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Flexibility, how to accommodate unknown future housing requirements

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Abstract

During the past centuries, human behavior in Europe was largely based on traditions; changes took place in a slow rate. Lifestyle and – consequently – requirements to housing conditions were changing in the same pace. Nowadays, societal development is accelerating; again and again new technical and relational challenges have an effect on housing requirements. It can be said that new technical developments and – in consequence – tenants' requirements are changing faster than the more enduring state of the existing housing stock in The Netherlands.

By now, at the beginning of the 21st century, though many buildings are technically in rather good condition, they do not match nowadays standard of living. Tenants make higher demands on a dwelling than before; they demand e.g. more square meters of living space. Demographic, socio-cultural, economic and other changes produce the effect that dwellings no longer meet the requirements. However, decisions to demolish buildings for others reasons than a lack of technical quality, are economically and with respect to sustainability, unprofitable. It is plausible that in the next years, new dwellings will be build with a limited functional lifespan; this seems to be a wasteful solution.

Some residential buildings do have the capacity to meet changing requirements. Many authors have argued that more sustainable residential buildings can be designed by applying specific solutions for problems with respect to adaptability. The term "flexibility" is used to describe several kinds of adaptability. However, different authors define "flexibility" in different ways. Therefore, a theoretical study has been conducted in order to survey various definitions and various kinds of flexibility. Based on a broad range of publications, a theoretical framework has been developed, and according to this framework, new building projects have been evaluated [1]. In the paper, this study is summarized, and, on the basis of some examples, the concept of flexibility and its value with respect to sustainability is discussed.

1 Introduction

In The Netherlands, the “Canal houses” from the “Golden Century” in Amsterdam, and in other towns as well (Leiden, Gouda, e.g.), often are considered as eminent examples of flexible buildings; since centuries, these buildings have proved to be adaptable to a range of changing requirements of users.
How can the history be interpreted? Rich patricians have built the houses, including a kind of office. As, in time, the available space turned out to be insufficient, the buildings were expanded at the back, (the “back house”); gardens were large enough for an extension of several square meters. In the fifties of the 20th century, the buildings – too large for living –proved to be appropriate for other use: prominent offices; the upper class moved out to the country side. Nowadays, offices need more space, as well as extensive technical facilities and traffic attainability; these requirements can be found outside of the city center. Again, the canal houses, frequently divided into apartments, offer space as dwellings. Apparently, these buildings can offer a large range of facilities. A high value, related to – among others - construction, site and architecture justifies rather high renewal or renovation costs. However, some other building characteristics will have facilitated renovation (instead of demolition) too: in one way or another, these buildings, sometimes after renovation, have the capacity to meet changing requirements. This kind of characteristics is called “flexibility”. In recent times, the concept of flexibility in buildings seems to be a promising solution for coping with rapidly changing requirements.
In the light of the problem of coping with rapid changes, the concept of flexibility will be discussed, as well as the objectives to be attained. Then, the ideas from several authors will be summarized and reviewed, examples will be mentioned and an answer will be sought to the question if flexibility can be considered as a solution for the problem of creating a more sustainable housing stock.

2 The concept of flexibility

According to Collins Dictionary, the concept “flexibility” refers to pliancy and adaptability [2]; in case of a “flexible building” (a product) the building will be pliant, and consequently adaptable to different or changing situations. The term “flexible” is also used for the building process; in case of a “flexible (designing and) building process”, the concept refers to a pliant and adaptable process: during development processes (designing, building), stakeholders (future users as well as commissioners) are being enabled to postpone decisions about requirements or design solutions until a late moment in the development process. In this paper, only flexibility of products will be focused on.
The concept can be considered as an answer to changing circumstances. In describing flexibility, the first point of interest is what circumstances are changing. In the context of housing, consumers’ behavior is changing and consequently, requirements for dwellings. Requirements of one single household change over time, and different types of households have different requirements. Priemus, from the point of view of one household, makes a distinction between cyclic and non-cyclic changes, and a distinction between intern (concerning one specific household) and extern (concerning the society influencing several individual households). Intern, cyclic changes, like having a meal, studying, sleeping, can be investigated; within a (slowly changing) society, predictions about behavior can be inferred, as well as the way buildings can meet these changing requirements. Intern, non-cyclic changes are more specific for each household, especially with respect to the specific moment a household will change: with respect to different households, at various moments children are born, grow up and move out . However, apart from the point of time, rather accurate predictions can be made and consequently, buildings can be designed, adaptable to these kinds of changes. According to Priemus, extern, cyclic changes are weekly, or monthly returning changes in behavior, like behavior on Sunday, at Christmas, in summer or winter; these changes are relatively known and buildings can be designed to meet the returning requirements. However, extern, non-cyclic behavioral changes,

