AN ANALYTICAL TOOL FOR THE EVALUATION OF 'OPEN BUILDING' PROJECTS

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By

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May 2002

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ABSTRACT

AN ANALYTICAL TOOL FOR THE EVALUATION OF ‘OPEN BUILDING’ PROJECTS

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Housing, being one of the most important concerns of architecture, has always been an unsolved problem for researchers, especially for architects. This judgement is also valid for the Turkish case. In this work, ‘Open Building’ approach, based on the main principles of leveling, adaptability, variety, and sustainability is proposed as a solution to the quality and quantity related housing problems in Turkey. Examining the principles, strategies, and methods employed in the applied ‘Open Building’ projects, an analytical tool is developed to encourage the application of these principles, strategies, and methods in the Turkish context. The two-staged analytical tool evaluates the previous ‘Open Building’ projects’ decisions according to their success in satisfying the ‘Open Building’ issues, and the applicability of these decisions to the housing projects in Turkey, in terms of legal and technical restrictions. Aimed at guiding the designers, who are to apply the ‘Open Building’ principles to the housing initiatives in Turkey, the analytical tool firstly helps to select the best ‘Open Building’ applications, and then evaluates them within the legal and technical framework to determine their suitability to Turkey. In this thesis, the two projects, Next 21 Experimental Housing in Japan, and Voorburg Renovation Project in the Netherlands are evaluated according to the developed tool to demonstrate its operation and benefits in the design phase of the housing process. As a result of this study, it is concluded that ‘Open Building’ principles can be applicable to the Turkish context, and the developed tool would be helpful in implementing these principles to the housing designs.

Keywords: Open Building, Analytical Tool, Housing Problem in Turkey, User Participative Design.

ÖZET

‘AÇIK BİNA’ PROJELERİNİN DEĞERLENDİRİLMESİ İÇİN ÇÖZÜMSEL BİR ARAÇ

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İç Mimarlık ve Çevre Tasarımı Bölümü

Yüksek Lisans

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Mimarlığın en önemli ilgi alanlarından biri olan konut, her zaman araştırmacılar, özellikle de mimarlar için çözülmemiş bir sorun olmuştur. Bu yargı Türkiye’deki konut üretim süreci için de geçerlidir. Bu çalışmada Türkiye’deki nicel ve nitel konut problemlerine çözüm olarak, ana prensipleri kademelendirme, uyarlanabilirlik, çeşitlilik ve sürdürülebilirlik olan ‘Açık Bina’ yaklaşımı önerilmektedir. Daha önce ‘Açık Bina’ adı altında uygulanmış olan projelerin incelenmesiyle, amacı bu projelerde kullanılmış ilke, strateji ve yöntemlerin Türkiye bağlamında uygulanmasını teşvik etmek olan çözümsel bir araç geliştirilmiştir. İki aşamalı bu araç gerçekleştirilmiş ‘Açık Bina’ projelerinin kararlarını, öncelikle ‘Açık Bina’ amaçlarına uygunlukları ve daha sonra da bu kararların Türkiye’deki konut projelerine teknik ve hukuksal açıdan uygulanabilirlikleri yönünden değerlendirmektedir. Amacı Türkiye’deki konut girişimlerinde ‘Açık Bina’ ilkelerini uygulayacak olan tasarımcılara yol göstermek olan bu araç, ilk olarak en iyi ‘Açık Bina’ uygulamalarını seçmede, ikinci aşamada da bu projelerin strateji ve yöntemlerinin Türkiye’ye uygunluğunu değerlendirmede kullanılacaktır. Bu tezde, geliştirilen aracın konut tasarım sürecindeki kullanımını ve yararlarını göstermesi açısından Japonya’daki Next 21 Deneysel Konut Projesi ve Hollanda’daki Voorburg Yenileme Projesi karşılaştırmalı olarak değerlendirilmiştir. Bu çalışmada ‘Açık Bina’ ilkelerinin Türkiye bağlamında uygulanabilir olduğu sonucuna varılmış ve geliştirilen aracın konut üretim sürecindeki faydaları vurgulanmıştır.

Anahtar Kelimeler: ‘Açık Bina,’ Çözümsel Araç, Türkiye’deki Konut Sorunu, Kullanıcı Katılımlı Tasarım.

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1. INTRODUCTION

The housing problem in Turkey can be identified in terms of quality and quantity issues. The ‘open building’ approach is suggested as a solution to the defined problem being an alternative to the current housing process. In this study, an analytical tool to evaluate the ‘open building’ examples and select their appropriate design methods and strategies to be applied in the Turkish context to solve this housing problem is developed. The proposed tool guides the designers by providing the set of the criteria to be satisfied in housing projects, during the design phase of the building process.

1.1. Problem Definition

The housing problem has been dealt by many authors focusing on both quality and quantity issues in Turkey. Kazaz (1996) defined the housing problem in Turkey, emphasizing the problem sources as follows:

> The most emphasized side of the housing problem in our country like many other countries are quality and quantity. The major reason for this is the increase in the population, the housing need, because of the urbanization, additionally, the cost increase in housing. … Besides not satisfying the housing need, the conditions of the houses produced and urban areas show the ignorance of quality (p.560).

The housing problem in Turkey associated with the quality issue originates from the architectural design of the housing units. There is an ongoing monotony in housing projects, because of applying the same plan type repeatedly, which makes the residents unable to identify themselves with the housing units (Kazaz, 1996). This problem in Turkey is also stated by Andiç (1999) as the dwelling’s being unable to satisfy the desired quality level of different users, as well as decreasing their functionality in time.

Dülgeroğlu et. al. (1996) also dealt with the quality related housing problems in Turkey, stating that post-occupancy evaluations in the mass housing estates in Turkey indicate that a single solution would not satisfy the needs and desires of residents, due to their social and cultural differences. Also, she pointed out the impacts of functional change and spatial requirements emerging in future. Basically, the main emphasized points in all researches are related to the single type designs which are unable to satisfy the diversified needs of various users, and these designs' inability to be adapted in future according to changing requirements and preferences of the individuals. Thijssen (1991) also pointed out the matter of inadaptability, explaining the reasons of such a problem as follows: "Adjustments, in terms of changing floor plans in some rooms are mostly impossible. The building structure and also the inner walls are not flexible or movable. New dwellings in mass housing are still being designed and built, based on the same standards and patterns of the past." (p.3).

On the other hand, the main reasons of quantity problems can be stated as the migrations to the urban areas and the urgent housing demands after the earthquakes. Gur (1996) explained the housing demand in Turkey, by relating its reasons to the migrating rural population, as: "The need for housing … is attributed to the migrations of the poor rural populations to the existing towns of Turkey" (p.801). In addition to this anticipated demand, as in the other developing countries, unforeseen massive losses in the housing sector occur after earthquakes, because of the poor housing quality and the lack of control mechanism.

Within the context of these problems, various alternative approaches are proposed in literature. To satisfy the diversified demands and to provide adaptability, the flexibility approach has been suggested. Also, involving users in the building process is another suggestion to determine their preferences. Flexibility principle is offered as a solution to satisfy the residents' preferences with different socio-cultural backgrounds (Dülgeroğlu et. al., 1996). Also Thijssen (1991) proposed a similar solution: "…[T]he need for different types of dwellings is increasing and also the need for flexibility inside the dwellings themselves. …[T]he statical and unchangeable way of building in the field of mass housing in Turkey should be adjusted, and the dweller should be introduced as a party in the decision-making process" (p.3). The need for user involvement in the housing process is emphasized by Şahinler (1996) as well, to overcome the housing problem in Turkey by "responding the various demands of social groups with different cultural and regional characteristics" (p.547). This user-oriented scheme developed by Şahinler (1996) proposed that:

- Housing is an action,
- The user should take part in this action,
- Authorities should support this action,
- Planning and production organizations supported by the design team have to be established (e.g. mobile teams, voluntary support teams, cooperation with universities),
- The one way flow should be changed,
- Social differences should be taken into consideration in planning,
- House production should be turned to a means of educational and social planning (p.547).

The role of the designer in this process can be defined as an organizer with a leading role in developing new relations in communication with the user (Şahinler, 1996).

In addition to the quality problems, the solutions offered to overcome the limitations in quantity point out to the necessity of using industrialized technologies that allow rapid as well as earthquake-resistant buildings. Ertürk (1996) claimed that applying prefabrication and fast building technologies in Turkey is a must to solve the housing problems.

This study proposes the use of ‘open building’ principles which is a holistic approach integrating all of the stated issues (i.e. flexibility to provide adaptability and variety, user participation in decision-making, and the use of industrialized technologies to achieve these goals in short time) to solve the defined housing problems in Turkey. Taking into account the already existing squatter developments in urban areas, the ‘open building’ approach is suitable to Turkey for the following reasons: Firstly, since in squatter settlements, users build for themselves, these people are supposed to participate to the design process for their dwellings. Secondly, these areas are adapted by the occupants according to the changing needs. Lastly, there is an ongoing recycling of building elements due to low-income of the dwellers. These facts support the suitability of the ‘open building’ principles to the Turkish context in terms of participatory and flexible design, and the environmental sustainability aspects.

Supporting this proposal, applying the ‘levels’ theory of ‘open building’ that has already been offered by Thijssen (1991) as an alternative to the current building process in Turkey is described by him as follows: “In order to change the present way of designing and building in Turkey, other methods, building systems and techniques should be developed. In this respect, the application of the ‘new’ system of support structure and detachable units can give a contribution in solving the problems that were mentioned" (p.3).

1.2. Aim and Scope of the Study

Having proposed the 'open building' (OB) approach as an alternative to the current way of housing provision, the study develops a practical tool for designers that aim to apply the 'open building' principles in residential projects. This analytical tool guides the architects or interior architects by providing the chance of the comparative analysis of international variations of OB projects on a common basis, and determining their potential transferability to the Turkish context.

The major goal of this study is to develop a tool to be used in decision-making process of OB projects. This tool is an aid in evaluating the strategies and methods employed in previous projects in terms of their success or failure in achieving the OB principles. Also, it serves decision-makers in examining the potential applicability of these strategies and methods to the circumstances of Turkey. This thesis encompasses the development of an analytical tool to evaluate the elemental aspects of selected OB projects to appraise how 'open' the building is, and to determine these aspects' appropriateness in the Turkish context.

The principles of 'open building' constitute the basis of this tool forming the fundamental categories which allow the partial or whole evaluation of the projects, according to the criteria defined in the literature review. The tool is intended to function in the design phase of the building process, helping designers to evaluate the 'open building' design strategies and methods according to their appropriateness to the Turkish context in terms of legal and technical limitations.

1.3. Structure of the Thesis

This introductory chapter elucidates the necessity of an alternative approach in the housing process in Turkey. Having defined the housing problem in terms of the quality and quantity issues, the 'open building' approach is proposed as an alternative in the first section. The second section clarifies the aim of the thesis as the development of an analytical tool to assist designers during the application of 'open building' strategies and methods within the Turkish context. The last section explains the structure of the thesis.

The second chapter gives the necessary theoretical background of 'open building.' In the first section, the definition and the origin of the approach are given. The following section deals with the necessity of such an approach for the housing process. In the third section, the basic principles are reclassified by the author to constitute the basis of the analytical tool developed in the next chapter. Then, the strategies and methods employed in an 'open building' based processes are summarized within the framework of the criteria defined by Tiuri and Hedman (1998). In the last section the economy of 'open building' projects are discussed.

The third chapter of the thesis introduces the analytical tool to be used for the evaluation of 'open building' projects and the choice of proper alternatives for Turkey. Firstly, the purpose of the tool is mentioned, addressing the related phase of the building process and the user of the tool. The second section elucidates the sources of information utilized in the preparation of the tool. Then, in the third section, the structure of the tool is explained through the fundamental categories and the two-staged analysis method. The following sections deal with the operation and evaluation method of the tool. The final section encompasses the questions constituting the first stage and the second stage of the analysis.

The fourth chapter demonstrates the operation of the analytical tool by the comparative analysis of two 'open building' projects, Next 21 and Voorburg. Firstly, brief information is given about the projects. In the second and third sections, the comparison of the projects is done within the framework of the developed tool, and the achieved results are discussed.

Finally, in the concluding chapter, the benefits of the developed analytical tool, its organization, and the ways of employing it in the design process are summarized. The necessity of further research on 'open building approach to encourage its applicability in different contexts and the requirement of models examining the organizational and cultural factors, beside the technical issues dealt in this study are emphasized.

