Future function building

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Abstract

The intended lifespan of buildings in general is longer than the specific function wherefore it is designed in the first place. This means that the building should accommodate multiple functions in time to make advantage of this durability. However, frequently a building is not able to adapt to changed requirements or function, with vacancy as result. To prepare the building stock for the future, measures regarding changing requirements and function change should already be taken into account during the design process. It is relevant to obtain insight in these different requirements, and to come up with ways to combine these. This paper will focus on two functions, residential and office, which should be made compatible in one existing building. Several layers and elements are distinguished which compose a building, and associated requirements are mapped. Residential and office are compatible on certain aspects, but not on every layer and element. The layers with a shorter lifespan expectancy are usually not compatible. The treated design approaches and strategies can be used supportively during the design process of multi-purpose building reuse.

Keywords*: Durability, existing stock, multiple functions, requirements, compatibility*

1. Introduction

Durability of buildings, the capacity to provide functional usable space for a certain time, as a concept of sustainable architecture forms the starting point for this research. As part of this main approach, the future function strategy should be introduced. This strategy contains an existing building which will be redesigned in a way that it can serve multiple functions in time, with minimal interventions needed to accomplish a function change. Hereby it is important to not confuse this approach with a mixed use building. The future function strategy intent to be independent from a location to be widely usable. However, in the end the location will demand the desirable functions.
In this paper, the choice of the selected functions is determined by the particular case of the marine terrain, where various buildings need a new function after the marine establishment has left in 2018. Specific for the marine terrain, residential and commercial space are the two types which the building minimally should be able to accommodate. Designing a building applicable for multiple functions means that it should be able to meet the requirements of these different functions. To discover what the consequences for a building are by designing this way, the following research question will be examined:

'Which functional requirements regarding dwellings and offices can be combined, by using different strategies and approaches, for multi purpose building reuse?'

To be able to define the impact of different influences on a building, it is eligible to dissect the building into multifarious layers and elements. By doing so, the influences can be categorized more precisely. (1) *Which building layers and elements can be distinguished? And what is the average lifespan of these layers, regarding the two functions?* The outcome can be used as framework to which the requirements can be related. (2) *What are the requirements and preferences for dwellings and offices, concerning the different building layers and elements?* These requirements and preferences together form the conditions for the design strategies and approaches. (3) *Which strategies and approaches are possible to combine the resultant requirements and preferences?* The findings can be used as input during the design process.

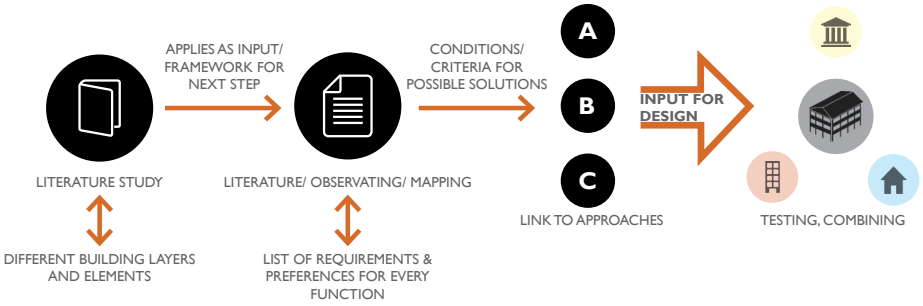

Figure 1. Methodology

2. Building composition

"Our basic argument is that there isn't any such thing as a building. A building is properly conceived in several layers of longevity of built components"

This quote by Frank Duffy (1990) explains the essence of the *shearing layers* concept, originally invented by Duffy. He focused his work mainly on the future of the office and flexible use of space. He states that a building should not be seen as a single object, but as a composition of different layers, containing elements, all with different consequences and lifespan expectations. Within this concept, the layers shell, services, scenery and set can be distinguished. Whereby the layer shell is explained as a permanent layer, while services, scenery and set are more exposed to change. It was Brand (1994) who elaborated further on this concept, resulting in the shearing layer concept which is widely known nowadays. New layers are introduced, and existing layers are separated, resulting in the six S's:

