

从过程洞察灵活性——回首25年前的房屋项目

Learning on Flexibility from Experiences: Revisiting Housing Estates after 25 Years

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摘要 二战以后，丹麦常用的建筑方法是带有十字承重墙的多层建筑，但该设计体系并不能很好地适应其后的建筑改造。因此丹麦住房与建设署于1983年颁布了条例来鼓励3~5层的非营利性住房的技术革新，以适应未来新的用户需求，增加建筑的灵活性。

2012年春天，丹麦科技大学DTU管理学院创新性地开展了一个评估工作，目的是研究在25年的建筑发展中原始竞赛作品中的创意是如何实现的。本文采用的数据取自始建于20世纪80年代的15个居民区里的1 000~1 200个公寓房。本文基于评估得到的临时结果包括在建筑规划和施工阶段把建筑的持续改变能力做到最出色的前6位方案。

关键词 房屋 灵活性 用户需求 经历 评估

Abstract In the wake of the Second World War the Danish government tried to increase the capacity of the building industry by establishing new research facilities, stimulating the housing sector and developing a framework for industrialization. The dominating building method during this period became multi storey housing with cross bearing walls. Within multi storey housing the developed system design appeared to be less adaptable to later alterations. Therefore The Danish Ministry of Housing and Building in 1983 issued an initiative to stimulate technology development of residential non profit housing in three to five storeys the target being "to focus on the possibilities to create buildings which in the future can be adapted to new user demands and applications that we do not know of to day - and in the short term add flexibility which can create possibilities for individual housing projects" (The Ministry of Housing, 1984,1)

During spring 2011 DTU Management at The Technical University of Denmark has initiated an evaluation with the aim of showing how the ideas from the original competition have been applied during the 25 years period. Thus this paper will review the above governmental policy aiming at stimulating the development of new building designs with an improved technological adaptability to new demands and flexibility.

The data input to this review is extracted from 15 residential areas with a total of about 1000-1200 apartments which were built in the 1980s after a competition which attracted the leading building companies. This paper is based on the provisional results from the evaluation and will conclude in a "top six" for most successful steps in the planning and construction of buildings with capacity for incremental change.

Keywords housing, flexibility, user needs, experiences, evaluation

概述

前几年，一种房屋项目的新的设计与规划方案被人们寄予了很高的期望：把针对未来改变而进行的规划作为补充经济、建筑 and 施工耐久性三者相互作用的第四维来考虑。发展反映了这样的事实：住户、新技术和多年后社会变化的需求将会使用户面对新的情况，并且以包含可持续性的一般形式呈现。

大体上说，传统的规划过程忽视了对未来变化的需求。在那些好的项目案例中，考虑到了用新构件代替旧有构件的灵活性和可能性，然而大多数的案例都是不理想的，新的建筑在交工后不久就要进行昂贵的基本维修和改动，这种现象并不少见。

如上所述，由于以四维角度对房地产业进行调整的适应性是政府调控房地产业必要和慎重的手段之一，本文将以政府的视角关注相应的经验数据。更进一步，本文关注政府机构和研究机构的合作如何对新类型房屋设计的发展产生贡献。具体的措施是否能成功？如果答案是肯定的，那它们又如何在未来的房屋设计中得到应用？

INTRODUCTION

During the last years a new aspect of the design and planning of a housing project has been given higher priority: planning for future changes as a fourth dimension to supplement the interplay between economy, architecture and durability of the construction. This development reflects the fact that wishes from tenants, new technology and altered requirements from society after some years will be constituting new conditions for user well being and – with a generic term – for sustainability.

The traditional planning process has by and large been ignoring the need for future changes. While in the best of projects there have been some considerations concerning flexibility and possibilities to replace appliances with new ones - in the worst (and majority of cases), however, it is not unusual that even new buildings must undergo basic alterations with costly consequences shortly after handing over of the building.