2. THE 'OPEN BUILDING' APPROACH

This chapter tries to constitute the theoretical framework for the proposed 'Open Building' (OB) tool. For this purpose, firstly, the definition and the origin of the OB are stated. Then, the necessity of the approach for the solution of housing problem is explained. Following this section, the basic principles of OB, and the strategies and methods used to achieve OB are elucidated to set the necessary framework for the analytical tool developed in the third chapter. Lastly, the possibility of efficiency in a residential project based on OB principles is discussed.

2.1. Definition and the Origin of 'Open Building'

The origin of the OB approach is based on the ideas of N. J. Habraken, who wrote the book *Supports: An Alternative to Mass Housing*, in which building support structures is proposed as an alternative to mass housing, in 1961 (Kendall & Teicher, 2000). Then, in 1965, SAR (Foundation for Architects' Research) was founded for encouraging industrialization in housing as the specific goal while placing itself to the center of the support movement (Kendall & Teicher, 2000). The targets of this support housing approach proposed by Habraken can be summarized as follows (Kendall & Teicher, 2000):

- support structures' being in harmony with local culture,
- separating individual decisions from the common ones,
- benefiting from industrial products.

As Tiuri and Hedman (1998) stated, “The principles of open building based on the ideas of N. J. Habraken link the efforts to develop industrialized building with an increase in the decision making power of the user. Open building is first introduced and developed in the Netherlands where pilot projects were built in the 1970s and 80s” (p.5). The objectives of OB are determined according to the principles of the historical environments which are sustainable by adapting themselves to the emerging needs (Kendall, 1999; Habraken, 1994; Kendall, n.d.; Kendall & Teicher, 2000).

> The open architecture … will produce very different kinds of built fields that respond to local and cultural demands. These fields may, in fact, incorporate high-rise and large-scale interventions. But they will, whatever their form, have exactly the same properties we found in historic fields: type, pattern and hierarchy will structure them; systematization will make them possible; intensification over time, driven by the powers of inhabitation, will enrich them. Above all, these fields will endure because they have the power to renew themselves from day to day” (Habraken, 1994, p.18).

The properties of the buildings in this kind of historical fields are summarized by Kendall (n.d.): “Most buildings, of any style, were relatively simple enclosure types, later filled in and subdivided again and again over time. Buildings were in general based more on convention and familiar types rather than tightly designed for specific users or their specific technical requirements.”

Basing on these historical principles, OB approach developed, and became an alternative to multi-family housing process with its own strategies and methods. Within this context, the current OB approach, evolving according to the economic, social and environmental consequences of the era, can be defined as follows:

> Open building is an innovative way of producing - and renovating -consumer-oriented neighborhoods and buildings. Its methods are aligned with the most advanced building technology, information management and construction logistics coming to market around the world. In large projects, application of open building principles means that a variety of interior layouts is no less

> difficult to install than uniform unit designs - thus leading to a better balance between supply and demand, reduced rework and happier customers. Open building assures that decisions made now - in new construction or major renovation - will enable buildings and urban fabric to remain valuable well into the future, because they are planned for change as well as stability (CIB W104, 2001).

Dekker (1998a) added this definition the objective of subsystem disentanglement by emphasizing the common attributes of open buildings as “modular and dimensional coordination, user oriented design and construction, computational support of design, construction and manufacturing, industrialization in the building industry” (p.311). Gann (1999) also underlined the use of industrial component parts in OB to deliver wider choice to residents.

These OB ideas, defined by CIB W104 (2001), Dekker (1998a), and Gann (1999), are not only valid for the new housing projects, but also for the rehabilitation of the existing housing estates, as well as the commercial, retail and institutional built environment (Kendall & Teicher, 2000). The usability of OB ideas to rehabilitations in residential and nonresidential contexts is also stated by Tiuri (1998), and Tiuri and Hedman (1998). Kendall (1999) explained how OB approach is employed in office building designs: “The main aspect of this approach – distinguishing a base building and tenant improvements – is a familiar process in other building types. Most office buildings undergo this process all the time; it is called ‘churn’” (p.95). In the office buildings, base buildings are constructed without determining the fit-out which is designed individually by the companies requiring different interior spaces, equipment and systems.

The OB approach differs from the conventional way of building in which a single program is adapted (Kendall & Teicher, 2000), since it is accepted in OB that single program is never enough to satisfy a wide range of needs and preferences, and also the future demands of occupants (see Figure 2.1). In the first diagram, households with differing preferences and economic possibilities are offered largely uniform, standard quality dwellings. For some, excess quality is provided, and for the others less than needed is offered. However, in open building approach, a multi-unit housing unit can be made in such a way that a variety of occupant preferences is satisfied. Gann (1999) pointed out to the need for designing buildings with capacity to accommodate different occupants and different uses. "In Open Building practice, **capacity** replaces the set program and its functional specificity during initial design. Capacity analysis is a complex and demanding practice at the core of Open Building. It is founded on two ideas: 1) designing form to be an open-ended and dynamic fabric; and 2) designing space or form (at multiple scales) with built-in capacity to accommodate more than one 'program of functions' over time" (Kendall & Teicher, 2000, p.38). Since supports of open buildings are designed and constructed with the capacity to allow variety and change, there is also a need for a method in infill designs to maintain these attributes. The 'pattern language' developed by Christopher Alexander that "describe the problems which occur over and over again in our environment, and then describe the core of the solutions to those problems" allow the design of units by using these patterns, without using the same type of design (qtd. in Haartsen, 1996).

a. traditional approach b. Open building approach

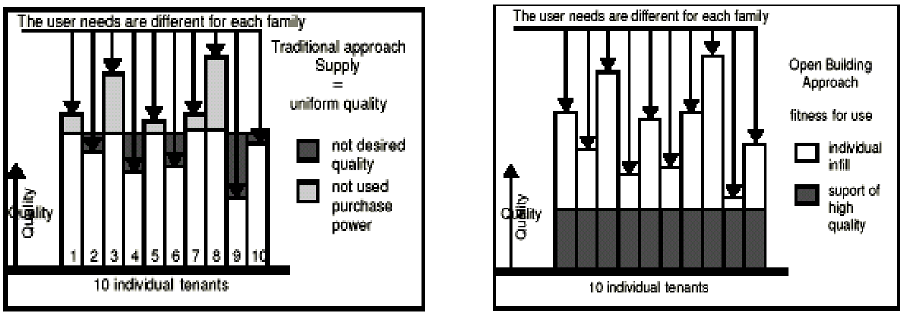


Figure 2.1. The difference of OB from the traditional way of building, where standard dwellings are provided to each occupant (Dekker, 1998a).

After defining the origin, the underlying historical principles, the current meaning of OB, and explaining where it can be employed, its basic difference from the traditional way of building is described in this section. The following section deals with the necessity of the OB approach as an alternative to the current housing process.

2.2. Necessity for the 'Open Building' Approach

The insufficiency of the current housing process necessitates an alternative approach to the housing problem. This insufficiency can be defined in three categories: a.dwellings' not offering any variety to users, b. inflexible designs unable to be adapted in future, and c. users' not participating to decisions related to them.

The standard houses provided to users, which are defined by Habraken as monotonous and repetitive (Gann, 1999), are unable to satisfy individual needs and preferences. However, as stated by Kendall (1996), the results of environmental design research indicate the fact that interiors of units which are designed according to occupants' preferences and budgets are better cared for and reduce expenses of maintenance, renovation, and rehabilitation. "The policy of building for an average dweller has led housing construction to produce quality which is partially unneeded while it remains unable to respond to the specific needs of all user groups" (Tiuri & Hedman, 1998, p.7). This leads to the problem of satisfactorily housing people, which is usually very complicated to solve in most countries (Harms, 1972).

The other reason for the inadequacy of today's housing solutions is that they are unable to be adapted according to the changing requirements. As Brezar (1996) stated, houses are used by many generations with differing needs: "In principle a flat, a house or a building undergo changes, accommodations and amendments during their lifetime. The life span (i.e. useable existence) of housing, especially in Europe, is much longer than of one, two or even three human generations" (Brezar, 1996, p.552). This issue is dealt by Zaman and Ganesan (1996) as well; mentioning that in a building's lifetime the needs of the inhabitants change continuously, which results in continuous refurbishment and readjustment of the environment. The causes of changing dwellings are defined by Habraken et. al. (1976) as:

a. The need for identification: People's need to recognize themselves and to be recognized.

b. Changes in life-style: Caused by contact with other cultures, and new ideas emerging about mankind and society and the availability of new technology, changing the ideas about what is 'practicable,' and new ideas about what is 'good' and what is 'bad' design.

c. New technological possibilities: New technologies' allowing changes in the utilization of available spaces, e.g. central heating's making open planning possible.

d. The changing family: Changes in the composition of family, not only in number, but also a series of different relationships and ways of living together, of different activities indoors and out-of-doors.

However, despite these needs of alteration, houses cannot be changed within the present situation. "…[H]ousing by nature is a dynamic process whereas the conventional dwelling unit is static and unable to adapt itself to changing dwelling needs" (Karni, 1995, p.39). Kendall and Teicher (2000) also indicated, "mass housing has proved inflexible, incapable of adjusting to social, economic and technical changes" (p.30).

The last reason for the insufficiency is users' not having any chance of being involved in the decision-making process of their own houses. "Mass housing had utterly excluded such participation and responsibility of individual households, entirely eliminating inhabitants from the housing process" (Kendall & Teicher, 2000, pp.9-10). This elimination of users from the decision-making process produces living environments unaware of users, mismatching the needs with the products. However, as stated by Habraken, it is a necessity for residents "to make independent dwelling decisions on their own behalf," rather than living housing units, all having the same character (qtd. in Kendall & Teicher, 2000, p.10).

The solutions for the above-identified problems are proposed in terms of providing adaptability, changeability, flexibility, and growth for dwellings (Brezar, 1996). The OB approach is offered as an alternative to the current housing process, asserting to satisfy these adaptability, changeability, flexibility and growth necessities in an efficient way. What OB presents more can be seen in Table 2.1 demonstrating the advantages of the approach to the traditional way of construction. These goals are examined in detail in the following section as the OB principles.

Table 2.1. Advantages of the OB approach (Gann, 1999, p.3).

Advantages
▪ High user satisfaction
▪ Adaptability for special needs
▪ Flexibility in initial design, to meet particular site requirements and future adaptation
▪ Choice of room layouts
▪ Improved space utilization and standards – e.g. use of roof space
▪ Choice of external finishes
▪ Improved sound insulation
▪ Separate structure from infill
▪ Location of electrical and mechanical services and differentiation by life cycle
▪ High environmental values, especially if recyclable and high quality of industrialized components parts, e.g. quick fit plumbing and electrical installation
▪ Multi-skilled labor requirements and speed of installation

2.3. The 'Open Building' Principles

When approaching to problems on housing OB uses a few basic principles as base. The topics to be discussed rest in the core of OB not only as basis but also as targets to attain. Different OB theoreticians emphasize different principles, however, a consensus is achieved on the terminology.

The key principles of OB are summarized by the Task Group 26 (TG26): Open Building Implementation of the International Council for Research and Innovation in Building and Construction (CIB), as follows (CIB W104: Open Building, 2001):

- working according to levels (urban fabric, base building, fit-out, furniture, etc),
- adaptability (changeability according to changing preferences and requirements of the consumers),
- variety with efficiency (variety is efficient using industrial capacity & advanced software),
- subsystems disentanglement (to decrease conflict and facilitate change of parts),
- sustainability (investment according to life cycle).

Another classification of OB principles is done taking into account the consumer satisfaction by Tiuri and Hedman (1998) in the context of a 'consumer oriented' approach. Some principles can be reviewed as "the development of more flexible structural systems and building services, adaptable and reusable infill component products, phased decision making and design procedures incorporating user participation, phased procurement and construction methods as well as products and services for the modification of the infill during the service life of the building" (p.5).

Kendall and Teicher (2000) also listed the key objectives of OB, adding the utilization of proprietary infill technologies as one of the OB principles in addition to tenant participation, consumer choice, flexibility for subsystem change out, disentangling systems and decision-making processes by level. These OB principles allow building projects that appreciate the financial situation and preferences of individuals reflecting their economic power directly to their unit designs (Kendall & Teicher, 2000). However, in fact it is not usually possible to apply all defined principles to a single project, but many housing designs exist where most of these principles are satisfied (Tiuri & Hedman, 1998).

In this study, the OB principles are explained to form the framework of the analytical tool developed in the following chapter. This section deals with the OB principles in four major categories trying to comprise all objectives defined in the previous studies. The first principle is the basis of the approach, i.e. the idea of levels, corresponding both to the level differentiation in decision-making of professionals and to the environmental levels of the building process (tissue, support and infill). Secondly, the category of flexibility is elucidated including the variety, adaptability and technical flexibility (systems disentanglement) issues. The third principle stands for the user involvement in the decision-making process, and lastly the sustainability objective of the OB approach is clarified dealing with the social and environmental sustainability concerns.