- Site; The geographical setting. Eternal layer, can't be changed.
- Structure; Consist of the foundation and load bearing structure. Longest possible lifespan up to three hundred years. Changing this layer is radical and expensive.
- Skin; Exterior surface which separates the inside from the outside, including roofing. Due to development of fashion and technology is the expected lifespan of this layer twenty to thirty years.
- Services; This layer includes wiring, plumbing fixtures, piping and HVAC. This layer needs frequent maintenance and the installations have an average lifespan of seven to fifteen years.
- Space plan; The interior layout; walls, floors, ceilings and doors. The lifespan strongly depends on the function. At offices the space plan will change more often, one to five years. Dwellings on the other hand will change less often, around thirty years.
- Stuff; All furniture and detached objects.

Due to development in the building sector, Leupen (2002) defined accessibility as an extra building layer to measure up to contemporary times. Originally, accessibility was an part of the layer space plan. Though the elements within this layer have a more permanent character, what justifies the disconnection of this layer.

- Accessibility; vertical transportation, lifts, emergency staircases, corridors and galleries. Ensures the accessibility of spaces. Longevity of the vertical elements will correspond to the structure. The lifespan of corridors and galleries on the other hand is depending on the type.

Not all layers are relevant regarding the requirements and preferences of functions on technical aspects of a building. The layers site and stuff can generally be left out of consideration. The site is an eternal layer which does not demand technical abilities of a building, although the composition of the soil determines the foundation and length of piles. Stuff has no direct relation with technical aspects of a building, but can affect the size of rooms by a particular way of furnishing. Because within the future function strategy the use of an existing building is essential, the existing structure will be preserved and used as starting point for the redesign. This does not mean that the preferred, to implement functions, have none requirements regarding the structure. The type of structure and maximum permissible forces which the functions require has to match with the existing structure of a chosen building. This will become clear after these requirements and preferences are mapped, where after a building can be linked. The remaining layers skin, services, space plan and accessibility will be further processed, and serve as framework to which the requirements and preferences of dwellings and offices will be linked. (fig.3)

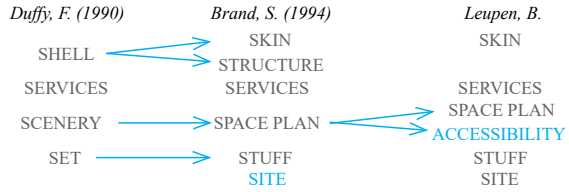

Figure 2. Evolution of building layers

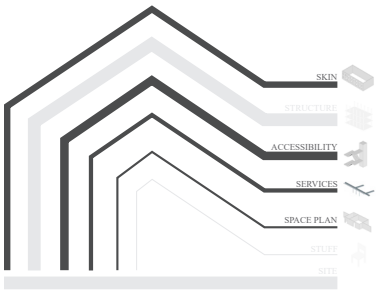

Figure 3. Treated layers

2.1. Layer lifespan

As mentioned before, Brand already linked every building layer roughly to a longevity expectancy, whereby the layer structure has significantly the longest lifespan up to three hundred years. However, this number strongly depends on the state of the construction and the load bearing capacities. In figure four is visible how the different lifespans of the layers relate to each other. These indications can be applied to buildings in general. Moreover, the lifespans can differ by function, which can lead to an alternative approach. Brand already mentioned that the longevity of the layer space plan varies at office spaces and dwellings. Due to development in way of working and changing trends, the space plan of office buildings alters rapidly, within one to five years. Residential space on the other hand, intent to keep the same layout for approximately twenty years to thirty, corresponding with the average length of residence. Also the layers services and skin of office buildings have an shorter lifespan compared with residential buildings. Because of a high use intensity of installations, these need to be replaced in an earlier stage. Regards the skin, office buildings have to keep up with the contemporary trends, because the skin determines the appearance of the building which represent the user.