As indicated this paper will be looking at the empirical data from a governmental point of view as adaptability to alterations in the housing estates in the fourth dimension perspective was an essential and deliberate part of the governmental trial to influence the housing sector. Furthermore the paper is focussing on how a governmental institution in collaboration with a research institute can contribute to the development of new types of housing

试验性建筑竞赛的背景

二战后丹麦政府推行了被称为丹麦开放系统方法的尝试，隐藏在在这一方法后的基本原理即为工业化建筑构件的生产创造开放的市场，这些具有精确化尺寸的构件能在很多独立的房产建设中得到应用。根据这个基本政策，政府的任务是建立一个有助于建筑业创造必要技术创新的发展框架（图1）。

发展体系似乎对于多层建筑后期改造的要求过于严格死板，因此丹麦住房与建设署在1983年开始鼓励在3~5层的非营利性住房领域内创新，其目标是“在建造建筑时要关注我们现在未知的但适应未来新的用户需求及应用的可能性，在短期之内增加建筑的灵活性，为独立住房项目创造可能性”。

这个政府议案旨在推动工业朝着建设更多灵活建筑并开放应对未来变化的方向前进，而并不直接干涉私有企业的生产技术和生意往来，因此它能为新的产品和生产技术创造市场。

二战后丹麦的非营利性住房组织有效地推动了公共住房和建设政策的落实，并对建筑业的发展产生了显著的影响。这些组织以甲方的身份参与私有公司的设计和施工过程，多年以来他们参与了很多建设过程，这毫无疑问使他们在工业化住房建设的长期发展过程中扮演了一个决定性的角色。

上述提案和设计竞赛对迄今应用在工业化多层住房建设中的设计方法和技术提出了挑战。工业、研究机构和住房与建设署的合作互动始于20世纪60年代，着力于关注有效使用预制混凝土建设承重十字墙和楼板，以产生最小的变形。工业化的主要原则包括：1）使用模数协调；2）项目中使用标准化构件；3）建设体型简单的建筑；4）除建筑骨架外还应关注整个建设过程；5）做好客户间的协调工作。

这个政策带来的后续效应是二战后丹麦房地产业迎来了集中使用预制混凝土构件的热潮，这是由于房产业发展是在开放的创新性框架下进行的，这种热潮顺利进入了房地产业的所有领域并促使传统的建筑技术更新换代。

设计竞赛和提案

竞赛只允许包含建筑师、工程师及承包商（还可以有次级承包商和生产商）的团队参与。竞赛的重要特征是设计师和承包商间要密切合作，在设计初始阶段进行经验和创意的交流，从而产生新的设计创新。

在对代表丹麦公司最高水平的40个团队进行初步的资格预审

design. Have the specified solutions been successful - and if yes, how can they be utilized in future building projects?

BACKGROUND TO THE EXPERIMENTAL BUILDING COMPETITION

The basic philosophy behind the Danish efforts since World War Two, called the Danish Open System Approach, was to create an open market for factory produced – dimensionally coordinated – building components that could be combined in a variety of individual building estates. In accordance with this basic policy, it was the government's task to establish the framework for a development within which the building trade itself could create the necessary technical innovations, see figure 1.

For multi storey housing the developed system appeared to be rigid for later alterations. Therefore the Danish Ministry of Housing and Building in 1983 took the initiative to stimulate the innovation within residential non profit housing in three to five storeys. The target was "to focus on the possibilities to create buildings which in the future can be adapted to new user demand and applications that we do not know of to day - and in the short run to add flexibility which can create possibilities for individual housing projects"(The Ministry of Housing, 1984,2).

Flexibility was furthermore considered an important quality in connexion with urban renewal because new estates in cities must be adaptable to the architecture of existing buildings.

This governmental initiative was taken with the intention to push the industry in the direction of more flexible housing and buildings, open to incremental changes - but not to interfere directly with the production technology and businesses of the individual companies. An essential tool therefore was to create a market for new products and processes.

In Denmark since WW2 the non profit housing associations have constituted a useful instrument for realizing public housing and building policy thus having a significant impact on the development of the building industry. The associations act as clients who engage private firms for design and construction – and as a consequence of their accumulated, continuous building activity these housing associations has clearly been playing a decisive role in the long term development of industrialized housing (Bonke et al., 2001).

The above initiative and the competition marked a general wish to question and challenge the design and technology hitherto applied to industrial multi-storey housing. Since the collaboration and interplay between the industry, research institutions and the Ministry of Housing and Building started back in the 1960s the efforts had been concentrating on an effective use of prefabricated concrete load bearing cross walls and floor slabs with a minimum of component variants.