2.3.1. Principle of Levels

> Levels only become meaningful to the design process when we define them in terms of intervention: levels are people making decisions and acting, as well as the physical form which is subject to manipulation. … These are the levels of the environment: a higher level sets the stage for the next lower level, giving freedom to that lower level, while also giving constraints. In this way, a base building sets constraints for the tenant fit-out, and the position of walls of interior construction give space for furniture arrangement. If a higher level must adjust, it forces the lower next level to adjust to suit, while lower level has freedom to 'move' without forcing a change at the higher level" (Kendall, 1996, p.3).

As Kendall and Teicher (2000) stated, there exists an extensive knowledge base on OB, in terms of theory and applied research on environmental and decision-making **levels**. In this section, a summary of the studies dealing with the levels approach is tried to be given. Firstly, what the term ‘level’ refers is explained based on the OB experts’ (CIB, TG26) definitions.

“Levels define both the environmental professions and their field of operation—urban planning (tissue), architecture (base building), interior design (infill), furnishings” (Kendall & Teicher, 2000, p.32), considering the fact that the responsible agents are different in the phases of design, implementation, and use of the building (Kendall & Teicher, 2000). In this levels approach, technical, aesthetic, financial and social decisions are differentiated under separate **levels** of decision-making (Kendall & Teicher, 2000) (see Figure 2.2). Tiuri and Hedman (1998) elucidated how these levels are utilized in OB approach: “In open building, the built environment is regarded as compromising elements with differing paces of change. The decision makers on each level are identified and the building process is phased accordingly so that decisions on lower levels can be left and postponed to a stage where the users are known and can be involved in the planning and decision making” (p.5). As Tiuri (1998) pointed out the fact that some changes, such as the ones inside the dwellings, are more often needed than the support changes. The OB approach to this necessity of different frequencies of change in distinct parts of the building is trying to provide “a situation where decisions made on upper levels leave the contents of decisions made at lower levels open” (Tiuri, 1998, p.34).

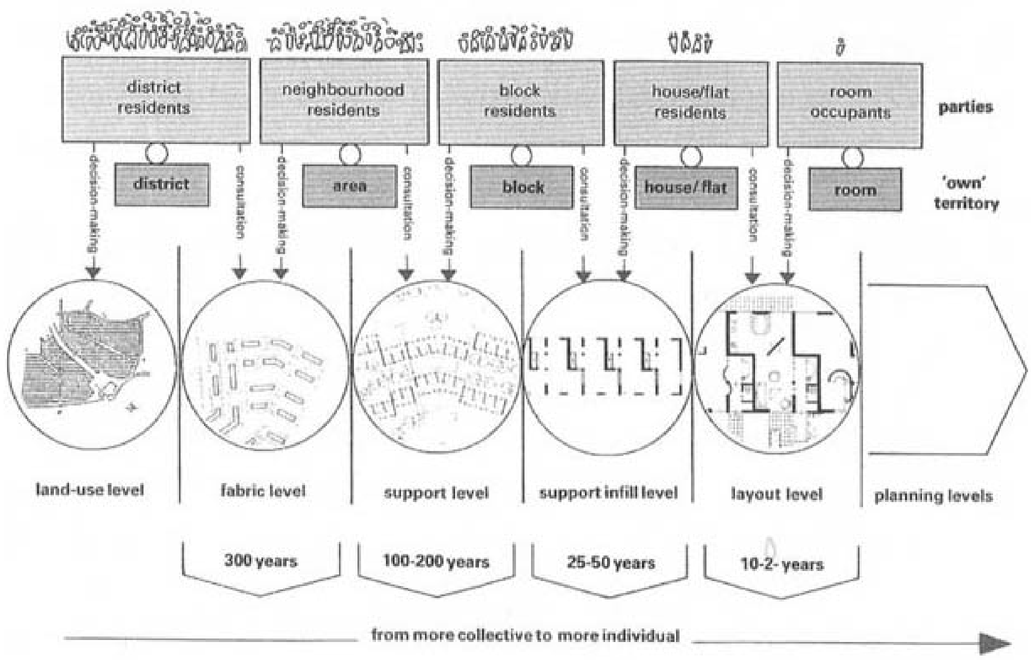


Figure 2.2. Decision-making levels in Open Building (Kendall & Teicher, 2000).

The benefits of this level-oriented approach are mentioned in many studies (Kendall & Teicher, 2000; Cuperus & Kapteijns, 1993; CIB W104, 2001; etc.). In the CIB W104 paper (2001), the possibility of fixing form and space at one level while offering capacity to the next lower level within the identified boundaries is stated, indicating, "it ensures that as buildings and neighborhoods are constructed and altered, each social unit (e.g. neighborhood council, condominium association, individual occupant) is assured a clear measure of freedom and responsibility, critical to the economic, physical and social health of a neighborhood or building complex" (CIB W104, 2001). This level-by-level change is also clarified by Cuperus and Kapteijns (1993), emphasizing the OB approach's distinction from the traditional way of building where building complexes are changed as a whole (see Figure 2.3). Since in OB, it is possible to change a level without disturbing the former one. For example, alterations can be made in infill without disturbing support level, whereas, in conventional building, the whole building must be altered.. Another benefit of the use of levels is the clarification among “the environmental agents in control – who controls what, and when” (Kendall & Teicher, 2000, p.31).

The difference between the levels separation and the systems differentiation in the traditional buildings, and the levels included in open building can be explained as follows:

> [In Open Building], [d]ecisions and physical parts are grouped according to distinct levels such as urban fabric (tissue), base building (support), fit-out (infill), and FF&E (furnishings, fixtures and equipment). … That is, levels correspond not to the normal division of building systems (structure, facade, mechanical systems, etc), but rather to a particular distribution of control which cuts across technical systems and jurisdictional boundaries (CIB W104, 2001).

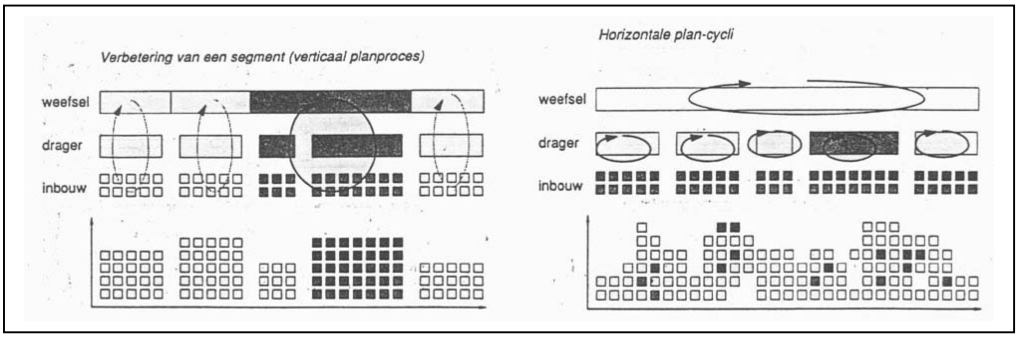


Figure 2.3. The difference between traditional building process (where levels change as a whole), and the OB approach of levels (Cuperus & Kapteijns, 1993).

Although the three basic levels in OB (tissue, support and infill) are separated, there is always a coordination among them: For example, buildings can be demolished and rebuilt, while the town fabric, a higher level than buildings (supports), stays the same

(CIB W104, 2001). This issue is also relevant for the support and infill levels' relationships (see Figure 2.4).

Related to the problem of which building elements belong to which level, it is not possible to find a single answer as Tiuri (1998) stated:

> The basic idea of open building, the different levels of decision-making, is in principle applicable to built environments irrespective of geographical, cultural, and economic factors. Yet these factors have an influence on what elements are considered to belong to each level and who is to participate in the decisions concerning their placement. Thus the levels concept has generated a wide variety of applications and differing outcomes all over the world" (p.5).

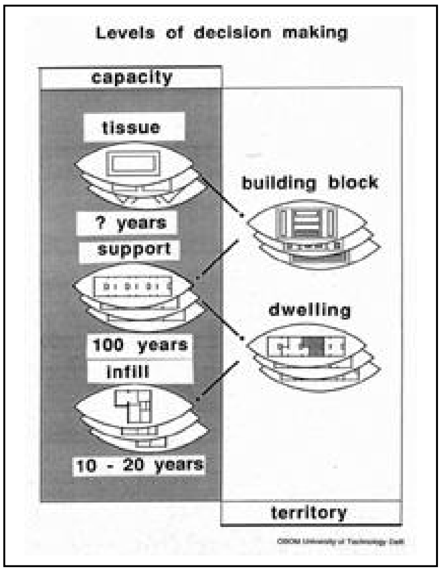


Figure 2.4. Levels of decision-making (CIB W104, 2001).

Habraken et. al. (1976) also dealt with this subject with the emphasis on the support and infill separation decisions, examining the effective factors. "…[T]he housing condition, on the image the people have of themselves and their society, on the amount of change of residential behavior and use of the dwelling over time" are mentioned as the determinants of the support-infill separation decisions, in addition to the technological possibilities (Habraken, et al., 1976, pp.22-23).

The separation between the support and infill levels corresponds to a strict technical /management distinction as well as a strict legal and contractual distinction among the decision-makers in the building process (Kendall, 1999). “By making a clear distinction between levels —based on distribution of control and technical systems—it is possible to make an accurate accounting of value and responsibilities. The separation between base building and fit-out—clarifying the shared parts and the parts for individual choice—is an accounting method applied to the built environment” (Kendall, 1999, pp.13-14). The major factor affecting this separation decisions is “the long-term and short-term cycles of value” (Kendall, 1999, p.13), i.e. the parts of building with longer lifetime belong to support level, whereas the individual parts with shorter lifespans to infill level.

The benefits of the distinction between support and infill is discussed by Gann (1999), Kendall (1986), and Kendall and Teicher (2000). Gann (1999) pointed out the worth of separating structure from interior, which allows the simplification of utilized technologies “with the potential to enable maintenance, change, adaptation and refurbishment to be carried out economically over a building’s lifetime” (p.16). Moreover, what Kendall (1986) emphasized is the consumers’ opportunity of “control all of the decisions rightfully made by them without affecting decisions rightfully made at the community level” (p.90).

> In open architecture, these infill parts may be independently installed or upgraded for each occupant in turn. … The separation intrinsic to an open architecture invests additional value, possibility and durability in the Support. Which is to say, the Support structure builds in valuable capacity for lower level change. Infill systems and parts will inevitably have to be changed many times throughout the life cycle of the building in which they are located. Therefore, they are designed and installed for optimum freedom of independent layout,

> construction, subsequent transformation and eventual replacement. At the same time, common systems and long-term durable parts shared by all occupants -for instance, foundations, structure, utility trunk lines, public corridors and stairs- are left viable and undisturbed (Kendall & Teicher, 2000, p.7).

Since in the following chapter, support and infill levels are handled separately in the development of the analytical tool, the definitions, characteristics, incorporated building systems, and the principles concerning their designs are elucidated individually for support and infill levels. As in this study, the single buildings are dealt with instead of the urban scale, the concentration is on the support (base-building) and the infill (fit-out) levels, not on the tissue. Thus, the explanations are focused on these levels and the separation among the support and infill, rather than the issues related to tissue.

a. Support

Support is a finished building, comprising those parts that are not part of the infill, allowing the provision of dwellings which can be built, altered and taken down, independently of the others by the help of variable fit-out (Habraken, 1972; Kendall & Teicher, 2000; Tiuri & Hedman, 1998). Supplying all common building elements that cannot be changed individually, "Supports provide the basic building shell" (Kendall, 1986, p.90), which encompass "the building structure and façade, entrances, staircases, corridors, elevators and trunk (main) lines for electricity, communications, water, gas, and drainage" (Kendall & Teicher, 2000, p.33).

Some of the advantages of support leveling, stated by Habraken (1972) are as follows:

- enabling the users involvement in the decision-making process by means of independent dwellings.
- enabling distinction between industrial production and site labor.

- distinguishing the general and the particular, thus allowing industrial development to take place.

- differentiating the field of the architect and that of the town planner.

The criteria to be incorporated by an ideal support design are defined by Habraken, et. al. (1976) and Kendall and Teicher (2000):

a. It should be possible to provide different layouts for the support units.
b. The floor area should be changed either by additional construction or by changing the boundaries of units within the support.
c. The support design should also allow non-residential facilities.