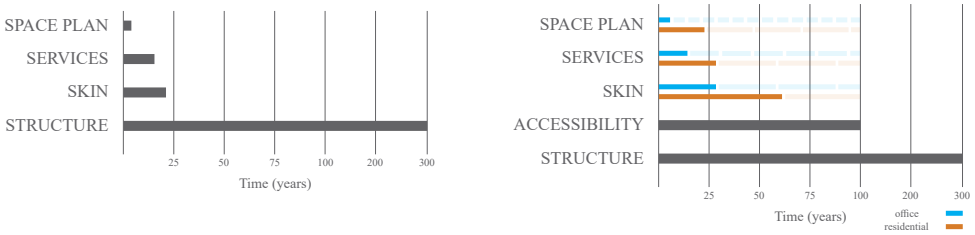

Figure 4. Longevity by brand (1990) and by layer according to Leupen (2002)

2.2. Disconnected layers

As visible in figure five, the expected lifespan of the layers diverge from each other. Layers as space plan, services and skin will need to be replaced or adjust in an earlier stage and with a higher regularity. In general, building layers with the longest intended lifespan have the largest impact on the functional use of the building, because they cannot be replace easily. From this perspective, the layers with a shorter lifespan are submissive to the long lifespan layers in the hierarchy of a building. Regarding existing stock, the structure is an important layer whereby the intent is to minimally preserve this layer. By doing so, the structure automatically functions as starting point and framework for the re-purpose assignment. Treating the structure as framework, provides opportunities for the remaining layers, and ensures a certain freedom of design for these layers. Designing in a way that the layers with a shorter lifespan are separated as much as possible from the longer lifespan layers, simplifies replacements and changes within the layers. Although integration of layers can save space and height, it makes it almost impossible to change one layer without affecting another. An important requirement for the building layer which functions as framework, is over dimension. As well in size and height as in structural abilities. A disconnected layer is successfully accomplished when it does not perform tasks which belong to another layer. (Leupen,2002)

3. Requirements regarding the layers

The resulting building layers, as shown in figure three, function in this chapter as framework to which the requirements and preferences for each function relate on. This to find out if these can be combined in a building, and to get insight in which combinations need interventions. The requirements visible in the figures are originative from the Dutch legislations and NEN.

3.1. Space plan

The space plan determines the layout of the building. From a large to small scale. The size of an apartment or studio is influenced by the available amount of natural daylight. For an apartment with daylight from one side, the maximum depth is circa eight meters. To create a double room apartment orientated to one façade, the width will be around seven meters, and for a three room apartment minimal nine meters. With a double façade orientation, the maximum depth will be sixteen meters. The existing structure and building measurements in combination with the access type (see building layer accessibility) determines the most suitable dwelling type. (Sprengers, 2015) The grid size within the build environment in general is a multiple of 300mm, whereby the optimal grid size for an apartment is between 6,6 and 8,4 meters. (Stichting VACpunt wonen, 2010)

The space plan of offices has changed radically the last century. From cells office (1) in the fifties to cocoon office (2) in the seventies. Contemporary types are the open plan office (3) and flexible office (4). Often an combination of an open flexible work environment and private cells is used to provide flexibility as well as privacy. Within these types, the layout depends on the depth of the floor plan. With a deep floor plan, innovative office types can be fit in easily. The depth can be expressed as window-to-window, window-to-atrium or window-to-core. An research, done by the Moscow Research Forum (2013), states that the maximum distances from window-to-window is twenty meters, window-to-atrium twelve meters and window-to-core ten meters. The minimum depth of an window-to-window office is set on 12,6 meters, wherein every office type should be feasible. The grid size of an office is in general a multiple of 1,8 meters, whereby 5,4; 7,2 and 9,0 meters are common grid sizes. (Sprengers, 2015)