among others depending on technical and societal innovations, are rather unpredictable; as a consequence, adaptability of a building is difficult to design beforehand [3]. Extern, non-cyclic changes refer to societal changes. Dekker and Szerkowski, in describing a macro-environment of business companies, mention environmental components influencing marketing conditions: demographic, cultural, economical, natural, technological and political-juridical factors [4] have an impact on the behavior and requirements of a household as well. These changing factors lead to changing requirements to the building [1]. Superficially, based on bad predictability of behavioral changes and change of requirements, it seems realistic that houses will be adaptable for the lifetime of a household, say 30 to 40 years. However, just as the “canal houses”, most buildings last for a much longer period. Evidently, after a period of 30 to 40 years, buildings have residual value that makes refurbishment or renovation, or just longer use, lucrative.
Roughly speaking, the technical performance of the structure has a longer useful lifetime than its functional performance. Brand offers a model, relating changes of a building to its structural composition; six “shearing layers of change” are discerned: site, structure, skin, services, space plan and stuff, each layer relating to a different lifetime; the structure can perform during a period of 200 or 300 years, while the stuff (furniture, kitchen equipment, etcetera), will be out of performance within about 15 years [5][1]. In one way or another, different layers should be replaced after different time periods, demolishment and development of new buildings being too expensive and too labor-intensive to carry out every 15 or 20 years. (The building capacity of the construction industry only allows replacement at a rate of 0,2 % of the housing stock per annum [6]). As Brand argues, different layers loose capacity to meet changing requirements after different periods of time [5]. The shorter the period of time, the lower replacement costs should be, and, in the opposite case, layers that are expensive – like structure and façades (in terms of Brand: skin), should stay for a long time. This means, that characteristic for a flexible building should be the pliancy of its expensive, long term layers (like the structure). A pliant structure allows for adaptation and replacement of short-term parts.
During its lifetime, a building should meet changing requirements; performance of a building that stays unchanged, will diminish year after year, and consequently, the value of the building will decrease[2]. This will continue until the level of performance is no longer acceptable. Renovation or refurbishment– or demolishment and rebuilding – should upgrade the performance level. At the time that renovation decisions are made, the value of the building can be described as the value after renovation (or refurbishment) reduced by the costs of intervention (renovation or refurbishment):

$$V(e) = V(n) - C \qquad (1)$$

V(e) representing the value of the existing building , V(n) the value of the new building after the intervention, and C representing the costs of the intervention [7, p.72]. If the flexibility of the building is at a high level, intervention costs for upgrading will be relatively low, which means that the new value, c.q. performance level will be attained at lower costs than if the building is “inflexible”. However, future flexibility in a new building has its price; the profit is postponed until renovation – after 30 to 40 years, e.g. – takes place. This leads to the question if it is worthwhile to invest in flexibility, only in the light of future savings.

3 Flexibility as defined by some authors

Priemus defines a dwelling as flexible if it has the capacity to remove the discrepancies between living situation and a customer ‘s aspiration image [3][3]. His focus is on the perspective of the user.

[1] Different layers are also related to different responsible stakeholders
[2] Value of a building is influenced by different factors [7]. In this paper, the concept will not be worked out.
[3] “Aspiration image” is really attainable, to be discerned from “ideal image” which is a kind of a dream [3]

Schroeder, in his description of flexibility chooses the point of view of the building: the discrepancy between the functional and technical lifetime. Both authors, however, come to the same solution categories in order to remove discrepancies: the user adapts to the dwelling, the dwelling is adapted to the user, or the user moves out to another dwelling. Schroeder adds the situation that lifetime of the fixtures and fittings equates the functional lifetime [3&8]. Schroeder discerns the capacity of a dwelling to adapt in the sense of “flexibility” (adaptation without changing building structure), and to adapt in the sense of “variability” (adaptation by changing building structure) [8]. Priemus, analogously, makes a difference between “adaptation by kind of use” and “adaptation by renovation”. Schroeder explicitly adds a difference between short term and long term adaptations. The authors have translated these broad concepts into building characteristics like multi-functionality (if the dimensions of a room or the technical equipment allow for different behavior, or activities [3]) and enlargement facilities (if a room or a dwelling can be expanded outside the walls [8]). The concepts will not be worked out, except for one which shows the influence of cultural-political circumstances, even on the conceptual framework. Schroeder describes possibilities to split up a dwelling into two apartments, one of which can be sublet for some time[8]. In The Netherlands tenants have the right not to move out, even if the owner needs the dwelling for his own use or if he wants to sell the house. Therefore, Dutch owners would not be inclined to let part of their house. In the Netherlands, this kind of flexibility is not useful, and not found in literature. It turns out that political circumstances contribute to the content of the concept “flexibility”. Although Schroeder mentions discrepancies between the pace of decreasing functional performance in relation to the structural performance, he focuses on cyclic household changes.