However, Habraken, et al. (1976) mentioned the fact that each support design is not required to fulfill all these conditions, but "The relevant criteria will have to be determined according to a particular situation" (p.45).

The characteristics that support buildings have are identified by many authors. For example, Habraken, et al (1976) emphasized the unnaturalness of supports in their spatial suggestions: "The support that offers specific kinds of space, which can be recognized, and evokes many different possibilities will be more successful" (p.24). Tiuri and Hedman (1998) and Kendall (1986) underlined the fact that the supports differ according to the site characteristics irrespective of their being constructed on site or from industrial components. Another issue indicating the support's site specificity is its dependency on local factors: "The Support is dominated by the local market, architectural styles, climate, building codes and land use rules, investment requirements and other local conditions. Thus, within its specific social and technical setting, the Support is built using locally appropriate means of design and construction" (Kendall & Teicher, 2000, p.33).

Another characteristic of supports is their potential of being transformed from existing building stock as well as being newly constructed (Kendall & Teicher, 2000). Moreover, they can be built "… of any conventional type multi-story elevator building, garden apartment walk-up type, or row house configuration, and of any conventional or unconventional construction method" (Kendall & MacFadyen, n.d.), but they should reflect values and preferences determined in common (Kendall & Teicher, 2000).

b. Infill

" Infill is defined as comprising the elements of the building whose positioning in or removal from the apartment is decided by the user irrespective of who designs, produces, installs or owns these elements. Elements of the infill have to be easily changeable, not necessarily by the user himself, to allow for the user and subsequent users to exercise their decision-making power" (Tiuri & Hedman, 1998, p.7). The parts constituting an infill are non-load bearing partitions, central heating, kitchen and bathroom equipment with all piping and wiring related to such equipment, doors, fixtures, cabinets, finishes and other elements needed to make an inhabitable unit in the support structure, totally differentiated from support level and given their own, independent deployment, which allows rapid installation according to the floor plan chosen for particular units (Habraken, 1992; Dekker, 1998a; Kendall & Teicher, 2000; Kendall, 1986).

Principles for the development of the infill system are categorized by Habraken (1992):

- **Reordering the deployment of conduits:** … The key to a successful infill system is … to find a new way to distribute all the conduits of the technical systems assuring that interfaces are eliminated as much as possible. …
- **Dimensions and Positions:** Once a certain system is deployed we want to know precisely where all its parts are and what dimensions they have. This is achieved by the use of a so-called 'band grid' … [which] allows for positioning rules for each subsystem.
- **Production and Installation:** … By the separation of these phases, the installation phase becomes relatively easy and can be done within a very short time, reducing the labor costs dramatically.
- **Saving onsite labor costs:** … the principles may be summarized as follows:
  a. the minimization of the interface between subsystems. …
  b. the prefabrication of parts. …
  c. the elimination of on-site measuring. …
  d. the elimination of on-site mistakes. …
  e. the elimination of the need for ad-hoc problem solving. …
- **Balance of costs:** The gain from saved labor costs in the installation phase pays for the production phase, resulting in a total for direct costs which is not more than what is needed with the traditional way of outfitting a dwelling unit (pp.6-7).

Since the infill is individually designed and adapted according to user's needs and preferences, "… it is introduced as 'the user's territory'" (Cuperus, 1998, p.5). This user-responsiveness and the changeability of the infill level are also stated by Kendall and Teicher (2000). This individuality of the dwelling units results in a different role for architects: "With the adoption of an infill approach, the roles of architects and consultants are altered significantly. Their work becomes more focused on architecture, which may be defined as the durable common part of the buildings" (Kendall & Teicher, 2000, p.35) i.e. in OB, the support is the realm of architecture.

One major property of the infill level is its being composed of industrialized components allowing the user to select among a wide variety: "Infill systems comprise elements based on a wide selection of variable non site-specific demountable components. They must be removable from the unit even after the building has been finished" (Tiuri & Hedman, 1998, p.8). However, it is not a necessity for infill being composed of industrially produced components, as stated by Kendall and Teicher (2000):

> It is quiet possible to fit-out a residential space in a Support using conventional construction. Infill elements need not be industrially produced. At present, both new construction and revalued building stock is fitted out with conventional residential infill, without systematic organization. From an organizational perspective, site-made partition walls are infill elements if the resident has control over their position, or if they can be changed independently of the Support without impacting any other dwelling (p.35).

To sum up, infills are user-responsive, changeable, and usually made up of industrial components to allow changeability, reusability, and variety; differing from the supports which are common, site-specific, reflecting local conditions and more durable.

2.3.2. Flexibility

Flexibility can simply be defined as the "design strategy that can accommodate the changing needs throughout the life-cycle of the occupancy" (Zaman & Ganesan, 1996, p.616). In this section, flexibility is dealt as variety—capacity to provide alternatives in initial design, and adaptability—capacity to be adapted according to changing needs, preferences, and desires of occupants. "A central idea in open building is to respond to the various needs of individual users through the phasing of the design, decision-making, and the implementation process" (Tiuri, 1998, p.5). Thus, the flexibility principle in OB is not only a way of adapting the units according to the emerging needs; moreover it is "a strategy for enabling the fulfillment of individual wishes without compromising the rights of the succeeding occupants" (Tiuri, 1998).

The necessity for providing flexibility in design is mentioned by Brezar (1996), Karni (1995), and Tiuri and Hedman (1998). Brezar (1996) explained this need due to the changes in family structure, psychological and sociological reasons, and the need for real improvement of living conditions, such as:

- the need to improve technical standards: to make better plumbing and fitting, to install central heating, provide hot water, to increase number of electrical plugs, to set better finishings (tiles, carpets, parquet), to build in better windows;
- the need for better security: to install window shutters, stronger entrance doors, to make entrance control easier, to provide more sophisticated ironmongery and locks;
- the need for better ecological performance: to add more thermal insulation, to improve noise protection, to control vapour penetration, to include alternative energy resources (e.g. passive solar gain by glazing balconies), to improve waste disposal facilities;
- the need for higher psychological standard: to provide privacy, to build higher and denser railings and parapets, to put additional glazed screens and overhangs;
- the need to improve general comfort: to assure more space (by decreasing the number of tenants), to improve the overall layout, to increase the usability of rooms, to remove various obstacles (thresholds, dead angles), to provide better lighting;
- to meet the desire for social position attributes: to offer the means of expressing the identity with architectural elements, furnishing, materials, colors and other symbols (p.553).

The similar reasons for the necessity of flexibility were also emphasized by Karni (1995): “Increasing/decreasing floor area or living space in housing projects is a natural demand resulting from familial life-cycle needs, living standards, modern household appliances, lifestyle and fashion” (p.39). A different issue related to the changes in family are also pointed out by Tiuri and Hedman (1998) mentioning another phase in the family’s cycle, which emerges the need of considering the requirements for the elderly people and accessibility, resulting in a necessity to alter wet spaces and their fitments.

To satisfy these different requirements, one basic need in the housing projects is the spatial changes (changes in layout) "to match personal needs without forcing dwellers to move into new apartments" (Karni, 1995, p.39). Beside changing the layout, the adaptations in a building can be increasing or decreasing the floor area either by adding new parts, or by changing the party walls between the units, and changing some functions in the units (Habraken, et al., 1976). To make these kinds of changes possible, OB has the objective of 'subsystems disentanglement' to allow the replacement or repairing of one system without disrupting other systems. Moreover, independent distribution of services to units is provided to allow the adjustment or replacement of them without disturbing other dwellings. Tiuri and Hedman (1998) explained this distribution of building service systems independently, "Building services are distinguished between systems serving the building and those serving the individual units. Services are supplied to each potential unit in risers belonging to support level and distributed to each unit independently (at the infill level)" (p.10).

To satisfy the needs of change in dwellings, three degrees of flexibility are possible in housing designs, as proposed by Friedman (1994) and Zaman and Ganesan (1996):

1. Maximum flexibility: This corresponds to providing maximum flexibility to occupants by totally separating the common and individual elements, i.e. the support and the infill.

2. 'Built-in' flexibility: This is design to provide installation of components either by industrial or conventional methods to allow flexibility within the defined boundaries. (In this kind of flexibility, "the dividing line between collective structure and built-in package is important, because this indicates the extent to which the dwelling is 'convertible'" (Priemus, 1993, p.22)).

3. Conventional: In this type of design, there is no flexibility offered to users.

Gann (1999) also dealt with this subject, stating a rough differentiation between the offered flexibility degrees: “There are different degrees of flexibility ranging from the capability to accommodate minor cosmetic changes, such as internal or external colour schemes and finishes, to the capacity to cater for major changes in spatial arrangements, including the reallocation of space and reconfiguration of dwelling size to meet changes in demand” (p.1). The factors affecting these degrees of flexibility can be simply based on the “design decisions as well as the structural systems forming the support” (Tiuri & Hedman, 1998, p.16). Cuperus (1998) explained the determinants of flexibility within the context of building’s physical characteristics, and lists “the three potential aspects of the capacity to change” as the levels of decision-making, the building’s structure, and its building parts (close connection or loose fitness) (p.7).

Based on the determined factors effective on the flexibility levels, Karni (1995) explicated the architectural methods for providing flexible interiors:

> …[A]rchitectural solutions for providing freedom to alter the sub-division of the interior space should enjoy the following characteristics: they should be easy to handle and to carry out (--implying unsophisticated attachment details and simple assembly equipment); building materials should be recycled as much as possible when changes are made in order to reduce costs; the infrastructure of the apartments should not be damaged whenever partitions are moved; a market for additional partitioning components should always be available; and finally a possibility for self-help building (no need to hire skilled workers) is highly beneficial (p.40).

He also mentioned some design guidelines in order to take advantage of the space-dividing capability of the partition walls. Some of the points Karni (1995) indicated were the partition's being an industrialized modular building element, lightweight and easy to be moved, installed by one or two persons, and compatible with the other industrialized building components.

To sum up, in this section, the aim and necessity of this principle are clarified, summarizing the design approaches and strategies to achieve flexible interiors for housing designs.

2.3.3. User Participation in Decision-making

Users' active role in an OB-based building process is stated by Tiuri and Hedman (1998), by asserting user's position "as a subject instead of an object" (p.3). "Increasing the influence of the user in habitation is the key objective of open building. The other aspects introduced in the criteria represent the means to accomplish this in spatial design as well as in terms of building techniques and the organization of the building process" (Tiuri & Hedman, 1998, p.8). Thus, in OB approach, one of the main objectives is users' participating to the decisions related to them. Here, the term 'participation' implies "the presence of the users during the whole course of the architectural operation which passes through three phases; the definition of the problem, the elaboration of the solution, and the evaluation of the results" (Sanoff, 1992, p.57). Sanoff (1992) summarized the theories and practices of participation in five statements:

1. There is no 'best solution' to design problems.
2. 'Expert' decisions are not necessarily better than 'lay' decisions.
3. A design or planning task can be made 'transparent.'
4. All individuals and interest groups should come together in an open forum.

5. The process is continuous and ever changing (pp.59-60).

Sanoff (1992) also defined seven forms of participation in design process as follows:

- Representation: Architects consider users' desires and personal needs.
- Questionnaires: Statistical information is gathered about users' requirements.
- Regionalism: Geographic and cultural situation is also cared in this method in addition to specific user requirements.
- Dialogue: This corresponds to informal conversations between the designer and the prospective occupant, who states his own preferences about the design. Alternatives (users' choosing among a set of alternatives within a fixed set of boundaries),
- Co-decision: In this form of participation, users are involved directly in the whole design process.
- Self-decision: Users are the only decision-makers, and architect's role is " to ensure that society's fundamental demands of security are respected" (p.63).

In the OB approach, the ideal participation forms among these seven are co-decision and self-decision, though offering alternatives can also be an OB-like approach when the other forms are not possible to apply.

The visualization tools which can be employed during this user participation process of OB approach can be examined in two categories: "traditional (pen and paper, paper maps, photographs, and models) and computerized (GIS, three-dimensional modeling, virtual reality, and urban simulation)" (Al-Kodmany, 1999, p.1). Al-Kodmany also makes some suggestions about using these tools:

> …[I]ntegrating traditional public participation tools with new technologies can be useful. Traditional tools may create the social learning environment that enables participants to talk about a project together, to interact with other

> stakeholders, and to propose ideas. Used on their own, however, the traditional, non-computerized tools lack the capabilities for sophisticated analysis, display, and visualization that may enable the public to make more informed decisions. Conversely, high-tech tools must do better at interactively engaging the public if they are to be used as stand-alone community planning tools…[W]hen choosing a computerized method for use with the community, it must be as simple and unintimidating as possible in order to facilitate a high degree of involvement" (Al-Kodmany, 1999, p.1).

