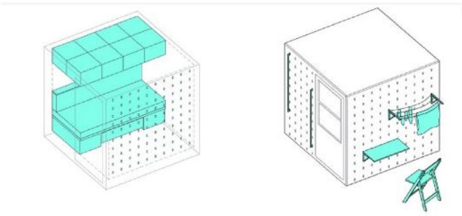
Appendix 16 Case study Project: Local+

Figure 1. Local+ case study analysis project plans, sections and isometric view (Meurers, n.d.)

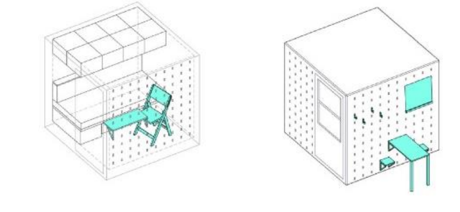


1. Low density house ground floor plan

2. Low density house 1st floor plan



3. Isometric individual sleeping compartment (1/2)

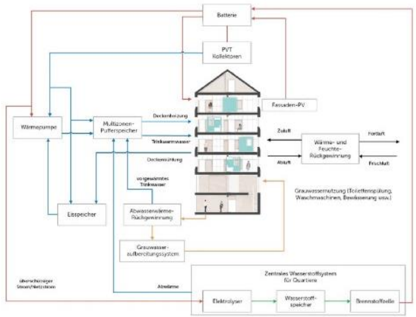


4. Isometric individual sleeping compartment (2/2)

5. Low density house section

6. High density apartment section

7. Individual sleeping compartment full scale model



8. High density apartment climate and energy section

Figure 2. Eight visualisation figures and picture of the Local+ case study project (Voss, n.d.)

Appendix 17 Research by design CiTG

Building: 23, CiTG

A. Individual student dwellings | B. Shared living | C. Maximized shared space

1. Building scale

Pro's:
+ Multiple access points

Con's:
- Few service points
- Long dark corridors
- Wide building form

2. House scale

Pro's:
+ Dimensions of structure
+ Multiple access points

Con's:
- Long dark corridors
- Wide building form
- Few service points

3. Dwelling scale

Pro's:
+ Openable windows

Con's:
- No services nearby
- Too big dwelling size
- Daylight inside building

Legenda

- Routing
- Individual kitchen
- Shared space
- Services
- Student dwellings
- Bathroom

Figure 1. The three student housing typologies applied by design and analysed over the CiTG building (by Author)

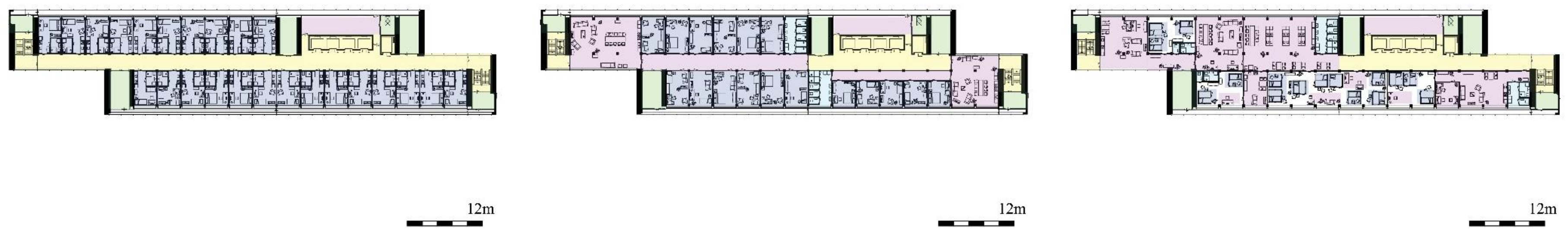
Appendix 18 Research by design EWI

Building: 36; EWI	A. Individual student dwellings	B. Shared living	C. Maximized shared space

1. Building scale

Pro's:
+ Slender building typology
+ Multiple access points
+ Multiple service points