Another framework, from Boerman a.o., focuses on cyclic changes too [9]. These authors distinguish non-structural and structural interventions (with or without the help of professionals), and scale levels of the object being changeable: furnishing of rooms, walls of room, interior lay-out and lay-out of the building[4]. The authors elaborate all possible combinations. The more professional intervention is needed to adapt a dwelling, and the higher the scale level (room, dwelling, residential building), the less pliant (flexible) a dwelling is.

Dittert, in describing flexibility as adaptability of “the system”, discerns functional , expansion and structure flexibility, comparable to the concepts of Priemus and Schroeder. However, Dittert adds the concept of flexibility as diversity in the stock: supply flexibility, variability within the stock of dwellings at a certain moment, in order to meet requirements of various household types[10].

Van Eldonk and Fassbinder, apart from functional (without professional intervention) and spatial flexibility (based on professional intervention), mention “character flexibility”, pointing to possible changes in façade or dwelling identity – aspects of architectural quality[11].

Geraedts, in developing a tool to assess the extent of flexibility of buildings, makes a difference between space flexibility and technological flexibility. According to Geraedts, the rate of technological flexibility (concerning building technology as well as installation technology) defines the boundaries of space flexibility. He takes into account residential as well as real estate buildings. (Companies often are confronted with expansion and shrinking, and required repulsion of parts of a building) [12].

Within the framework of Open Building , scale levels have been related to levels of participation with regard to different stakeholders in building processes. There is a congruency between the level of flexibility and the degree of participation for different stakeholders. At the level of a room in an apartment, tenants have a right to decide about the furniture; at this level, flexibility is high. At the level of the apartment, (future) tenants should be allowed to participate in the process of deciding on the floor plan. The structure should have the capacity to permit different floor plans, but in itself the structure is much less flexible. (This is an example that applies to all plan levels) [13]. In the Open Building theory, flexibility is conditional for participation, and conditional for accommodating unknown future changes [14]. Technically, the system has been worked out to a high level.

[4] This kind of flexibility plays a role in residential buildings, e.g.

Hofland [1], in his study on flexibility aims at sustainability for a long period (200 years); based on the work of Dekker and Szerkowski, he discerns different societal changes (demographic, socio – cultural, economic, political- juridical, natural and technological ones) [4]. On different levels, from dwelling up to building, neighborhood, and so on , societal changes have influence. Participation in decision making follows the same levels, according to the OBOM model 14]. Hofland has worked out implications of the changing environmental state with respect to changing requirements. The requirements are related to different types of flexibility. The result is a list of 13 types of flexibility that could be used as checklist to measure the extent of flexibility of a design. Fig, 1 shows the list [1].

Flexibility:
1. neutral for furnishing
2. possibility for change of floor plan
3. possibility to reshape apartments
4. modernization flexibility
5. Character flexibility (identity)
6. flexibility for changing safety requirements
7. multi functionality
8. finance flexibility
9. wheel chair adaptability
10. capacity for expansion
11. capacity to shrink
12. robustness for calamities
13. parking flexibility

Figure 1: Types of flexibility according to Hofland [1]

From all definitions and models of flexibility, it can be concluded that flexibility is a complex concept of which the problems have not yet been solved. Problems have not been solved in a theoretical sense: different definitions and models all have their value, and they have not been solved in a practical sense: flexibility makes high demands on a building plan, and consequently the investments are considerable. In the next part, two complex examples are presented. The first is a building, under construction now; the design is aimed at flexibility to a high degree. The other example is a design for renovation of an old warehouse.