Zaman and Ganesan (1996) suggested the use of full-scale 'mock-up' models for the involvement of the occupants, mentioning the positive outcome of this visualization tool in terms of satisfaction level of users and designers' being able to collect individual preferences on fittings as well as the overall layout.

Sanoff (1992) defined the designer's role in the participation process as "the technical specialist who makes recommendations and develops the necessary design documents … which everyone can read clearly …" (p.76). Moreover, Habraken et al (1976) pointed out the position of the designer indicating the necessity to "design a set of rules, governing possible variations, … which are simple enough for the resident to visualize all the possible options for change open to him" (p.23) during the participation process, to provide enough freedom to make decisions.

In brief, Kendall and Teicher (2000) summarized the ways of allowing user choice and decision-making as:

- Recasting the role of the dwelling designer as a professional who assists inhabitants in realizing their own dwelling preferences.
- Utilizing information management tools that immediately show dwellers the implications of their design decisions. For example, utilizing software that illustrates the effect of each appliance, system or finish selection on the final installation price of an infill package.
- Supporting and enabling the free configuration of space by tenants.
- With rental housing, allowing tenants to own and maintain infill within rented space(p.47).

2.3.4. Sustainability

One of the primary goals of OB is providing sustainable development in the built environment. Before examining how OB achieves this goal, what is meant by the terms sustainable development and sustainable construction is examined. Bourdeau (1999) gave some definitions for sustainable development:

- improving the quality of human life while living within the carrying capacity of supporting ecosystems (Caring for the Earth, IUCN/UNEP 1991);
- development that delivers basic environmental, social and economic services to all residences of a community without threatening the viability of natural, built, and social systems upon which the delivery of those systems depends (International Council for Local Environmental Initiatives, ICLEI 1996) (p.357).

Related to the issue of sustainable construction, Kibert's definition can be considered as a starting point: "the creation and responsible management of a healthy built environment based on resource efficient and ecological principles" (qtd. in Bourdeau, 1999, p.357).

The key elements in various sustainable construction definitions are summarized by Bourdeau (1999) as:

- reducing the use of energy sources and depletion of mineral resources;
- conserving natural areas and bio-diversity;
- maintaining the quality of the built environment and management of healthy indoor environments (p.358).

Below is summarized the main results of the CIB Report (225): Sustainable Development and the Future of Construction — A comparison of visions from various countries (1998) (Fujita Research, 2000) to demonstrate the major foci of sustainable construction (Table 2.2).

Table 2.2. Summary of the sustainable development concerns (Fujita Research, 2000).

Built environment and ecological systems • Understanding impact of built environment on ecosystems • Impact of human activities on ecological systems • Producing research-based information to contribute to the ethical discussion • Investigating problems and solutions for sprawl of city agglomerations.
Energy saving • Continuing with a policy of energy saving • Targeting technologies which will allow buildings to use 50% less energy • Adopting an integrated process to energy consumption • Using innovative design, systems and products to reach energy efficiency goals: integration of renewable energy systems in new construction and retrofitting existing stock • Developing energy efficient designs for low cost housing • Assessing energy use in materials used (and in the construction process itself) when considering energy efficiency.
Health and comfort • Understanding impact of built environment on health • Improving air quality • Decreasing health risks • Investigating social sustainability of self-build • Improving clean-up procedure of contaminated land
Waste • Improving waste management • Reducing environmental impact of construction waste through minimization and recycling
Resources saving • Forecasting fresh water shortages • Development and use of water-saving technologies • Development of systems for collecting rain water • Developing construction materials savings • Supporting use of indigenous materials • Recycling, reuse and substitution of recyclable materials • Developing efficient use of raw materials • Development of new, innovative materials • Understanding of natural sand transport phenomena • Improvement of contaminated land clean-up procedures • On-line product information systems • Improved durability of coatings • Increasing the life-expectancy of indigenous materials and technologies
Building stock • Upgrading performance of existing building stock • Developing non-destructive diagnostic tools for condition assessment • Developing models for service life prediction. • Development of new technologies for renovating and retrofitting.

Table 2.2. Continued.

Tools • Publication of best practices in sustainable building • Developing assessment methods • Introducing performance-related environmental standards • Introducing a reliable labeling scheme • Increasing the emphasis, at R&D stage, of life-cycle analysis and multi-criteria evaluation of materials, services and constructions • Developing tools for the assessment and certification of life-cycle performance of buildings • Inventory of all life-cycle costs and suitable indices for measuring performance • Development of tools to allow linking of environmental and economic costs • Development of usable environmental accounting tools • Modulating a 'building-to-last' concept • Comprehensive databases • Tools to estimate preference for temporary or long-lasting buildings • The development (and dissemination) of techniques for reviewing environmental impacts • Compiling a set of performance indicators to cover: the construction process, completed buildings and civil engineering projects, the operation of existing works, deconstruction and disposal, and tolerance levels for radioactive building materials
Building process • The need for short (as well as long) term construction activities • The improvement of the building process • Pushing life-cycle thinking as the guiding principle for the construction process • Renewal engineering methods • Management and business practices • Design technology: new standards, open buildings, advance jointing and assembly techniques • Construction: open building, process reengineering • Materials and systems: new function integrated building components, durability, reparability, and retrofit-ability of the products • Investigate social sustainability issues surrounding self-build

Koebel (1999) mentioned the durability, energy efficiency, and minimizing the waste of land and material resources as major objectives of sustainable residential development, stating that achieving this sustainability necessitates innovation in building technology as well as innovation in the building process. An OB approach to satisfy the sustainability objectives defined by Koebel (1999) is extending the lifespan of building materials, which is accomplished in OB by employing reusable components, by using industrialized standard components, which allow coordination in the connections (Haartsen, 1996). “Within the context of the whole service life of a building, open building identifies the parts with different lifespans and promotes the reuse of the more rapidly changing infill elements” (Tiuri & Hedman, 1998, p.8).

In addition to these technical issues which are related to environmental sustainability, built environment should also satisfy the sustainability issues related to social and individual preferences and values. Koebel (1999) also indicated the significance of appreciating that "… longer-lasting buildings will witness multiple occupants and multiple uses, some of which we simply cannot foresee" (p.76), and thus, suggested that to achieve sustainability, during the design of buildings, adaptability should be considered as well. Kendall (1999) also points out this issue, suggesting "… to view the built environment as an artifact that is never finished" (p.2), allowing change according to occupant needs and choice. Another goal in sustainable development policies is maintaining income and household diversity according to the social sustainability point of view, and OB is a way to achieve reasonable income and household diversity in new housing estates (Kendall, 1999).

Within this context, OB approach is an attempt to satisfy both the environmental and social issues of sustainability, and to provide a sustainable residential environment. "This perspective of a building stock with planned stability and capacity to change is fully complementary with the pressing issues of environmental ethics, cradle-to-grave embodied energy, recycling, use of non-toxic materials and other vital issues in the worldwide sustainability agenda" (Kendall, 1999, p.1).

> Recognition is growing worldwide that environments that achieve sustainability do so in part because they can adjust with reduced waste and disruption. Many now realize that making sustainable buildings involves not only better technical systems and know-how, but also the direct involvement of professionals and everyday citizens. In that sense, open building is an alternative to the functionalist paradigm of design and construction inherited from simpler times, in which activities are fixed and physical systems are wrapped around and entwined with these 'functions.' Because human activities change in unforeseen

ways at varied time cycles, such entangled buildings prove to be dysfunctional, wasteful and a burden on society. The challenge is to find the optimal relationship between the use of resources for energy and water and the levels - destination - tissue - support -infill (CIB W104, 2001).

2.4. 'Open Building' Strategies and Methods

In this section, a brief explanation of the specific OB strategies and methods is given within the framework of the studies of Tiuri (1998) and Tiuri and Hedman (1998)., which provide the OB criteria for housing. The studies provide the detailed OB criteria employed for housing designs (see Table 2.3).

Table 2.3. Open Building Criteria in Housing with Regard to the Levels of Support and Infill (Tiuri, 1998, pp.40-41).

User as a Decision Maker A1 User decides on floor plan with infill A2 User participation on the support level
Open Spatial Structure A3 Regulation of the distribution of spatial units A4 Free configuration of the floor plan of individual units
Separation of Support and Infill Systems A5 Open frame structure A6 Distribution of building services independently to each unit A7 Access floor or service zones A8 Infill systems for services A9 Infill systems for partitions A10 Infill systems for facades
Open Building Process A11 Distinction between support and infill in decision-making and design A12 Procedures for user participation A13 Distinction between functional and technical design A14 Implementation of infill unit by unit

1. User as a Decision Maker

- User decides on floor plan with infill: According to OB criteria, users should participate individually to the decisions about their own dwellings, change the interiors when needed. However, when it is not possible to design units individually, users can choose their floor plans between the offered alternatives, or only the first users can be involved in the design phase to achieve a more 'open' building (Tiuri & Hedman, 1998).

- User participation on the support level: In an OB-based approach, users are also involved in the decision-making process of common facilities. They participate collectively to the support decisions (Tiuri & Hedman, 1998).

2. Open Spatial Structure

- Regulation of the distribution of spatial units: In OB projects, spatial units are organized according to the specially developed positioning and dimensioning rules, such as the band grid developed by the SAR (Kendall & Teicher, 2000). These rules guide the architect while designing the units according to user preferences and needs.
- Free configuration of the floor plan of individual units: To allow maximum freedom to users for designing their own dwellings, the building components belonging to individual dwelling units are in the infill level, such as "the elements defining the floor plan and services inside the units…" (Tiuri, 1998, p.40).

3. Separation of Support and Infill Systems

- Open frame structure: Open frame structures improve the degree of flexibility achieved in the OB designs.
- Distribution of building services independently to each unit

- Access floor or service zones: "Access floor or service zones are needed for the distribution of infill service systems inside a unit independently of other units to allow for alternative floor plan configurations" (Tiuri & Hedman, 1998, p.10).
- Infill systems for services
- Infill systems for partitions
- Infill systems for facades

  For the infill systems, one major objective is "manufacture and design for assembly, disassembly, and reuse," (Kendall, 1999, p.14), i.e. used elements should be compatible with other elements irrespective of their being produced by the same company or not. This means that the chosen systems should have "standardized technical interfaces, dimensions and locations, so that any subsystem which adheres to industry-wide performance standards may be used" (Kendall & Teicher, 2000, p.47). When compiling an infill system, another objective is employing the building elements available in the local market (Habraken, 1992).

4. Open Building Process

- Distinction between support and infill in decision-making and design: The decisions are differentiated according to their belonging to support or infill levels. The support decisions determine the limits and allow a variety of infill designs. At the same time, different infill designs do not affect the design of the support (Tiuri & Hedman, 1998).
- Procedures for user participation: For the user participation process, group meetings and consultation by architects or interior designers are mentioned as a necessity by Tiuri and Hedman (1998), for determining the plan layout and

deciding on the places of infill components. "…[V]isualization and evaluation methods based on 3D drawings or full scale models" (Tiuri & Hedman, 1998, p.11) are also important in this participation process for users' full involvement. The importance of the use of software technologies in both design and manufacturing processes of OB was pointed out by Gann (1999), and Kendall and MacFadyen (n.d.). Moreover, Tiuri and Hedman (1998) indicated "… the necessity of methods for immediate calculation of the cost or rent implications of alternative choices" (p.11) in the user participation process, especially for infill designs.

- Distinction between functional and technical design: By the use of modular, standard building components, it is possible to differentiate the technical and functional design.
- Implementation of infill unit by unit: In OB, infill packages are installed unit by unit. Sometimes, infill parts are implemented by the resident (Tiuri & Hedman, 1998), resulting in decrease of the labor costs.

2.5. Economy in Open Buildings

There is an ongoing debate on the economy of the OB projects. Although the cost efficiency of the approach is not the concern of this study, a brief explanation is given to demonstrate that beside the other advantages provided by OB, the approach constitutes a feasible alternative to the current process as well. Habraken (1992) mentioned that OB "… is also economically competitive compared to existing modes of outfitting dwelling units. It therefore constitutes a breakthrough combining increased adaptability with more efficient products" (p.1). One of the reasons that OB can also be economical was explicated by Kendall (1993):

> The idea coming to be recognized is that if certain processes are realigned, it can cost the same or even less to have users decide their dwelling plans. … By dividing the residential project into base building and fit-out, a developer can defer unit decisions until time of purchase or lease, rather than try to forecast demand many months or years in advance (p.96).