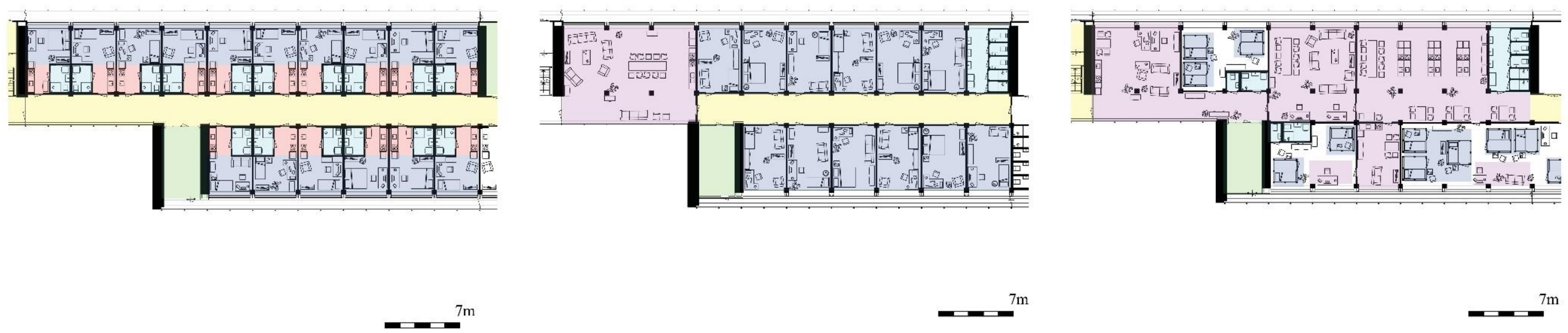
Con's:
- Long dark corridors
- Dependency on lifts



2. House scale

Pro's:
+ Dimensions of structure
+ Multiple service points

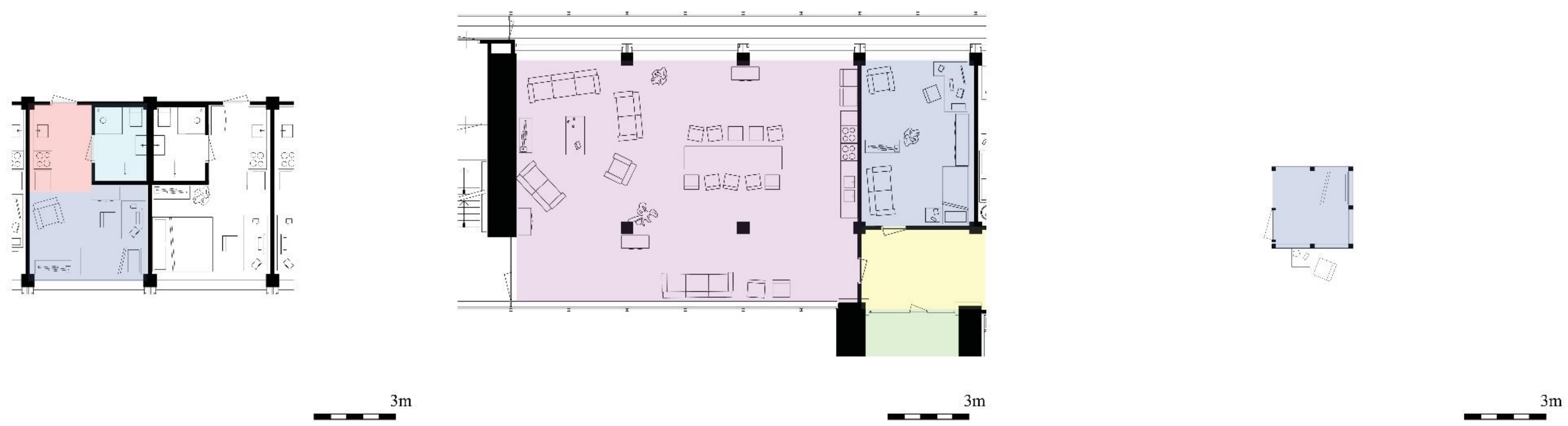
Con's:
- Services far away from dwellings
- Long dark corridors



3. Dwelling scale

Pro's:
+ Dwelling size

Con's:
- No services nearby
- No openable windows



Legenda

- Routing
- Individual kitchen
- Shared space
- Services
- Student dwellings
- Bathroom

Figure 1. The three student housing typologies applied by design and analysed over the EWI building (by Author)

Appendix 19 Research by design TNW

Building: 22; TNW

A. Individual student dwellings | B. Shared living | C. Maximized shared space

1. Building scale

Pro's:
+ Slender building typology
+ Corridor/wing layout
+ Multiple access points