4 Examples

The new building “Multifunk” is checked on flexibility. The project contains various dwelling types at several price levels, for rentals as well as for owner-occupied properties. In one building block also commercial accommodation is located. A basement, stretched underneath the major part of the complex, provides parking space for cars and bikes. Fig. 2 shows the building.
Multi-functionality is offered in the sense that offices can be changed into apartments, and vice versa . (During the development process, the designed flexibility already proofed to be worthwhile: demand for offices was severely decreasing, so partly a switch was made from offices to apartments). Another aspect of multi-functionality is formed by the access systems: every single floor is accessible separately. So, employees can have access to their offices and residents to their apartments using “free” entrances. All structures and fittings are arranged in a way that they meet the most severe requirements from both residential and commercial purposes. In spite of the technical provisions, however, the possibilities to change the size of the apartments by relocation of floor space are limited. To do so, all involved residents should agree in the first place, and at the same time. In practice, this can hardly be expected to occur.

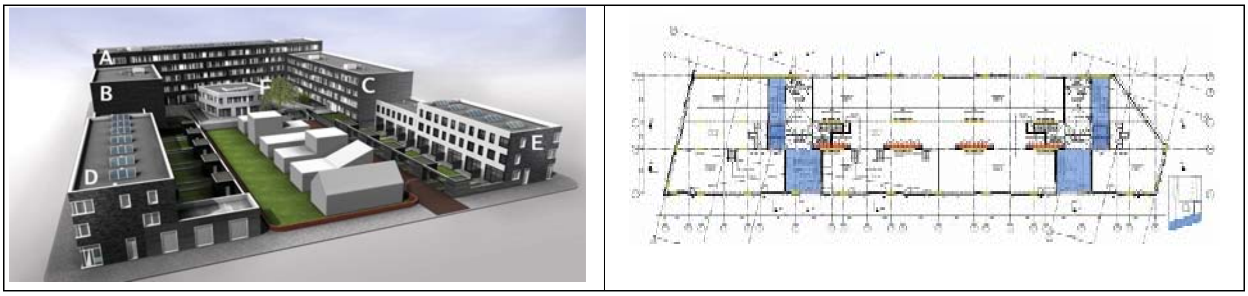

Figure 2: The Multifunk building (floor-plan of part A)

A change of floor plan is possible to some extent; inside walls can be removed, but kitchen equipment is fixed at the moment of completion. With respect to modernization flexibility, pipe and wiring systems are oversized, and after completion yet partly out of use. Different heat sources can be installed. With respect to its capacity for expansion, the extra load bearing capacity of the structure and a staircase provision in the concrete roof structure allow the owner-occupied houses to be expanded with a third floor. Except from financial flexibility, Hofland has checked all 13 types of flexibility in this project. All criteria have been met, at least to some extent. While detailed cost data were not available, it is unknown if the investments will turn out to be profitable in the long run.

The other example is an old canal house from the 17th century; many times, it has been renovated (fig.3). The building consists of two ware houses, the left one being renovated (1890) into a fire station, the right one into a school. Afterwards, both buildings contained a police office (1926-1980). Since 1980, part of the buildings has been renovated, and used as apartments, another part functioned as t.v.-studio. The most recent renovation (10 new owner-occupied apartments in a part of the building) has taken place in 2001.

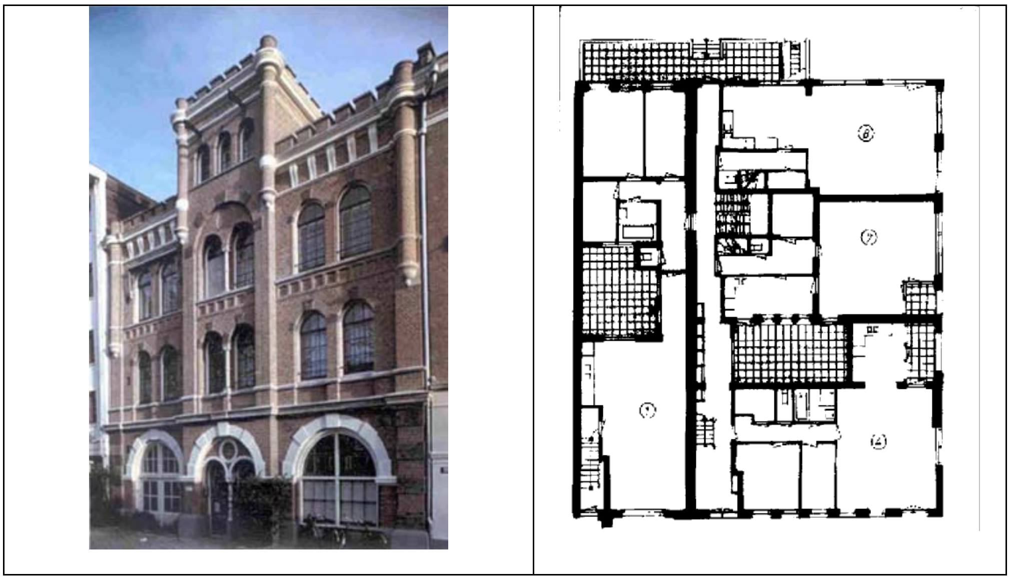

Figure 3: The warehouse (CASA architects)