The main principles in the industrialisation approach consisted of

- Use of modular coordination
- Use of standardized components in the project
- Uncomplicated buildings
- Not to focus only on the carcass but all trades
- Coordination between different clients

As a consequence of this policy a dominating characteristic in Danish housing industry since WW2 became an extensive use of prefabricated components

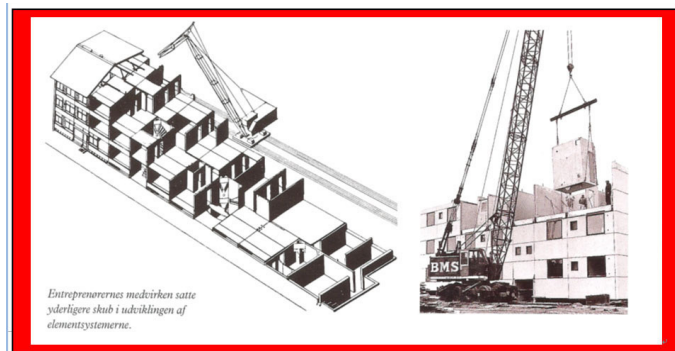


图1 20世纪60年代丹麦的工业化原则（企业的介入进一步推动了元素系统的发展）

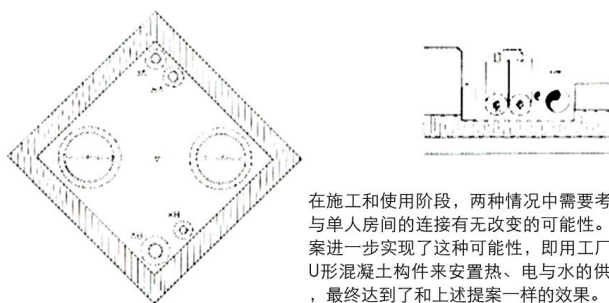


图2 两个提案有关单元的安装设备排布：在建筑中间还是在外面周围

后，1984年4月6个团队被遴选出进入实质的设计竞赛。竞赛的提案表明，在未来的多层住房中，无论是规划阶段还是使用阶段都需要注入更大的灵活性，这就指向了结构体系的改变。一个主要的创新特征就是用柱子代替承重墙受力。特别是在有关技术服务等方面，竞赛作品给出了很多可能的发展方向，其中一个创新是对现存暖气系统的改进，例如在暖气系统中添加空气加温装置；另一个是热空气热能的使用，例如通过单元的形式给单户居民集中供热气和热水。

在获胜方案中，底层楼面可以安放家用设备，上层楼面可以设计成两层公寓。可上人露台和宽阔的走廊为公共和私人区域提供了转换的空间。建筑能适应现存的高密度城市环境，可以被设计成位于开放郊区环境中的自由街区。结构基于板柱体系。柱截面可以是圆形或是方形，从建筑内外的角度都能看到柱截面。方形实体板单元可以通过竖向浇注预制。提案迎合了上面提到的丹麦房地产业使用预制构件的大体发展趋势，同时受到了Habraken思想的启发。而且隔墙和外立面构件都与骨架结构的受力部分分离，这样对于新老承包商和生产商来说，这些构件都是便于替换的。

20世纪80年代后半期，指定团队在15个居民点建造了1 000到1 200个公寓（图5）。在其他的居民楼项目中也进一步采用了很多创新的点子。

评价

丹麦的常规做法是在建筑建成1~5年后进行评估，而且只关注技术缺陷。这些评估结果是甲方和有关单位签订的合同中必备的标准性条款。

现在人们对于评估的兴趣越来越高，范围扩大到用户体验、对建筑元素的感官和建筑建成后的运营情况。同时，人们倾向于在更长的时间后对建筑进行评估。

上述发展提议经由丹麦建筑研究协会近十年的评估，在检验了短期灵活性目标是否能够达到并得到贯彻后，于1994年提出。这个评估主要关注一些技术要点，如结构体系、建筑及用户价值、室内气候及设备安装、施工单元和基于市场与经济因素的建筑技术。

丹麦科技大学DTU管理学院目前正在开展一项旨在揭示这

(see above) which – because the development took place in an open innovation framework - without serious impediments entered all areas of the building industry and substituted traditional building technologies.