Con's:
- Long dark corridors
- No room for outdoor space

2. House scale

Pro's:
+ Multiple access points
+ Services at each dwelling
+ Dimensions of structure

Con's:
- Long dark corridors

3. Dwelling scale

Pro's:
+ Services nearby
+ Openable windows
+ Dwelling size

Con's:

Legenda

- Routing
- Individual kitchen
- Shared space
- Services
- Student dwellings
- Bathroom

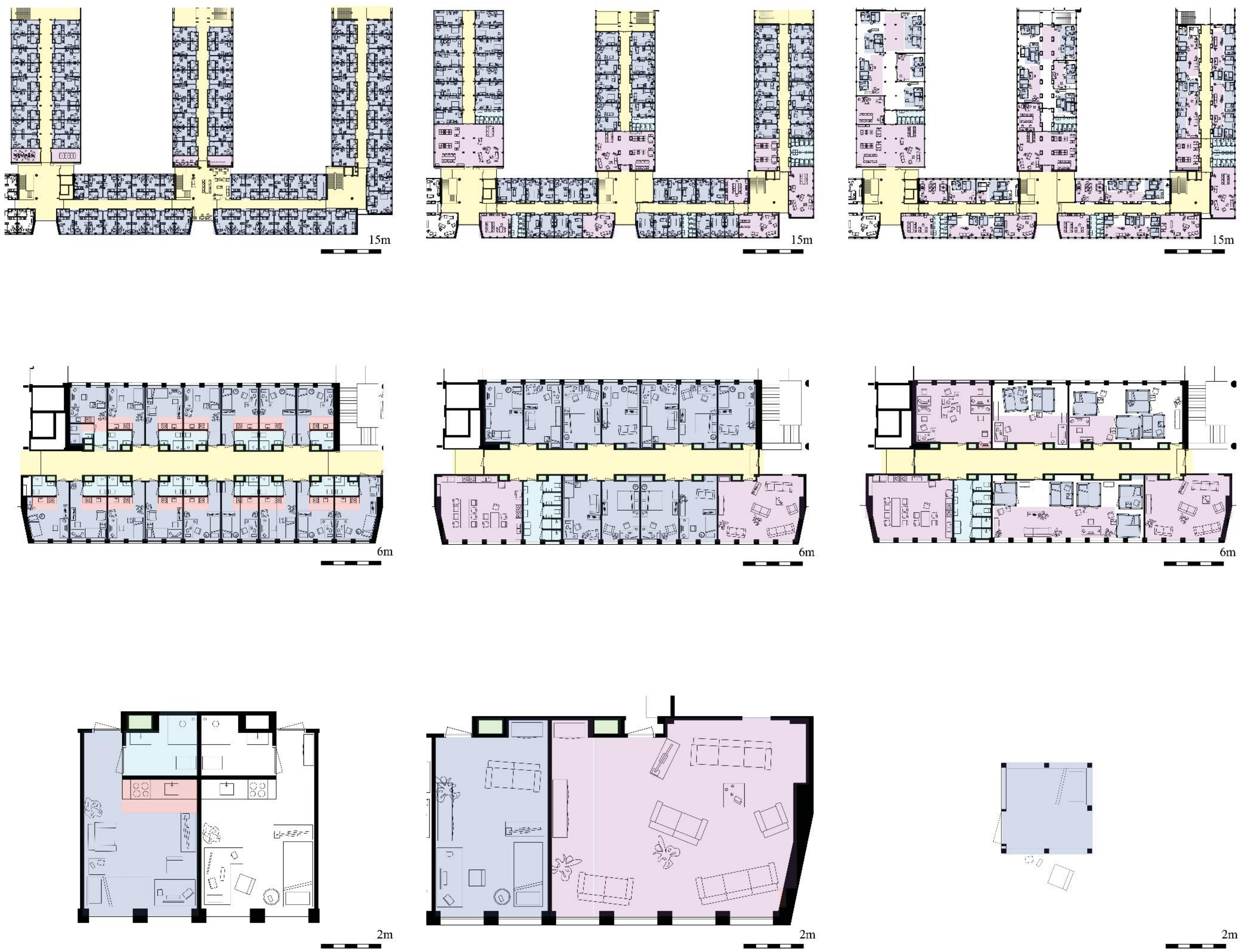


Figure 1. The three student housing typologies applied by design and analysed over the TNW building (by Author)