UPGRADING THE FLEXIBILITY OF BUILDINGS

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ABSTRACT

The buildings market and the use of commercial and residential buildings are characterised to an increasing extent by a mismatch between supply and demand. Consumers need a faster and more adequate response to their changing requirements, including those related to the actual use of buildings. Too little investment has so far been made in the future flexibility of buildings (weighing initial costs against life cycle costs). The fact that the feasibility of modifications and adaptations to buildings is determined to an increasing extent by their installations is a very important issue.

Strategy for Flexibility

By using a flexibility strategy based not only on the structural design of a building and its components but also on its installations, it will be possible to make a distinction between permanent and variable aspects, and between a long life cycle and a short life cycle. Such a strategy will help achieve a better match between supply and demand. It will make it possible to offer every consumer a minimum, but adequate and sufficient, basic quality at the support level or base building. Additional quality at the infill or fit-out level can be added in response to individual consumers’ wishes. Thus the quality level is exactly tailored to fit consumers’ needs.

Research method and recommendations

An extensive, itemised literature survey, based among other things on publications from the Foundation of Architectural Research (SAR) in Eindhoven, the Netherlands, revealed the measures that can, in general, be taken to increase the flexibility of both existing buildings and those still to be developed. This paper formulates 13 recommendations to increase the flexibility of buildings by considering a case study, involving a building- and installation analysis, of the former headquarters of a large Dutch bank in Amsterdam.

KEYWORDS:

Flexibility; buildings; upgrading; consumers; performance.

INTRODUCTION

The ever-changing demands of users make it unavoidable that both houses and offices must undergo structural modifications regarding their spatial, architectural and technical installation characteristics. It is therefore necessary when building new properties and renovating existing ones that adaptation to users’ needs is possible. This makes flexibility, adaptability and changeability crucial concepts that cannot be ignored.

A distinction can be made between process flexibility and product flexibility. Process flexibility is flexibility in a decision-making process, for example one that takes place in an organization and involves people with managerial positions. Process flexibility also refers to flexibility in a development process, from initiative and design to construction and operation of buildings. Product flexibility is flexibility in the structural design and the technical aspects of an installation system in specific projects, buildings or building components. This research project mainly addresses the technical flexibility of buildings.
An extensive, itemised literature survey, based among other things on publications from the Foundation of Architectural Research (SAR) in Eindhoven, the Netherlands, revealed the measures that can, in general, be taken to increase the flexibility of both existing buildings and those still to be developed. This paper and the presentation belonging to it, formulates 13 recommendations to increase the flexibility of buildings by considering a case study, involving a building- and installation analysis, of the former headquarters of a large Dutch bank in Amsterdam.

![Figure 1: Former headquarters of an Amsterdam bank as a case study](image)

**RECOMMENDATIONS to upgrade flexibility**

The recommendations formulated in this paper for upgrading the flexibility of buildings apply equally to buildings and building products. Further, a distinction is made between recommendations for building technology and those concerning installation technology. The recommendations for making buildings more flexible are oriented especially towards the demand side of the building market, and apply to those who commission buildings and who specify the criteria the buildings must meet.

1. **Integrate the design of installation systems into the structural building design**
   The flexibility of buildings and homes is inextricably linked with the flexibility of their installations, which more and more constitute an important component of buildings. Developing an oversight of a building’s flexibility, and the flexibility of its installations are inseparably bound to each other – both should be integrally developed. The development-, construction- and operate processes must distinguish between two different decision-making levels – the support level and the infill level – to ensure that buildings can be optimally modified to meet changing (future) use.

2. **Avoid using penetrating connections between support structures and installation systems**
   Accommodation of installation systems in load-bearing walls and in floors leads to a confusion of different systems and causes problems in the coordination of each individual system.
Bearing future adaptability in mind, it is strongly inadvisable to incorporate installation distribution components in walls or floors that form part of the architectural construction. Since modifying rooms involves moving inner walls, it is much better to leave them free of ducts or pipes. If installation components are built into structural components because they have to be accessed for future modification, they should not be built into weight-bearing architectural constructions.