THE COMPETITION AND THE PROPOSALS

The competition was open only to groups comprising architects, engineers, contractors and, if applicable, sub-contractors and manufactures. An important feature was the requirement for a close cooperation between designers and contractors and in this way an exchange of experiences and ideas at an early stage with the aim of coming up with new ideas and innovations.

After a preliminary pre-qualification phase with 40 participating teams, representing leading Danish companies, six groups were selected in April 1984 for the actual competition.

The six groups submitted their project proposals in late 1984, and the jury's evaluation was available in December 1984.

The proposals for the competition indicated that the demand for greater flexibility in future multi storey housing, both during the planning and the occupation stages, points to changes in the structural system. A general innovative feature thus encompassed use of columns instead of load bearing walls.

Specifically concerning the technical services the competition produced a variety of possible developments. One innovation was about an improvement of existing radiator systems. For example, radiators could be combined with injection of pre-heated air. Another possibility involved the use of hot air heating. For example, heat produced within the individual dwelling by means of a unit which also produces hot domestic water.

In the winning project the ground floor may be used for common facilities and the upper floors can contain two-storey flats. An access deck on the floors and wide corridors provide a transition zone between the public and private areas. The building can be adapted to existing, high density urban areas or may be designed as unattached housing blocks in open suburban surroundings.

The structure is based on a column/deck system. The columns may be round or square in section and visible on the exterior or interior of the building. The solid, square deck elements can be prefabricated in vertical shuttering.

The proposal follows the above described general development towards use of prefabricated components in Danish housing industry and is at the same time inspired by thinking from Habraken (Habraken, 1982). Furthermore the partition walls and the façade elements are kept free from bearing parts of the carcass. In this way they are easy to substitute, also by new contractors and manufactures.

During the second half of the 80s the selected teams constructed 15 residential areas with a total of about 1000-1200 apartments (as shown in figure 5 below). Elements of the innovative ideas were furthermore used in other residential projects.

EVALUATION

In Denmark the normal practice is to evaluate a building after one and after five years but only concerning technical defects. These evaluations are elements in the standardized conditions for contracts between clients and companies.

There is an increasing interest for evaluations which go beyond those evaluations and take into account user experiences as well as opinions concerning the architectural aspects and the operation of the finished buildings. And at the same time also an interest to make evaluations after a longer period of time.

The above described development initiative was evaluated after about ten years in 1994 by the Danish Building Research Institute to see whether the short term flexibility goals has been reached and used. This evaluation focused mainly on technical topics such as the building system, architecture and user value, indoor climate and installations, construction elements and building technique plus market and economy.

DTU Management at the Technical University of Denmark has now initiated an evaluation with the aim of showing how the development results of this experimental building programme have been exploited after app. 25 years (say during 25 – 50 % of the expected lifetime of the buildings. This evaluation will include topics such as alterations due to new user demands during the

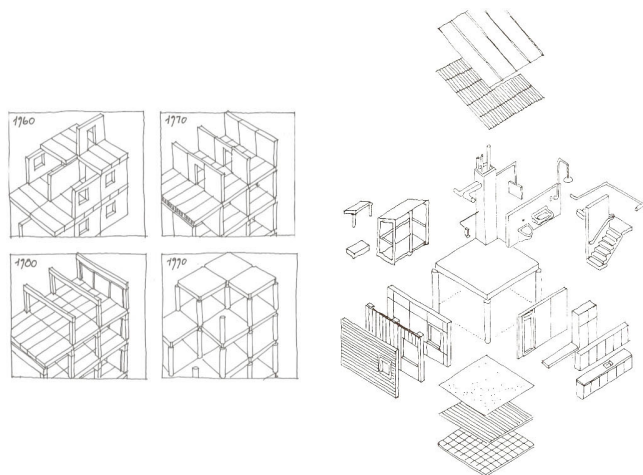


图3 结构体系自20世纪60年代以来的发展和对90年代的展望（左），展示了获胜方案如何构建包含预制构件的体系（右）

种试验性的建筑项目在将近25年之后的发展利用现状的评估项目（时间跨度大约占建筑目标使用期的25%~50%）。评估项目包括在25年周期内根据用户的新需要而进行的设计变更、现代化翻修、技术性构件替换、建筑维护和建筑环境的开发。