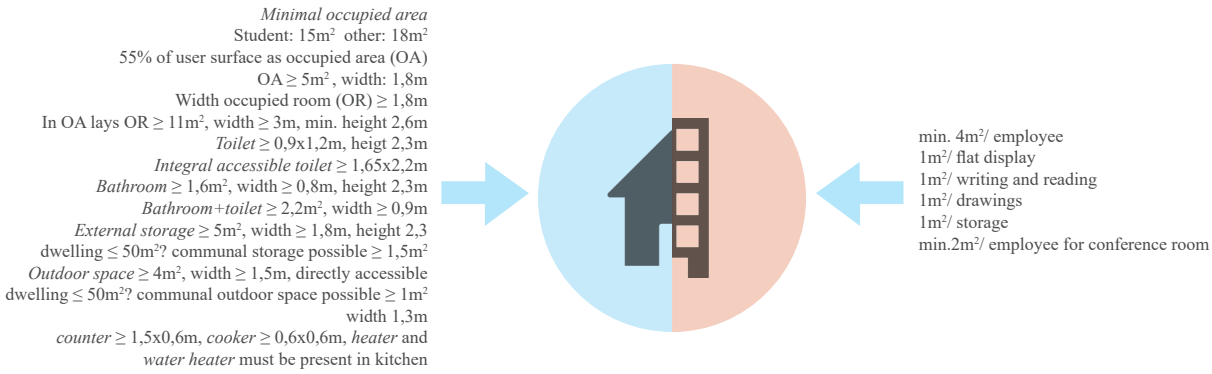

Figure 5. Regulations space plan

3.2. Services

Services contains the serving installations and equipment. In general, three themes can be distinguished. First of all the indoor climate by heating, ventilation and cooling (HVAC). Depending on the type of system, this includes all the pipes and ducts necessary. Offices usually have a collective climate system, from which the whole space is controlled. This is in contradiction with residential use, whereat the system is individualized on a single dwelling level. Especially the extraction of air is more bounded to fixed places, regarding the toilet, bathroom and kitchen.

The second topic is water management. The supply and drainage of water. Offices generally have a low density of toilets, which are positioned centralized at one particular place, and do not accommodate shower facilities. Remaining areas where water is necessary are the pantry or canteen. Dwellings on the other hand, have a high density of toilets and requires facilities for personal care (shower, bath) and washing (washing machine). This also involves a higher water supply and provision for indoor drainage.

The third and last topic is energy. Offices have a strict lightning plan, whereby the capacity of a light source must meet certain values for workplaces. It is also important to have enough outlets for all devices, although there are no prescribed rules for this. Dwellings need in general more outlets, due to kitchen equipment and multimedia devices and the lightning differs strongly from an office variant. (Voordt, 2007)