As Kendall and Teicher (2000) stated, “Analyses by Karel Dekker and others had shown conclusively that Supports represented a viable economic model” (p.15); and in the European context, the costs of the OB projects have been equivalent to the projects employing traditional methods of design and construction (Kendall & MacFadyen, n.d.). However, as mentioned by Gann (1999), the viability and cost-effectiveness of OB still necessitates “the development of effective mechanisms for eliciting user requirements and understanding life-cycle costs” (p.2).

In this chapter, the relevant literature review about the ‘open building’ approach is given. The definition, and the necessity of such an approach are explained; and the major principles, and the strategies and methods specific to ‘open building’ are elucidated in a detailed manner to provide the necessary framework for the following chapter, where the analytical tool to examine the appropriate OB methods and strategies to achieve the OB principles within the Turkish context is developed.

3. AN ANALYTICAL TOOL FOR THE EVALUATION OF ‘OPEN BUILDING’ PROJECTS

Taking into account the necessity of change in the housing process in Turkey, in this chapter, a practical tool for the comparative analysis of international variations of OB projects, and for determining their potential transferability to the Turkish context is developed with the focus on urban multi-family housing. After determining the relevant criteria to be satisfied in a successful OB project and the applicability criteria to the Turkish context, the analytical tool is structured in the form of questions, acting as a checklist for designers.

3.1. Purpose of the Tool

The aim is to develop a tool to be used during decision-making process:

a. to evaluate the strategies and methods, employed during previous projects, in terms of their success or failure in achieving OB principles,
b. to examine the potential applicability of these strategies and methods in Turkey.

The main purpose of this tool is to guide the designers in the application of OB principles to urban housing projects to evaluate the elemental aspects of selected OB projects to appraise how ‘open’ the building is, and to determine these aspects' appropriateness in the Turkish context. Besides it provides the chance of evaluation of OB projects on a common basis, and the systematic assessment of the OB issues within the Turkish conditions and limitations.

In the previous chapter, the literature review relative to OB approach is conducted to identify the main principles of OB that function as the fundamental categories of the tool. The tool is intended to function in the design phase of the building process through the problem definition (needs assessment), design, construction, and use phases (Pultar, 2000). In an OB-based approach to building process, since both design and construction phases act in two stages as support and infill, the analytical tool would be helpful in both support and infill design phases (see Figure 3.1).

A total design process encompasses the 'analysis, synthesis, and evaluation.' In the analysis, the definition and acceptance criteria are derived; the synthesis is the process which contains the creative element of design, and in the last stage, the proposed solutions are evaluated according to the criteria derived in the analysis (Cornick, 1991). The tool proposed in this study is related to the criteria to be defined in the analysis stage of the design process for the selection of design strategies (see Figure 3.2).

> The selection of both [design and implementation] strategies depends upon several characteristics, among them the builder's organizational capability, the technical skill of his trades and the availability of system components, demand and supply factors in the housing market at the time of project conceptualization, 'needs,' 'wants,' and affordability of the particular users' group in the project's proposed location and the project's physical characteristics as influenced by the architect, by-laws, codes, and standards, among other factors (Friedman, 1994, p.5).

If OB principles would be one of the factors to affect the design decisions and the selection of design strategies, this tool will guide the architect or the interior designer to regard OB approach during the decision-making process, providing the relevant criteria to analyze within the context of the approach with respect to the Turkish conditions.

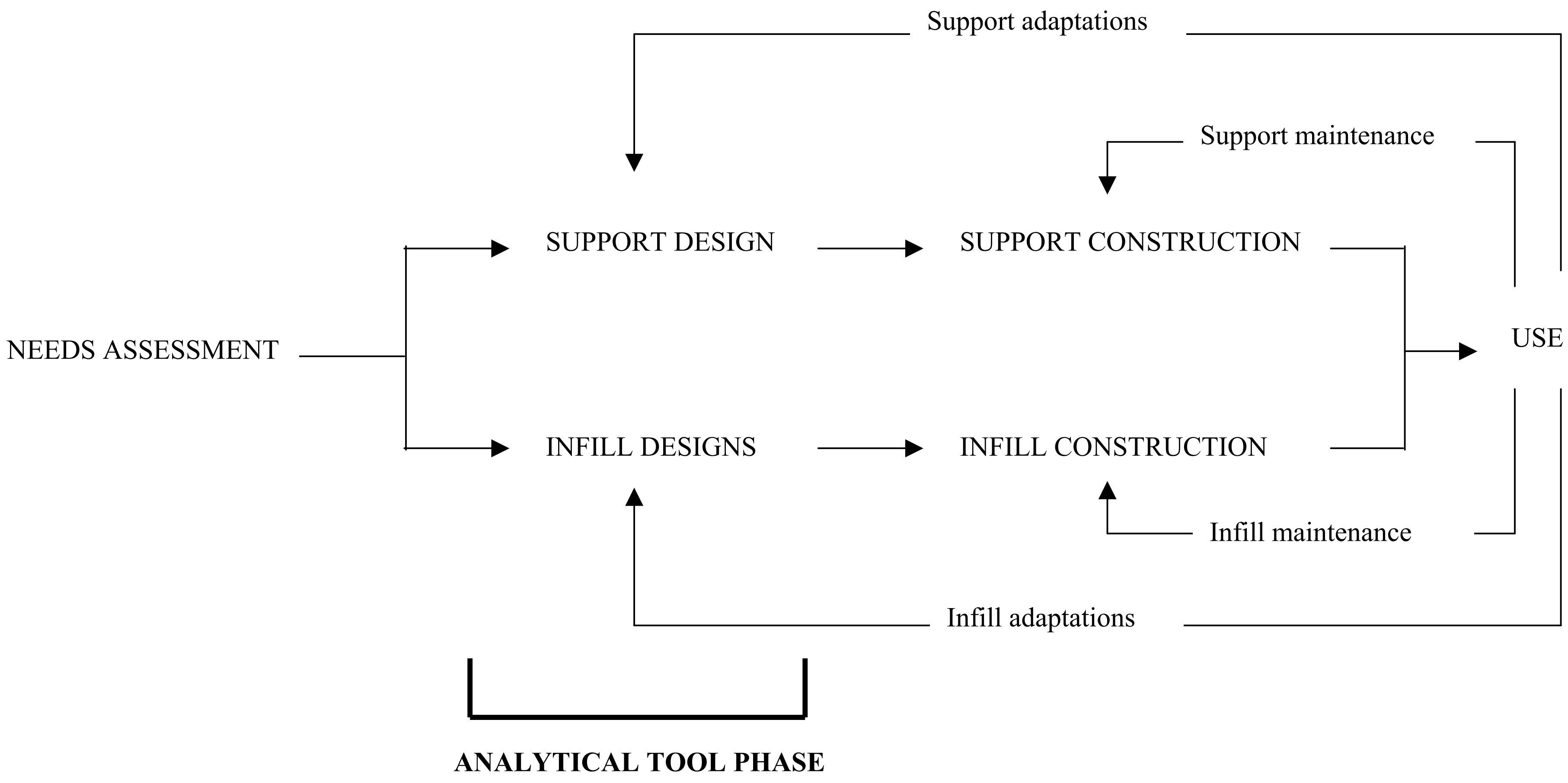


Figure 3.1. Building process based on OB approach, indicating the analytical tool phase (adapted from the building process model (Planning-Programming→Design→Construction→Use] by Pultar (2000)).

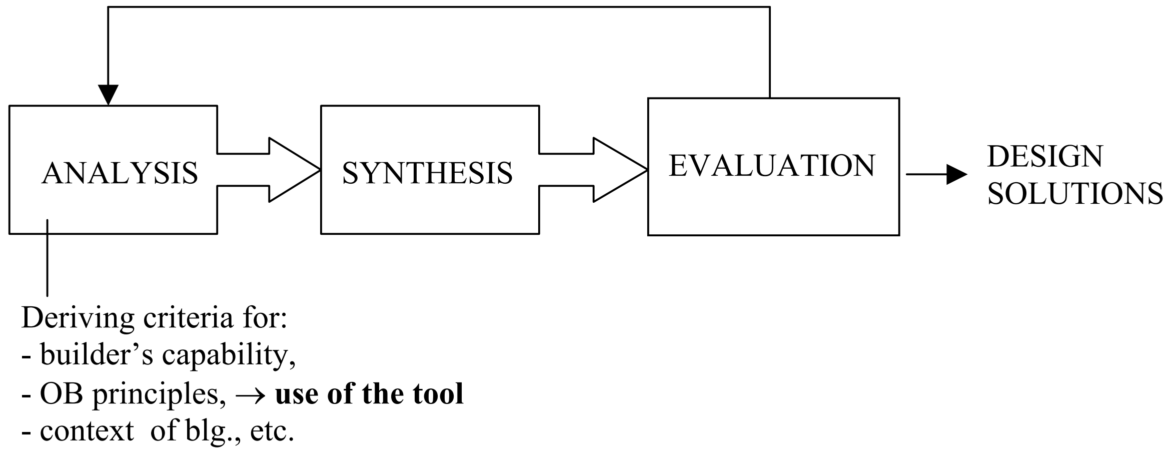


Figure 3.2. Design process model, showing the stage of using the analytical tool (adapted from the design process model by Asimow (1962)).

Since this study only concerns the design phase of the building process from the designer's point of view, neither the organizational or institutional contexts, nor post-construction (use) periods are dealt. Thus, the OB principles examined only include the ones related to the decisions of architects and interior designers.

3.2. Sources of Information

While preparing the tool, basic sources of information for the first stage are the theoretical knowledge about the OB approach, and the written document and drawings of the OB or OB-like projects. Research on the OB principles was the first step to define the fundamental categories of the tool. After defining the categories of the tool, an examination of the international OB projects was done to determine the primary criteria of these projects. Following this search, the first-stage questions of the tool are formed relative to the critical factors considered in the design and construction phases of the OB projects.

The second stage deals with the information that is effective in the technical aspects of design within the Turkish context. For the second stage, national and local building codes are investigated to identify the requirements of buildings to be constructed in Turkey, and the guidebooks about the available technologies are examined for the designers during the evaluation process (see Table 3.1). Questions of this part are prepared based on the relevant sources to help the user in quickly determining and assessing the compatibility of decisions to Turkey.

Table 3.1. Source and type of information related to the technical aspects of design in Turkey.

SOURCE	AVAILABLE INFORMATION
- Building Codes of Municipalities	- Minimum standards of functions and sizes, - Lighting and ventilation requirements, - Environmental compatibility requirements.
- Fire Safety Codes	- Fire resistance properties necessary in material selection for walls, slabs, roofs, etc. - Standards related to means of egress.
- Regulations for the Buildings in Disaster Prone Areas	- Seismic design limitations in Turkey for structural system.
- Turkish Standards - Turkish Standards for Accessibility	- Standards about construction materials and building - Standards for corridors, stairs, doors, elevators, etc.
- Flat Ownership Law	- Common functions in a residential building.
- Elevator by-laws	- Minimum dimensions for elevators.
- Thermal Insulation Regulations	- Standards for thermal design (minimum, sizes, numbers, ventilation requirements).
- Building Catalogues	- Technical data provided by manufacturers concerning available building materials, systems, etc.

3.3. Structure of the Tool

The two-staged analytical tool is structured under the main **categories**, which are derived from the results of the search on OB principles. Each category is again classified according to the major **goals** of the relevant principle. This classification is employed in the first stage of the analysis, to compile the questions related to the strategies and methods of OB principles being specific to the stated goal. In the latter stage, the previous questions are examined within the framework of their applicability to Turkey.

3.3.1. Fundamental Categories

The categories of the tool are based on the characteristics that define the OB approach, such as support-infill separation, user as a decision-maker, sustainability, and flexibility, as mentioned by Tiuri and Beisi (qtd. in Kendall & Teicher, 2000). In this study, a new classification is done depending on the previous studies. Each category of the tool includes sub-categories related to the major goals (key factors), which are essential considerations of an OB project that is to succeed in Turkey. These questions deal with either the success level of the previous decisions in achieving the presumed results, or applicability of these decisions to a project in Turkey in terms of technical and governmental restrictions. Under each category, criteria related to the strategies and methods used in achieving the goals of the OB principle are examined. The categories can be evaluated as a whole, or the user can select the relevant factors, while ignoring or discarding those that are not pertinent to the project.

3.3.2. The Two Stages

The analysis is composed of two stages. In the first stage of the analysis, the user evaluates the chosen project by means of a series of questions that have been developed for the four categories with respect to the major goals of each category. The purpose of this first stage is to evaluate the elemental aspects of a selected OB project to determine whether this project satisfies the most or all of the OB principles, i.e. how 'open' this building is. This stage allows the designer to select the successful examples of OB cases to be assisted for the housing designs in Turkey. Moreover, these first-stage questions can be employed independent of the second stage, to evaluate OB projects regarding their 'openness.'