发展轨迹——数据收集

在1994年进行的早期评估中，丹麦建筑研究协会发现获胜方案的体系灵活性已经充分发扬，创造了很多各式各样的新式寓所、寓所通道和公共环境区域。

竞赛处于技术的前沿，展示了很多新的创意，如主要基于预制构件的结构单元和统筹可持续性的安装设备新形式。由此有可能改变迄今仍使用在非营利性住房建设领域中的多层住房的常规设计模式。

在竞赛中，主要的单元——柱子的使用有很多不同的方式。以一些开发工作和相关试验为基础，对板柱节点和梁板节点的使用可能创造出新的构造形式。安装设备的关键点是充分利用穿行在建筑内部或外立面管道内垂直或水平布置的管线（图2）。但同时，提案包含了从传统暖气设备的应用到基于热空气加热的设备等一些不同形式的暖通设施，一些情况下还涉及到电加热板的调整。1994年的评估总结道：“毋庸置疑的是，他们的建筑设计和结构布置中考虑到了灵活性，这将会影响未来多高层居民建筑的设计”。

2011年DTU管理学院的评估中关注了对创新创意的后续利用，以便更大程度发挥灵活性。评估在开篇把整体灵活性和出现增长性改变的可能性分为以下9个主题来考虑：1）建筑中实施过哪些更大的改动？2）哪种类型的改动不可行？3）寓所和公共空间的改动程度有多大？4）实施过哪些有关公共管线及排污设施的连接部分的改动？5）安装设备改动或替换的时间和程度是什么？6）周围建筑环境有无变动？7）建成建筑的运行遇到过哪些障碍？8）建筑骨架的构件被改动过吗？9）其他有关的改动情况。

更进一步，评估会遵循德国环境评估系统DGNB中定义的价值稳定性原则，这个原则不久就会被丹麦引入。这里的关键点是空间使用的效率、环境适应性（模块化和与公共系统的连接情况）和其他功能变更的可能性。

25 years, modernization, technical replacements, maintenance and the development of the surroundings.

EXPERIENCES - GATHERING OF DATA

In the early evaluation from 1994 the Danish Building Research Institute found that the flexibility in the winning system had been used to create many different and new forms of dwellings, of accesses to the dwellings and of common areas and surroundings, see figures 4 & 5.

Some excerpts from the evaluation: 'It would seem from the housing projects completed that by transferring the quality of low-dense housing to multi-storey buildings, the latter have been added with important new qualities'. And furthermore: 'architecturally as well as in terms of use, the projects on Alekistevej and Engen in Rødovre, (see figures 4 & 5), serve to widen the concept of multi-storey building' (The Danish Building Research Institute, 1994).

On the technical front the competition has shown new ideas concerning structural elements mainly based on prefabricated components and new form of installations with an eye on sustainability (The Ministry of Housing, 1984, 2). In this way it actually seemed possible to change the normal design of multi storey housing, hitherto used in the non-profit housing sector.

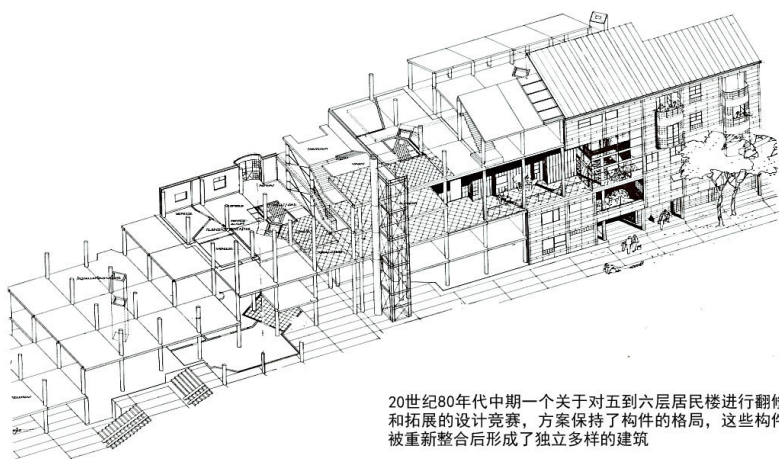
The use of columns which was a main element in the competition has been applied in different ways. Based on development work and testing it became possible to create new principle for joints between columns and slabs and in some cases also beams.