3 Keep a support structure disconnected from infill elements

Use both the structural design of the building and the technical design of an installation system to make a distinction between support and infill elements, collective and individual aspects, permanent and variable flexibility and long and short life cycles.

If the support and infill elements are easily separated, and well-interfaced, this reinforces the building’s flexibility. A flexible system of inner walls also contributes to overall flexibility. However, it is just as important to ensure that connections to support structures are of a loose-fit type, with no male-female connections. It is also possible to distinguish between support and infill at the installation level, in a similar fashion to what is more or less applied already at a building level. Support structures and their various components are designed and implemented to fulfil various long-term functions as well as possible. Infill components are designed and implemented to meet short-term changes in organizational and individual requirements. The support installation is the installation component that results in the minimum necessary and permanent basic installation facilities, regardless of the present or future use of the building. The infill installation is the installation component that specifically meets the characteristic requirements of the continually changing organizational and individual requirements.

4 Base the structural design for construction and installations on a maximum partition plan

Base the structural design for building construction and installation systems on a maximum partition plan, based on the smallest independent and connectable unit. The repartitioning of a building means that both the spaces and the installations can be split up, depending on changing user requirements, into smaller independent units. Units can also combine to form a number of larger units, and be redivided (figure 3). It is therefore recommended to base the design of a building or installation on the smallest possible independent connectable unit. In this case, combining smaller units into larger ones presents no problems. If the design is based on larger independent units, a future division into smaller units can be problematic.
5 Make the support structure partitionable

A partitionable support structure gives a repartitionable building that can accommodate various types of functions and units, including residential ones, as the functions change and vary in number and size over the years. The possible future independence of departments, or the partial disposal of building components, places different demands on the building from the point of view of efficient control. Consider in this respect the separate or collective use of entrances, lifts, stairs and facilities, the individual measuring of energy and using the data infrastructure. The ability to easily compartmentalize a building for various independent users or occupiers increases its flexibility. In this respect, it is important to determine both the smallest and the largest possible control- or living units.

6 Set specific requirements for the interconnection of construction and installation components

It is important that construction and installation components can be easily disconnected, removed or repositioned. Constructable connections must meet the following requirements:

- Disconnectable. This refers to the possibility of disconnecting various components from each other in order to limit the knock-on effects of changes. In other words, ensuring that changes or modifications at a lower level have no influence or effects on higher levels, and that they take place independently of each other. It is recommended to use pluggable connections as much as possible, or plug & play products.
- Standardised connections. The specifications of the connections are standardised so that components from one connection can be used with other components, which is necessary during changes or modifications to a building or installation. To make this possible, connections must have standardised fittings.
- Size, shape and position tolerances. To maintain flexibility, it must be possible to remove (installation) components from a building and refit them elsewhere (such components are called open or project-independent products). If cables and power lines are not present, it is necessary to ensure that position- and dimensional tolerances are taken into account in the connections (modular coordination).
- Individual removable. The connection must allow for the removal of single components from the installation without the need to first remove or replace other components.
- Direct useable. An (installation) component must be useable immediately after positioning and mounting (plug & play) without requiring any further maintenance, adjustment or control.

Figure 5: Disconnectable and pluggable (plug & play) connections for electric- (left), gas- (middle) and water facilities (right)

Figure 6: Modular radiator and window ledge system with inner walls that are easy to dismantle or connect (case study)

An example of installation components that are quick and easy to dismantle is a modular heating radiator and window ledge system with stopcocks in the hot water pipes. It is easy to dismantle and connect inner walls (figure 6).

7 Use modular coordinated systems
Agreement on size and position of construction and installation components enables easy exchange and repositioning of components. The applicable position and size systems must facilitate dismantling, repositioning and mutual exchange of construction and installation components. In this respect, refer to the various standards for modular coordination, and to building measurements (size tolerances), and the advice they contain that applies to zoning for the various systems.
These standards and guidelines constitute a tool kit to coordinate the process lifecycle from its global phase to its specification phase with no obligation to adopt a specific process form.