In the second stage, the design decisions of selected OB projects are evaluated according to their appropriateness to the Turkish context, in terms of:

a. technological availability,
b. suitability of design decisions to the building codes, regulations and standards in Turkey.

In this part of the tool, user is directed to the guidebooks about these codes, regulations, and standards, where it is necessary.

3.4. Operation of the Tool

In the first stage of the analysis, the user refers to the project drawings and written documents about the building or the building complex to answer the questions about the presence of relevant OB criteria in the project decisions. The output of the first process is an implication of the success or failure of the project within the context of OB approach. By assessing the projects on a common basis, user of the tool can select best

OB example(s) according to a specific principle, or taking into account all categories (see Figure 3.3).

In the second stage, design decisions of the selected OB project(s) are subjected to another set of questions to find out whether these decisions are applicable to Turkey in terms of legal and technical limitations. The output is the selection of design strategies and methods of best OB examples which are also appropriate for Turkey.

THE ANALYTICAL TOOL

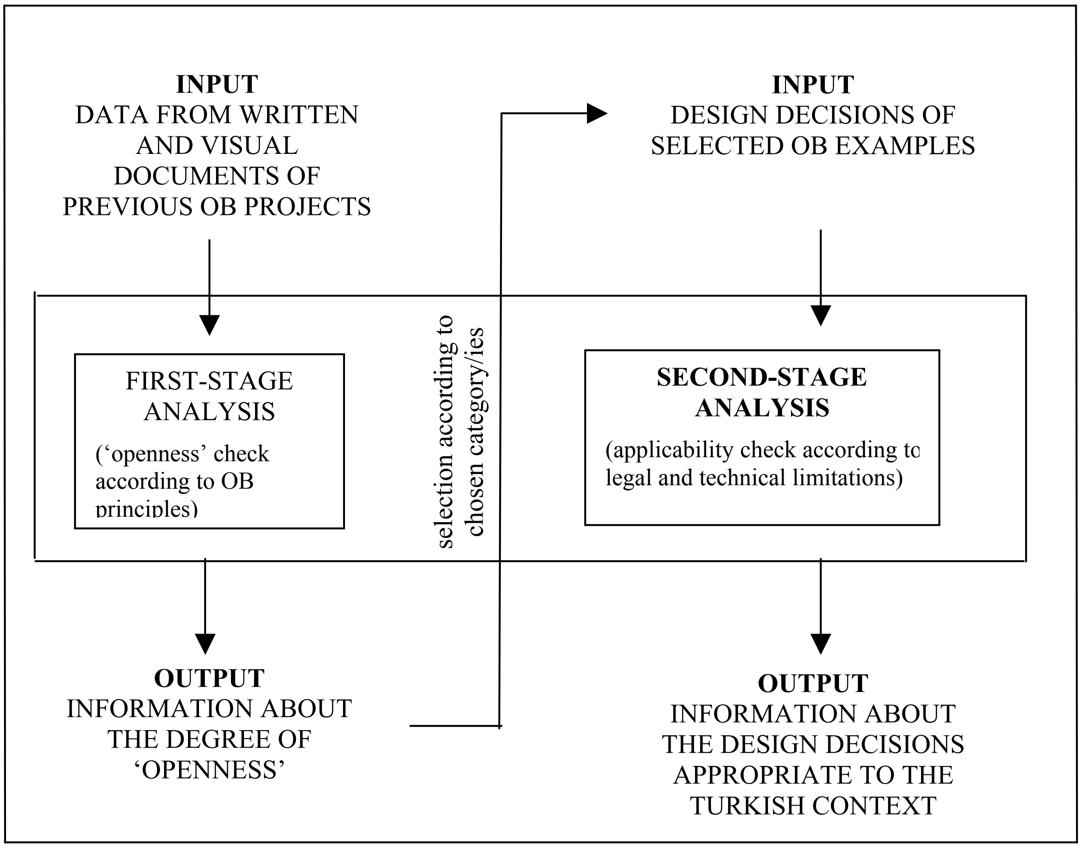


Figure 3.3. Model showing the inputs and outputs of the analytical tool.

3.5. Evaluation

There is an extensive set of questions to assist the user of the tool, intended to be the designer, for the decision-making process about OB methods and strategies, during the design phases of support and infill. While answering the questions with ‘yes,’ ‘partially,’ ‘no,’ or ‘not applicable,’ the user can formulate some implications about the success and suitability of the evaluated OB procedure. All questions in the tool will provide a ‘yes’ answer if the corresponding feature of the project demonstrates a success as a valid OB criterion and relevance to Turkey. The answer ‘partially’ is the sign of limited success of the aspect. A ‘no’ answer indicates that the corresponding feature fails either as a valid OB issue, or in its potential applicability. A blank answer signifies that insufficient information is available to answer the question, or the question is not suited to that particular feature, i.e. not applicable. By the analysis of the answers, the information about the best practices of OB approaches, and the potential applicability of the OB decisions to the housing designs in Turkey can be extracted.

3.6. The Analytical Tool

The analytical framework evaluates the specific project(s) in terms of the four fundamental categories, which allow the user of the tool to evaluate the success and failure of the OB projects in terms of these principles, and determine the applicability of the strategies and methods of the principles individually or as a whole. These four categories are:

a. Support and infill characteristics,
b. Amount of flexibility,
c. User involvement in decision-making process,
d. Sustainability.

I. First-Stage Analysis

A. Characteristics of Support and Infill

1. Support

Major goals of support level are as in the following:

a. **accommodating different infill designs**: A support design should allow a variety of unit designs with different infills. The criteria to be satisfied in this goal are as follows:

   - using specific support technologies to support different interiors,
   - providing open frame structure,
   - using specific OB methods during support design.

   Questions for this goal can be seen in Table 3.2 ('Support' sub-category, questions 1, 2, and 3).

b. **housing all common functions independent of infill designs**: Support design has to accommodate all common functions in itself. The criterion of this goal is:

   - separating common functions form individual realm (see Table 3.2, 'Support' sub-category, question 4).

c. **reflecting the architectural style, local market, and the other local conditions** (Kendall & Teicher, 2000, p.33): Support design should be compatible with the local features. The criteria are:

   - suiting the appearance of surrounding buildings, in terms of materials, design, and color,
   - suiting the scale of surrounding buildings,

- using locally available materials (see Table 3.2, 'Support' sub-category, questions 5, 6, and 7).

d. **building's being used by all occupants throughout their lives**: Different occupants should dwell in an OB throughout their lives without the need of moving. This goal necessitates

- design considering accessibility for elderly and disabled (see Table 3.2, 'Support' sub-category, question 8).

Table 3.2. The first-stage questions of the analytical tool.

I. FIRST STAGE QUESTIONS **A. Characteristics of Support and Infill** **1. Support**	
1. Are specific support technologies (such as depressed floor slab trenches, flat beam skeleton, inverted slab-beam floor structure, Z-beam structure, etc.) used to support the use of infill systems (Kendall & Teicher, 2000)?	
2. Does the support provide 'open frame structure' to accommodate and outlast infill changes (Tiuri, 1998; Kendall & Teicher, 2000)?	
3. Does the support utilize specific OB design methods, such as the zoning rules defined in *Variations* "to allow for all the desired variations while using a few detachable units as possible" (Habraken *et. al.*, 1976, p.24) or the SAR 65 principles?[1]?	
4. Is the support totally separated from individually varied infills, including all common functions in it?	
5. Does the support design "suit the appearance of the surrounding buildings"(Sanoff, 1991, p.57) in terms of: a. roof type and materials, b. façade finishings and color, c. opening proportions?	
6. Does the scale of the building (support) "suit the scale of the surrounding buildings" (Sanoff, 1991, p.57)?	

[1] *Variations* is a handbook for the ones who desire to apply OB principles to housing design. In this book, "the design of a support is based on a set of standards that are incorporated in a specific zone/margin system" (Habraken et. al., 1976, p.40). This zone/margin system guides the designer while determining minimum and maximum sizes of spaces and their locations (see Appendix A). On the other hand, SAR 65 are "basic methods for designing residential Supports without predetermining the size or layout of dwellings," developed by SAR (Kendall & Teicher, 2000, p.12).

Table 3.2. Continued.

7. Is the support composed of locally available materials in terms of: a. structural system, b. service systems, c. floors and walls, d. doors and windows e. finishings?	
8. Is 'accessibility for elderly and disabled' thought as a basic criterion for the support design?	
2. Infill	
1. Are the units designed according to the positioning and dimensioning rules for each subsystem developed for OB approach, such as the 'band grid' utilized by SAR (Habraken, 1992, p.6; Kendall & Teicher, 2000, p.47)?	
2. Are specific infill technologies, allowing individualization of designs with little or no extra cost, used?	
3. Are prefabricated elements available in the local market employed to allow quick installation, to eliminate onsite cutting and adjusting dimensions, and thus to save onsite labor costs (Habraken, 1992, p.7)?	
B. Amount of Flexibility	
1. Can users determine the size of their dwellings at the beginning?	
2. Is flexibility allowed for partitions?	
3. Is flexibility allowed for facades?	
4. Is flexibility allowed for service systems?	
5. Is flexibility allowed for the choice of kitchen and bathroom locations and sizes?	
6. Are different flexibility levels offered in a single project to users with differing participation potentials in terms of economic level, background information, etc.?	
7. Can support and its parts be adapted to varying needs of occupants?	
8. Do the unit sizes have possibility of adaptation for future alterations?	
9. Do the selected technologies of infill allow user to adapt their dwellings by do-it-yourself or unskilled labor work, without any expert assistance?	
10. Is independent distribution of services to units provided to allow the adjustment or replacement of them without disturbing the other dwellings?	
11. Are the subsystems totally disentangled so that replacement or repairing of one is possible without disrupting the other subsystems?	
12. Does the support design have technical flexibility to be rebuilt in different locations with different climatic and ground conditions by adaptations?	
C. User Involvement in Decision-making Process	
1. Can users participate to the support decisions for the common facilities?	
2. Do experts (architects and interior designers) assist users during the design of their own dwellings?	
3. Are users offered optional plans, if they cannot design interiors of the units?	
4. Is it possible to calculate the cost implications of alternative choices during infill design (Tiuri & Hedman, 1998, p.9)?	
5. Are specific user participation tools (mock-up models, CAD technology) available to assist users during design process?	
D. Sustainability	
1. Does the design take advantage of orientation, form, shading, color, and landscaping (Lovings & Browning, 1991, p.16)?	
2. Are passive heating and cooling methods, and renewable energy sources	

Table 3.2. Continued.

considered during the design period?	
3. Are the 'green building' materials used?[2]	
4. Is ease of maintenance of the selected building components or systems considered during design?	
5. Does the design focus on minimizing the impact of the external environment through the use of good insulation, controlled ventilation (esp. passive, i.e. user controlled), and economic use of space (Mackenzie, 1991; Edwards, 1998)?	
6. Can building components be reused or recycled to decrease energy and material waste?	
7. Is treatment of drainage within the building considered?	
8. Is everyday waste of household treated in the building in terms of pre-separation, composting, etc.?	
9. Are industrial building components (dry-construction techniques) used to decrease waste in site?	

2. Infill

Basic objectives in the infill level are as follows:

a. **dwellings' being designed on a 'unit-by-unit basis,' and independent from support decisions** (Kendall & Teicher, 2000; Kendall, 1996): The criteria of this goal include:
   - using specific OB positioning and dimensioning rules to provide independent fit-outs,
   - using specific infill technologies to provide individually designed infills in an efficient way (see Table 3.2, 'Infill' sub-category, questions 1, and 2).

b. **infill systems' reflecting the market conditions**.
   - using industrial building components, which are available locally (see Table 3.2, 'Infill' sub-category, question 3).

[2] "Adopting a preference for environmentally sensitive [green] products requires a holistic approach, in which architects must consider factors, such as 'embodied energy,' pollution, indoor air quality, resource depletion, and solid-waste disposal, along with such traditional components as materials' performance, durability, appearance, and cost," as Wilson mentioned (qtd. in Lehman, 1998). The study, "Selection of Green Building Materials" offers an analysis system to identify and select 'green materials' (Reilly, 1997). Environmental Resource Guide, being developed by AIA to compare the toxic consequences of common building materials, helps architects limit the detrimental effects of buildings on the environment (Lehman, 1998).