A leading principle for installations was use of pipes in special shafts in the interior of the building or at the facade – vertically and in some cases horizontally, see figure 2. But otherwise the proposals contained different forms of heating – from traditional use of radiators to heating based on hot air and in some cases adjustments with electrical heating plates.

The 1994 evaluation concluded that 'There is no doubt that, together with the considerable flexibility, their design and layout will affect the future design of multi-storey residential housing'.

Focus in the DTU Management evaluation of 2011 is on the subsequent utilization of the innovations for greater flexibility. The evaluation has taken its starting point in a division of the overall flexibility and possibility for incremental changes within the following 9 themes:

- Which bigger alterations have been executed?
- Which types of alterations have not been feasible?
- To which extent have dwellings and common areas been altered?
- Which alterations concerning connections to public supply and sewage services have been executed?
- To which extent and when have installations been altered or replaced?
- Have there been alterations in the surroundings?
- Have there been barriers to the operation of the finished building?
- Have elements in the building carcass been altered?



20世纪80年代中期一个关于对五到六层居民楼进行翻修和拓展的设计竞赛，方案保持了构件的格局，这些构件被重新整合后形成了独立多样的建筑

（建筑Arkitektgruppen i Aarhus A/S, 结构Viggo Michaelsen A/, 承包商Højgaard & Schultz A/S）

图4 获胜方案一览



图5 项目的第一期房产建筑



图6 展示了具有内部灵活性的获胜方案如何适应城市已存环境

2011年，有关居住体验的评估结果取自仍旧在同一公司供职的1994年的评估团队及来自方案获胜团队的一个结构工程师这五位住房使用者。方案获胜者建造了15栋建筑中的5栋，因此数据就在这些建筑中采集。通过对房产公司经理进行电话访问得到了日常运营和维护的情况。接下来的工作是询问用户的意见，最后调查参与施工的公司是如何落实最初的建筑创意的。

关键性问题是，和传统的工业化房屋设计相比，为了使房产项目适应用户不断变化的新需求，那些与设计竞赛有关的创新构想是否能使设计相对容易地应对建筑改动及增长性改变。重要的是，我们要意识到竞赛所选项目的特征同样也是提案体系的灵活性要适应不同的环境，例如要与所在城市的建筑或新区环境相适应（图4~6）。

建筑的评估过程被总结如下：1）使用、发展建筑体系并进行创新以适应包括城市中心或新区的不同环境是可能的。这些建筑都是开放的系统；2）迄今为止，结构体系的技术创新停滞不前。单栋公寓会有一些因应用新结构体系而产生的改动；3）迄今为止，除了维护需要外，人们对外立面的改动兴趣不大。但如果外立面构件不受力，那么即使是在传统的设计方法中，这种外部的改动也不难操作；3）获胜项目中的外部电梯井和电梯都是建筑的薄弱结构；4）方案的创新性给供暖系统的安装带来了一些小问题，在一些情况下，有必要用新的安装设备来作补充，而建筑内部的灵活性中并没有考虑这些问题；5）多考虑设计和施工阶段的运营情况将会使清洁和维护工作变得容易。

讨论

在新建筑的设计和施工阶段，常规做法是关注决策阶段，一个例子是造价，这样就会忽视已建建筑的运行情况和建筑在一定程度上的使用情况。目前在丹麦，人们越来越多地让客户参与到设计中来。但问题是，很难让用户参与涉及100年甚至更长时间的设计，而100年是丹麦建筑的常规设计使用周期。因此，从已存建筑中吸取的经验就很有价值，特别是那些在为激发专业用户和公司进行建筑内部灵活性新创意的竞赛中建造的建筑。

• Other alterations

Furthermore the evaluation will draw upon the guidelines for value stability, as defined in the German system for environmental evaluation DGNB, which is due to be introduced in Denmark. The main points here are effectiveness of the use of the area, adaptability (modularity and connections to public services) and possibilities for change to other uses.