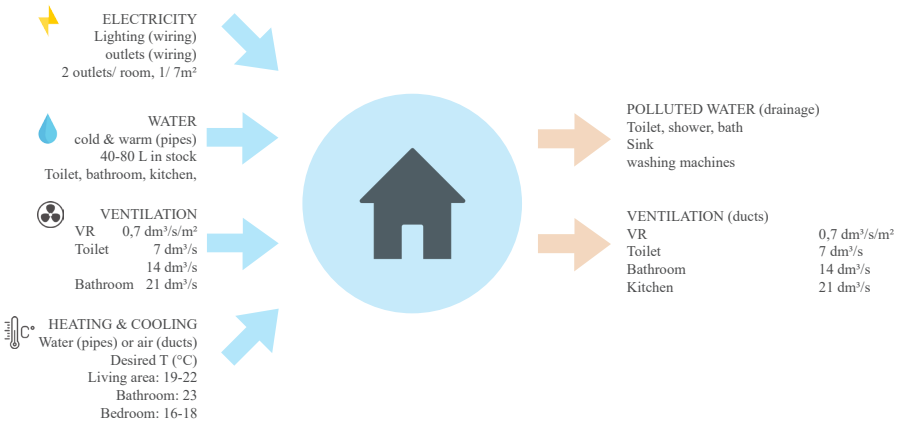

Figure 6. Regulations services housing

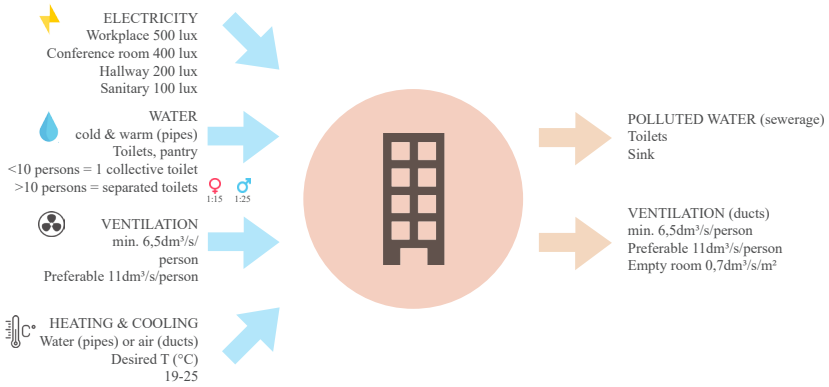

Figure 7. Regulations services office

3.3. Skin

The skin forms the barrier between in- and outside. Both horizontal and vertical surfaces. The skin has to meet a number of performance requirements regarding the Dutch building legislation. The skin can be divided into closed parts, transparent parts, open-able parts and the roof. In figure eight is visible which requirements apply to both functions and which to a specific function. Although open-able windows in office buildings are not required, several studies have shown that it is preferred by building occupants. Due to personal preferences concerning the indoor climate, being able to control this climate, results in a higher satisfaction regarding the work environment. (Rohles, 2007) Regarding offices, direct sunlight into the building should be avoided. It has a negative impact during working with a computer, by impaired visibility.

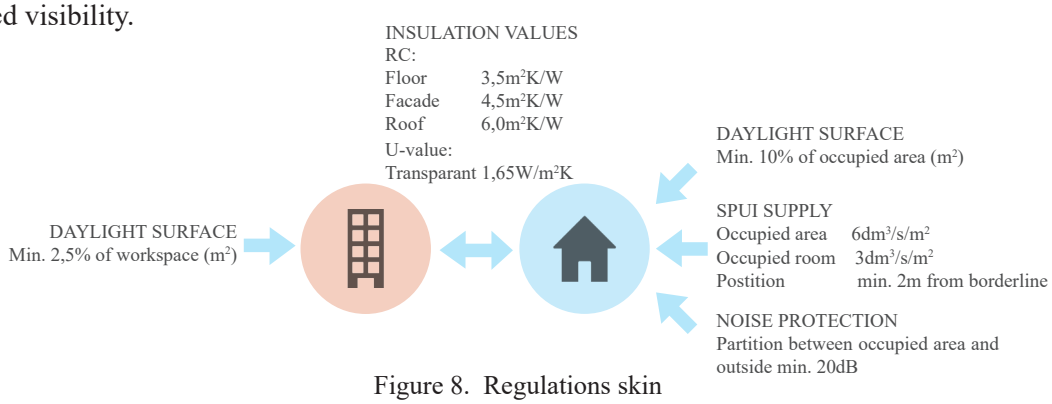

Figure 8. Regulations skin

3.4. Accessibility

This layer ensures a safe access to all rooms and floors. Within this layer, the horizontal and vertical transportation can be distinguished, with corresponding fire safety requirements. Beginning with the horizontal transportation. In general, four types can be defined; (1) gallery, (2) corridor, (3) porch and (4) central access. Depending on the dwelling and office type in combination with the existing structure, the most appropriate type should be chosen. In the next chapter, different space plan types will be linked to the most suitable and favourable access type. The vertical transportation consists of stairs and elevators. The position of these are closely related to the access type. Figures nine and ten show all the requirements regarding horizontal and vertical transportation, as well as the fire safety regulations.