To meet contemporary requirements during a period of 50 years, far-reaching interventions have been made. For security, foundation has been renewed, further, new staircases have been built, rooms are 4 m in height, acoustic isolation between apartments by “box-in-box-system” has been constructed, and

every apartment has outdoor space. The quality of the building is high, and so are the costs (ƒ 285.000, excl[5]). Apparently, the selling price (ƒ 525,000 – ƒ 950,000) is conform market value. It is plausible, that not every building should be renovated against that price; some characteristics of the building made renovation worthwhile.
Can we confirm that this ware house from the beginning has been a flexible building, as pretended in the introduction? Comparison with a new building at a comparable location would give an answer. At any rate, some characteristics turn out to be worthwhile: the socio – cultural or historical value (character flexibility, according to Hofland), the opportunity to (re)build spacious rooms (neutral for furnishing, possibility for change of floor plan, capacity for isolation between apartments (modernization capacity), room for outdoor space (possibility for change of floor plan). However, the costs of renovation are high, despite this original aspects of flexibility.

5 Summary and conclusions

In summary, many authors have studied flexibility in housing. Although names and definitions are diverse, the core of the results seems the same: during a household cycle of 30 to 40 years, changing behavior is fairly predictable, as well as the diversity of households. However, an important aim of flexibility in buildings is to prolong lifetime – particularly functional lifetime – , withstanding societal changes that make future tenants' requirements hardly predictable. Socio – cultural and economic changes, but, first of all, technological innovation contribute to these uncertainties. The problem of a building loosing performance in several aspects should be solved in a financially acceptable way. Investments at the time of completion, may reduce the costs of interventions in the future. It is impossible to renew the housing stock every 40 years; therefore, renovation is necessary for a larger part of the stock. The big issue is to design pliant buildings at minimal extra costs, particularly while long term future requirements are not predictable: who can foresee if investments of today can be regained – not tomorrow, but the day after tomorrow.
Hofland has developed a checklist which is based on the studies of several authors. The list has been applied to building projects, some of which have been described in this paper; it is evident that the items of the list can rather easily be verified from the plans. So the checklist can be used by commissioners and future users to be conscious of future options for alterations, for a short and – much more tentatively – for a longer period of time. A combination with cost consequences should be made in order to attain conscious choices for the required – and feasible –level of flexibility. It should be noticed, that the commissioner, in the light of costs and possible profits, will have the burden to decide, eventually supported by the opinion of (future) users.
However, as has been shown, uncertainty about future developments – in the technical as well as in the economic and socio – cultural sense – will occur. In the 17th century, who could have guessed that a warehouse, after four centuries would be worthwhile to renovate at extreme high costs? Which characteristics contribute to its high value today, and could this high value be predicted at the time of construction? Apparently, some buildings have architectural or esthetical characteristics that fit in the city image, and have historical meaning. Also, it should be recognized that appraisal is a question of taste and of fashion, and the older the building, the more historical meaning it has, and the more valuable it seems to be. In short, future (functional) requirements are hardly predictable, but intrinsic value of a building – and thus feasibility of renovation – is neither.
Concluding, it is worthwhile to invest in flexibility for a short period of time (30 – 40 years), because changing requirements are predictable, and can be met (multi-functionality, neutrality for furnishing, options for changing floor plans, capacity for expansion and shrinking, e.g.); the required investments can be related to the profits. Over a longer period of time, investments and the ultimate returns are a

[5] Price in Dutch guilders; $ 1,-= ƒ 2,-

matter of chance. However, because many buildings have proved to have unforeseen characteristics that have survived even for centuries, extra investments for sake of flexibility seem worthwhile. One should find an optimum between a maximum of adaptability and a minimum of costs, the last being at least feasible for the first users. The developed checklist, combined with an indication of the building costs, can support this decision process and contribute to the creation of a more sustainable housing stock.

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