In the 2011 evaluation answers about experiences have been collected from five building owners, a member of the 1994 evaluation team plus a civil engineer from the winning project, still occupied in the same company. As the prize winner constructed 5 of the 15 estates the gathering of data has been focussing on those projects. The answers were procured by telephone interview with the responsible estate manager for the daily operation and maintenance. In the coming work it is considered also to ask the users about their opinions. Finally an option is also to investigate how the involved construction companies have utilized their learning.

The question in focus is whether the innovations developed in connexions with the competition have made it easier, compared to traditional industrialised housing design, to make alterations and incremental changes to adapt the estates and buildings to new demands. It is important to note that a feature in the selected projects in the competition also was the flexibility of the proposed building system to be adapted to different surroundings as for example the architecture of an existing city as well as in new areas, see figures 4, 5 and 6.

The experiences can be summarized in the following statements:

It is possible to use and adapt the developed building systems and the innovations to different surroundings in inner cities as well as new areas. They are open systems.

The technical innovations in the structural system have up to now not been exploited. There have been some alterations within the individual dwellings, made possible by the new system.

Up to now there has been no interest for changes in the façade, apart for maintenance purposes. However, such exterior changes are not particularly difficult to execute even in traditional designs when the facade elements are not load bearing

The outside tower for the elevator in the winning project, as well as the elevator itself, is a vulnerable construction.

There have been some smaller problems with the heating system installations due to their innovative character. In some cases it has been necessary to compensate with new installations and the in-built flexibility has not foreseen such problems.

More considerations on the operation during design and construction phases would have made the cleaning and maintenance tasks easier.

从研究的角度来看，对建成建筑的评估会进一步帮助我们理解如何设计和建造建筑才能够实现可能的增长性改变并因此而达到可持续性的目标。

结论

根据设计竞赛和对方案的初步筛选，我们总结出：在更广泛的意义上，若要使建筑设计蕴含增长性变化的能力，甲方、设计师和承包商必须考虑到以下6个步骤：1）在房产和单栋建筑公寓的全面设计中，应当考虑到对空间进行灵活使用的可能性；2）单栋公寓的结构应当采用柱体系，这有助于后期改造时采用轻质隔墙，也有由厚重墙单元支撑的大楼板单元这一方案；3）基于隔声与降低造价的需要，两个公寓间的隔墙用厚重单元更合适；4）要考虑到安装设备的可更换性和能源、电力及排污等新系统的安装；5）在设计和施工阶段预先考虑建筑建成后的运营和维护细节是很重要的；6）对结构的裸露和脆弱部分的可更换性必须予以特别关注，例如外立面木材的使用和电梯中钢结构的使用。

DISCUSSION

In the design and construction phase of new buildings the normal practice has been to focus on the execution phase. An example is concerning costs. In this way the operation of the finished building and to some extent also the use of the building has been neglected. For the moment in Denmark there is a growing interest to involve the coming tenants in the design phase. But a problem here is that it can be very difficult for the users to anticipate up to 100

years – or more – which is a normal lifetime in Denmark for a building.

Therefore experiences from existing estates can be valuable. Especially in this case as the buildings are the results of a competition with the target to challenge professional owners and companies to come up with new ideas and suggestions concerning in-built flexibility.

From the research perspective, a method of evaluation of finished buildings can give numerous possibilities for further studies. For example, the preliminary findings presented in this paper could be extended through more contacts to the involved parties – administrators as well as users and companies. Doing so may further help to understand how buildings can be designed and constructed to make incremental changes possible and thereby more sustainable.

CONCLUSIONS

On the basis of the competition and preliminary experiences from the cases it may be concluded more generally that clients, designers and contractors have to take the following six steps into consideration when targeting design of buildings with capacity for incremental change:

In the overall design of the estates as well as of the individual buildings and dwellings considerations shall contain possibilities for flexibility in the use of the space.

The structure in the individual dwellings can be based on columns which permit use of light weight partition walls with the possibility to later alterations. A solution is also large floor elements supported by heavy wall elements.

For walls between dwellings it is more convenient to use heavy elements due to demand of reduction in noise and costs.

The installations shall take into account possibilities for replacements and new systems of energy, electricity, garbage and sewage.

It is important to consider operation and maintenance aspects of the finished building during the design and construction phase.

Special care must be taken for the possibilities of replacement of exposed and vulnerable parts of the structure as use of timber in the façade and steel construction for lifts. **AT**

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