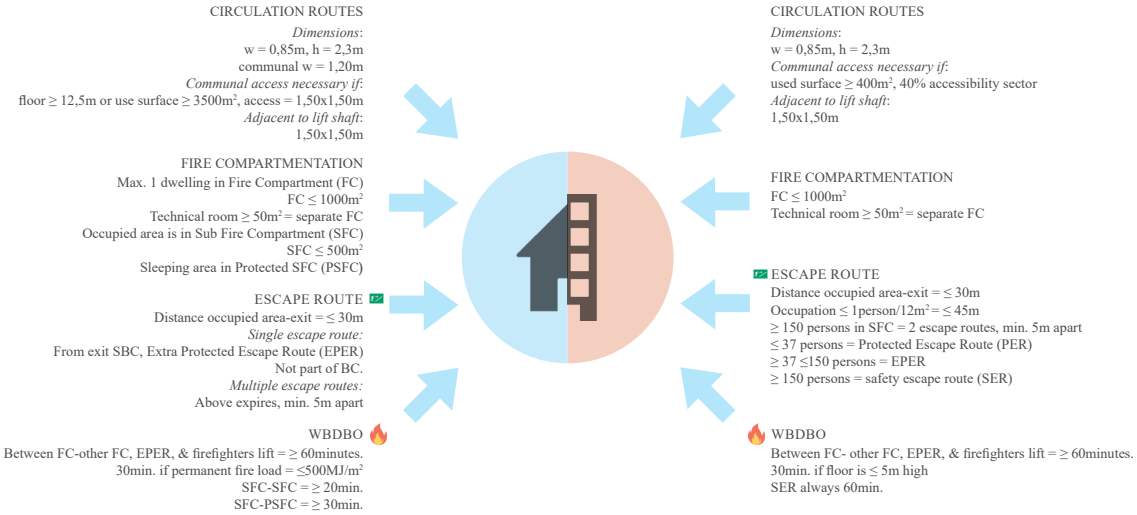

Figure 9. Regulations horizontal transportation

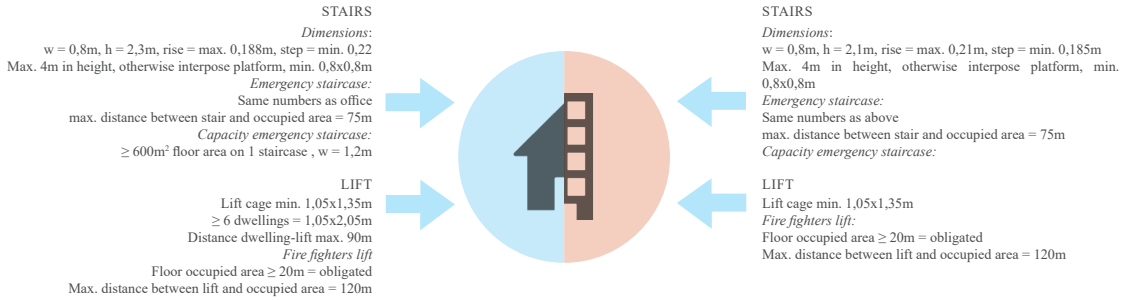

Figure 10. Regulations vertical transportation

3.5. Structure

Although it is within the future function strategy not the intention to make major adjustments to the existing structure, the structure has to meet certain conditions to be considered as usable for an transformation. Three important factors for an usable structure are: independence, excess in load capacity and excess in space provided by the construction. The more the structure is independent from other building layers, the better it can provide disconnected layers. In figure eleven, the regulations regarding the structure are visible. (Sprengers, 2015)

Figure 11. Regulations load bearing structure

3.6. Compatibility scheme

In the scheme below, for every layer, important and defining requirements and characteristics of both functions are compared to each other, and checked if those are compatible. In the next chapter, several requirements from different layers will be linked to each other.