8 Make construction and installation components readily accessible
Access is improved considerably when elevated floors, suspended ceilings, skirting or trunking are used to duct installation systems. Installation components that are easy to access are closely linked to their level: infill level or support level. Construction and installation components at infill level are easy to access and, as a rule, have a short technical, functional and economic lifespan.

9 Provide local (individual) and central measurement and control facilities
Provide local and central measurement and control facilities for individual units, for individual partitions or for the building as a whole. The separation of support installations and infill installations involves two kinds of transfers. The transfer of heating, cooling or, for example, lighting at a support level, which amounts to at least the largest common denominator of possible user requirements, and the transfer of the same installation functions at a local level to meet individual needs. To maximise flexibility at local and central levels, it is necessary, as with local and central
transfers of installation functions, to measure consumption. The most flexible way of doing this is to measure consumption per user component.

![Image](image.png)

*Figure 9: Individual control at the lowest possible decision forming level*

10 **Ensure that there is surplus capacity**

Make sure that the various levels have an overcapacity or surplus. This should exist at both location and building levels for both horizontal and vertical expansion of the building, at space levels to allow floor surface areas to be usefully deployed and at the construction level in weight-bearing walls and floors, and finally at the installation level.

Enlarging or extending a building is an alternative to moving to a new building. Building one or more wings can extend buildings horizontally as well as vertically, for example. To do this, ground must be acquired, and it must be tested to check that it meets certain regulations. It is also possible to add a complete new building to an existing location.

![Image](image.png)

*Figure 10: Left: modular construction of the exterior walls with surplus of standard connection possibilities for inner walls; Right: surplus of weight-bearing walls and floors for modified use and modified loads*

Whenever the power or capacity of an installation can be adjusted to different values, users have the flexibility to react to changing circumstances. In principle, an installation is more flexible when the capacity it can deliver exceeds the capacity required of it. The term surplus installation capacity refers to the installation ability to easily and quickly adapt to new situations (figure 11).

The sizing of installation components with respect to flexibility for expansion is particularly related to the measurement of dimensions of the distribution network, both concerning supply to and from the installation.
Restrict distribution facilities and ducts
Restrict distribution facilities and ducts, for instance by using remote control facilities. Maximum flexibility is achieved when distribution cables (both in- and outgoing) are not necessary. In this respect, product development plays an increasing role. Cable-free systems are increasingly appearing on the market, which are sometimes equipped with low-current, infra-red, acoustic or presence switching. This particularly applies to information and computer technology, but also applies to lighting, heating, ventilation and cooling. Control flexibility is considerably increased if distribution systems are kept to a minimum (figure 12).

Make removable user facilities
It is advisable to shift the balance from high levels to low levels, from support to infill and from infill to furniture. By locating architectural and organizational elements at the lowest possible levels, they will be closer to the user, and consequently easier to change and replace.

For example, a table is easier to move than a fitted kitchen unit, and a free-standing storage cupboard is easier to move than a built-in cupboard. Free-standing inner wall elements are easier to dismantle, relocate and reuse than fixed elements (figure 13).
13 Flexible thinking
A final recommendation is flexible thinking. Take notice of other opinions and standpoints, new developments and particularly of the continually adapting needs of users. This applies not just to the program, design or construction phases, but also during the user or rental phases. The success or failure of a project strongly depends on the human factor. This means that customers, architects and contractors should not be afraid to change a project, should new information come to light, while it is being developed or implemented.

CONCLUSION

By using a flexibility strategy based not only on the structural design of a building and its components but also on its installations, it will be possible to make a distinction between permanent and variable aspects, and between a long life cycle and a short life cycle. Such a strategy will help achieve a better match between supply and demand. It will make it possible to offer every consumer a minimum, but adequate and sufficient, basic quality at the support level or base building. Additional quality at the infill or fitout level can be added in response to individual consumers’ wishes. Thus the quality level is exactly tailored to fit consumers’ needs. This paper formulates 13 of the most important recommendations to increase the flexibility of buildings.

REFERENCES