	SPACE	SERVICES	SKIN	ACCESSIBILITY
OFFICE	*Building size* 20m, min.12,6m window to window 20m 12m, 12m window to atrium 12m total *24-30m* 10m, 10m window to core 10m total *20-30m* *Interior lay* Required space based on m^2 per person. Presence of certain rooms not required. cells office cocoon office flexible office open plan office *Lifespan* 1-5 years for interior	*HVAC* - collective or centralized system - mechanical ventilation system - temperature control by convection - space dependent extraction *Water management* - low sanitary density, clustered - minimal shower facilities - low capacity indoor sewerage and hot water supply regularly distributed lighting plan outlets based on workspaces 15-20 years	*Transparent part* 2,5% of occupied area transparent in facade *Sun shading* To avoid direct sunlight in the building, a sort a sun-shading system is preferable *Lifespan* 30 years. Keeping up with contemporary trends. Facade needs to be representable for a variety of companies.	gallery corridor central porch
RESIDENTIAL	max. 8m min. 9m one side oriented max. 16m 6,6m two side oriented *Interior lay* List of required spaces: toilet, bathroom, bedroom, kitchen, external storage and outdoor space. *Lifespan* 20-35 years for interior	*HVAC* - individual or decentralized system - natural ventilation system - temperature control by radiation *Water managment* - high sanitary density, diffuse - shower and bath facilities - high capacity indoor sewerage and hot water supply *Energy* specific distributed lighting plan outlets needed in every room 20-30 years	*Transparent part* 10% of occupied area transparent in facade *Open-able parts* Open-able parts are required to enable spui supply Up to 60 years. Depending on location and street-view	gallery corridor central porch
COMPATIBILITY	YES Two combinations possible: (1) window-to-window *two side oriented* (2) window-to-atrium window-to-core *one side oriented* NO Interior walls are not compatible to both functions and need to be easily adjustable, especially by an office, due to frequent changes in layout. The need of outdoor space for dwellings can affect the floor plan radically.	NO *HVAC* Same medium for temperature control and ventilation system can lead to common use of certain parts. Ducts and pipes will have to be moved , added or replaced. *Water management* Pipes and sewerage will have to be repositioned and added. *Energy* Wires need to be replaced for shifting lighting points and outlets.	YES/NO A more transparent facade has an positive effect on the energy consumption of light, although direct sunlight is not favourable for offices. Open-able windows are also preferable for offices. Appearance of the facade has to represent both functions, has to be neutral. Characteristics can link to location.	YES Two accessibility types suitable for both functions: (1) corridor (2) core

4. Design approaches

As result from the compatibility scheme, described in the previous chapter, a few complications in divergent layers occur. As expected, on several topics the requirements of dwellings and offices are not completely compatible. However, the challenge hereby is to come up with design approaches which ensure that the conversion from one function to another appears with minimal effort, and that the building provides an framework which is suitable for both functions.

Several types of offices and dwellings are compatible in one building. These combinations demand certain measurements. The first combination, window-to-window office and two sided oriented dwelling, determine a minimal depth of 12,6 meters and an maximum depth of 16 meters. Closely related to the floor plan, is the accessibility. To establish dwellings from window to window, a gallery is basically the only providable access type which is able to accommodate this type. However, a gallery access does not fit any office type. An solution could be to position the vertical transportation on the side of the building, and construct the gallery out of a demountable system, which could be easily placed and destructed after a function change occurs. The second combination, window-to-core/ atrium with one side oriented dwellings, can be combined with the access types core and corridor. Hereby the depth of the building can be more then 16 meters, depending on the depth of the core or atrium.

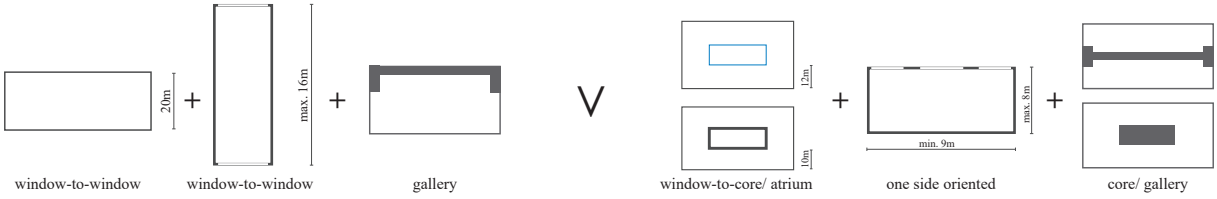

Figure 12. Possible combinations

Within these main boundaries, the interior lay-out must be constructed. Due to the short longevity characteristic, especially by offices, it is desirable to have an customizable system, which can also be reused after a function change occurs. In general, three approaches can be used for the design of the layout, (1) infill-able, (2) changeable and (3) multivalent. The first approach, infill-able, is an useful strategy for offices, due to the freedom in positioning interior walls, within a certain grid. However, this system requires an column structure to provide an open floor plan. The changeable approach focuses more on the flexibility of the grid. The grid can be changed in time, which is preferable during a function change. The third approach, multivalent, can be seen as a combination of the two previous mentioned strategies. It encompasses a room which is completely flexible dividable, both the layout and grid. Hereby it is conventional to use a demountable wall system, which consists of dry compounds, so it can easily be disassembled and moved or replaced. (ANA, 2014)

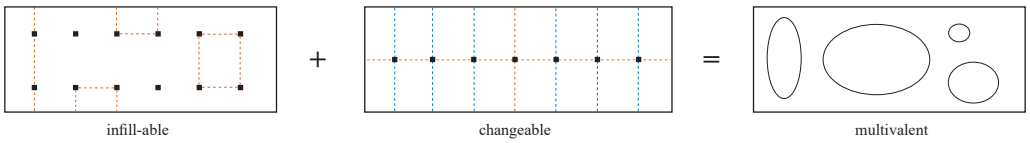

Figure 13. Layout approaches

Regarding the building services, after a function change, pipes, ducts and wires will need to be repositioned and added or removed. Important hereby is also the vertical transportation through shafts. From an office, which is more centralized, to an dwelling, which is more localized. The amount of shafts and position is closely related to the chosen vertical access type. With a core type, it is plausible to use a central shaft. Multiple de-central shafts on the other hand, ensure a shorter distance to installation equipment, with as result that the size of pipes and ducts can be reduced. With both options, it is essential to include enough excess in the design. For the horizontal adjustments, attainability is an important factor. As mentioned in chapter one, detaching this layer will reduce necessary adjustments to other layers.

There are multiple options to keep the installations reachable, which are closely related to the finishing of a room. A computer floor provides maximum accessibility to the installations due to the removable panels. Installation equipment can be moved and added in two directions. A condition is that the finish layer of the floor is executed in a removable tile variant. For office this could be implementable, however for dwellings an other finish floor is usually preferable. A derivative form of the computer floor, is the zone variant. The removable panels are only used in certain zones, as circulation areas. With this system, the desirable finish floor can be chosen. Nonetheless, there must be taken into account that the independence of shifting the equipment is limited to the zones, which therefore should be positioned on strategic places. A different approach is the lowered ceiling. Concerning the accessibility, basically the same principals apply to this approach. Dwellings prefer in general a stuccoed ceiling instead of panels. (Sprengers, 2015)

Figure 14. Left; approaches with panel finish. Right; approaches with desirable finish

The division of transparent and closed parts within the facade can be made compatible for both functions. Also the requirements of performance are broadly the same. The division of the open and closed parts depends on the constructive role. If the facade is part of the load bearing structure, it should be able to transfer certain forces. If the facade only has to carry it's own weight, more flexible systems can be introduced. Prefab systems with demountable elements become hereby an possibility. Thus the consideration whether the facade is constructed for both functions or for each one in particular is decisive. A facade representable for both functions should contain a certain value of neutrality, whereby more value can be accomplished by relating to the surroundings and environment. The necessity of outdoor space can have major consequences for the facade and the placement of the thermal layer. Parts of the facade should be made open-able and niches should be created. Another option would be to place prefab balconies against the facade. However, mounting possibilities and extra load bearing capacity should be taken into account.

5. Conclusion

The conclusion is an answer to the following main question, formulated in the introduction:

'Which functional requirements regarding dwellings and offices can be combined, by using different strategies and approaches, for multi purpose building reuse?'

In general for every layer there are elements which are compatible and elements which not. These elements are not only related to other elements within a building layer, but also to elements from other layers. These elements from multiple layers influence each other and determine which combinations become possibilities. Also the existing building will determine heavily which combinations can be implemented in the existing structure and which not. This has to do with the load bearing structure type and the size and measurements of the building. Essential for the realization of an multi purpose building for dwellings and offices is a feasible combination of types from these two functions. (1) Two combinations can be made from which, depending on the existing building and structure, a choice can be made. (2) Also the accessibility is compatible. Not only between the different functions, but also in relation to the building layer space plan. (3) Depending on certain factors, the facade can also be made compatible. These three components have in common that the average lifespan is, in perspective to the remaining layers, longer. Concerning the (4) interior layout and (5) building services, changes and adjustments are unavoidable. The aim hereby is to decouple these layers as much as possible from other layers to minimize the affect on these. During the design process, the different possible combinations and approaches can be used as input and guiding principals, depending on which fits the best to the existing building.

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