B. Amount of Flexibility

In this section, the goals of a flexible design are determined with respect to flexibility types. **Flexibility types**, defined by Gann (1999), are:

a. variety—flexibility to provide choices in initial design: The criterion to be satisfied for variety is:

- users' determining dwelling sizes (see Table 3.2, 'Flexibility' category, question 1).

b. adaptability—flexibility to allow future alterations: The next five criteria defined for adaptability are also relevant for the first objective – providing variety.

- providing flexibility for partitions,
- providing flexibility for facades,
- providing flexibility for service systems,
- providing flexibility for kitchen and bathroom locations and sizes (see Table 3.2, 'Flexibility' category, questions 2, 3, 4, 5, and 6).

The following three criteria refer only to the goal of offering adaptability:

- providing adaptability for support,
- providing adaptability for unit sizes,
- allowing self-help adaptations (see Table 3.2, 'Flexibility' category, questions 7, 8, and 9).

c. flexibility to enable periodic maintenance, renovation, and upgrading of components, equipment, and systems: The two major criteria of maintenance flexibility are:

- independent distribution of services to individual dwellings,

- disentanglement of subsystems (see Table 3.2, 'Flexibility' category, questions 10, and 11).

d. technical flexibility to fit different locations, climate and ground conditions: The criterion for technical flexibility is:

- support's having the potential to be adapted to different locations with different conditions (see Table 3.2, 'Flexibility' category, question 12).

C. User Involvement in Decision-making Process

Primary goals of this principle are defined by Tiuri and Hedman (1998):

a. users' participating the support decisions—users participate collectively in decisions concerning common facilities or common outdoor space. The criteria for this goal can be mentioned as:

- users' being involved in the decision-making of support,
- using specific participation tools to assist users (relevant also for the following goal) (see Table 3.2, 'User involvement' category, questions 1, and 5).

b. users' deciding the infill—the users decide on the infill in their apartments. To achieve this goal, the criteria to be satisfied may be listed as follows:

- providing expert assistance to users for the infill design,
- offering optional plans, when individual designs are not possible.
- being able to calculate the costs of infill alternatives (see Table 3.2, 'User involvement' category, questions 2, 3, and 4).

D. Sustainability

What is dealt here is the environmental sustainability of the built environment among the "futurity (concern for the future conditions), public participation, equity (concern for the poor and disadvantaged), and environment issues" (Cooper, 1999, p.326). The other points are assumed to be satisfied by user as a decision-maker, and flexibility (variety and adaptability) principles of OB, and thus are not the concern of this part. Main objective of the environmental sustainability approach is "minimizing the ecological impact of building" (Talarico, 1997, p.149).

Major goals in environmental sustainability are defined by Talarico (1997) as:

a. design considering site and land use: The decision criterion is:

- taking advantage of site characteristics, such as orientation, form, landscaping, etc. (see Table 3.2, 'Sustainability' category, question 1).

b. energy efficiency: This goal corresponds to:

- considering passive heating and cooling methods, and energy efficiency during design (see Table 3.2, 'Sustainability' category, question 2).

c. selection of environmentally sensitive materials[3]: The criteria for material selection are:

- using 'green materials,'
- considering ease of maintenance of selected materials (see Table 3.2, 'Sustainability' category, questions 3, and 4).

d. efficiency in providing indoor ecology: The criterion is:

[3] The sustainability concerns for 'material and waste' are "renewable materials, recyclable/reusable materials, easy disassembly, standardized dimensions, low embodied energy, and non-toxic materials" (Bourdeau, 1999, p.360).

- minimizing the impact of exterior environment by good insulation, controlled ventilation, and economic use of space (see Table 3.2, ‘Sustainability’ category, question 5).

e. waste reduction: The criteria related to reducing waste are as follows:

- selecting reusable and recyclable building components,
- treating drainage in the building,
- treating everyday waste of occupants in the building,
- using industrial building components to decrease waste in site (see Table 3.2, ‘Sustainability’ category, questions 6, 7, 8, and 9).

II. Second-Stage Analysis

In this section, the criteria related to the technical and legal restrictions of Turkey, which would affect the application of the determined OB criteria in the Turkish context, are compiled. Thus, the defined criteria of this second stage are directly related to the applicability of the criteria explained in the first stage of the analytical tool. At the end of each criterion (and question), user of the tool is directed to the guidebooks to check the suitability of the decisions to Turkey. These guidebooks are as follows:

i. Typical Building Codes for the Municipalities outside the Law 3030 and the Building Codes of İstanbul and İzmir—B.Cd.,

ii. Regulations for the buildings in Disaster-Prone Areas—DPA,

iii. Thermal Insulation Regulations for Buildings—TIR,

iv. Accessibility Standards—TS 9111 (ANSI 117.1),

v. Fire Safety Codes—FSC,

vi. Elevator By-laws—EB,

vii. Turkish Standards about Construction Materials and Building—TS,

viii. Flat Ownership Law—FOL,

ix. Building Catalogues (TMMOB and YEM)—BC.

Under each category, the relevant criteria for the applicability to Turkey are mentioned.

A. Characteristics of Support and Infill

1. Support

- using locally available industrial building components, or traditional materials of Turkey (BC),
- selected materials' satisfying fire-resistance requirements (FSC),
- common use decisions' being suitable with the common property regulations (FOL),
- support's satisfying the environmental compatibility requirements defined by the municipalities (B.Cd.),
- support design's satisfying the accessibility standards of Turkey (TS 9111) (see Table 3.3, 'Support' sub-category, questions 1, 2, 3, 4 and 5).

Table 3.3. The second-stage questions of the analytical tool.

II. SECOND STAGE QUESTIONS **A. Characteristics of Support and Infill** **1. Support**	
1. Is the support composed of either the available industrial building components in Turkey, or traditional building materials? (BC)[4]	
2. Do the selected materials satisfy the fire-resistance requirements for a. party walls, b. slabs,	

[4] Senturer (1997) examines different types of industrial systems according to their "…countrywide application, suitability to the technological level of country, economy of investment and transportation, static continuity, building type flexibility, and the possibility of catalogue system integration" (p.26); which may guide the determination of the appropriate industrial structural systems, also suitable for the OB approach.

Table 3.3. Continued.

c. facades, d. roofs? (FSC)	
3. Are the determined common uses belonging to support suitable according to the common property regulations? (FOL)	
4. Does the support satisfy the environmental compatibility requirements defined by the municipalities in terms of a. roof type and materials, b. façade finishings and color, c. building height, d. opening proportions? (B.Cd.)	
5. Does the support design satisfy the accessibility standards of Turkey? (TS 9111 [ANSI 117.1]) a. Are the staircases suited to the codes in terms of widths and step dimensions? (see also B.Cd., FSC) b. Does the support have the essential elevator(s) with the required dimensions? (see also B.Cd., FSC) c. Do the doors (entrance, service spaces, etc.) satisfy the minimum widths? (see also B.Cd.) d. Are the corridors suitable in terms of wheelchair widths, and turning space dimensions? e. Are the finishing materials of corridors non-slippery and not obstructive for the movements of handicapped and elderly?	
2. Infill	
1. Is the used infill system able to be constructed either by using the available industrial building components in Turkey, or by conventional methods? (BC)	
2. Do the selected materials satisfy the fire-resistance requirements for a. interior partitions, b. façades, c. slabs? (FSC)	
B. Amount of Flexibility	
1. Do the infill units have all the required functions which dwelling should have according to B.Cd, although they are designed separately?	
2. Do the spaces satisfy the minimum dimensional requirements, while providing different layouts according to varying needs? (B.Cd.)	
3. Do the openings (door, window, and other facade openings) always satisfy the necessary horizontal distance between each other in all different infill designs? (FSC)	
4. Do the areas of the window openings satisfy the allowable areas? (TIR, B.Cd.)	
5. Do the individually designed units care for the ventilation and lighting requirements for spaces? (B.Cd.)	
6. Does the support have the required areas for service shafts (light wells and ventilation shafts)? (B.Cd.)	
7. Are the chimney necessities satisfied in each unit in terms of both dimensions and numbers? (B.Cd., FSC)	
8. Does the design care for the allowable changes in floor heights, e.g. for bathrooms, while achieving the desired flexibility level? (B.Cd.)	
9. Does the support design satisfy the thermal insulation regulations in Turkey? (TIR)	
10. Is the support's structural system suitable for the seismic design limitations in Turkey? (DPA)	
C. User Involvement in Decision-making	
1. Are the employed user participation tools available in Turkey?	

Table 3.3. Continued.

D. Sustainability	
1. Can the used building elements easily be maintained by the use of available technologies and local skills?	
2. Do the used building elements have the required industry of reuse and recycling in Turkey?	

2. Infill

- using locally available industrial building components, or traditional materials for the infill (BC),
- selected materials' satisfying fire-resistance requirements (FSC) (see Table 3.3, 'Infill' sub-category, questions 1, and 2).

B. Amount of Flexibility

- infills' having all required functions which a dwelling should have (referring to unit size determination) (B.Cd.),
- spaces' satisfying minimum dimensional requirements, despite the individually placed partitions (B.Cd.),
- providing the necessary horizontal distances between façade openings, while providing flexibility in facades (FSC),
- window openings' not exceeding the allowable areas (TIR, B.Cd.),
- satisfying the ventilation and lighting requirements for spaces, while providing variety (B.Cd.),
- support's satisfying the required areas for service shafts, for flexibility in service systems (B.Cd.),
- satisfying the chimney necessities in terms of dimensions and numbers in all dwellings (B.Cd., FSC),
- caring for the allowable changes in floor heights, for example, in bathrooms, while achieving the desired flexibility (B.Cd.),

- support's satisfying the thermal insulation regulations in Turkey (TIR),
- structural system's suitability to the seismic design limitations in Turkey (DPA).

C. User Involvement in Decision-making Process

- employing the user participation tools that are available in Turkey.

D. Sustainability

- considering ease of maintenance of selected building elements, by the locally available technologies and skills in Turkey,
- building elements' having the industry of reuse and recycling in Turkey.

In this chapter, the analytical tool which can be used for the evaluation of OB projects, according to their satisfying the criteria of OB principles, and the applicability criteria of their decisions to Turkey, is developed. These criteria are compiled in the form of a questionnaire to guide the user of the tool for the quick determination of suitable decisions. In the following chapter, this analytical tool is tested to demonstrate its operation, and the results to be achieved at the end of an evaluation done by this analytical tool.

4. SIMULATION OF THE ANALYTICAL TOOL

In this chapter, two projects are evaluated according to the developed analytical tool to demonstrate its operation within the limitations of the available information about the project decisions. Firstly, information about the evaluated projects, Next 21 Experimental Housing and Voorburg Renovation Project, is given briefly to indicate the different contexts and priorities affecting the selection of OB methods and strategies employed in the projects.

4.1. Information About the Evaluated Projects

The two projects, Next 21 Experimental Housing and Voorburg Renovation Project, are chosen as subjects for the simulation of the developed tool to demonstrate its applicability to both new constructions, and rehabilitation projects. In fact, also a Turkish case, an OB-like project is evaluated according to the analytical tool, but it is decided not to mention in detail. This case is multi-storey housing for low income-families in the form of unfinished concrete skeleton flat in the Eastern Black Sea Region (Aydemir & Akkol, 1996). This approach is mentioned as OB-like according to its allowing variety according to household's preferences and income levels, and participatory design supported by self-help construction. However, the lack of control mechanism in this way of building, resulting in many quality related problems, and the lack of planning and design decisions in the process directed the author not to choose this case as a subject of the simulation. Before analyzing the two selected projects comparatively, the necessary background information is given to clarify the factors effective on the design decisions.

4.1.1. Next 21 Experimental Housing in Japan

"General concern toward conserving energy and preserving the environment has been growing rapidly. Residences in the 21st century must provide solutions to these problems while maintaining comfortable living environments. Osaka Gas constructed Next 21 as a model case so specialists of various fields could examine and discuss the technologies necessary for achieving these goals" (Osaka Gas, n.d.). Next 21 project was initiated by Osaka Gas Company; and Osaka Gas, Next 21 planning team and several other architects cooperated for the design of the project. It is an experimental 18-unit housing project whose support construction is reinforced concrete skeleton (Kendall & Teicher, 2000) (see Figure 4.1). "The project was initiated in October 1993. For a five-year period from April 1994 to March 1999, the Next 21 Complex became the home for the families of 16 Osaka Gas employees" (Osaka Gas, n.d.). Next 21 project was realized with the main objectives of effective use of resources, energy efficiency, treatment of everyday waste and drainage for 21st century (Tiuri, 1998).

Figure 4.1. Façade of the Next 21 Housing (Next 21, 2001).

Two-stage supply system was employed in the project to make the residences suitable to the individual preferences and lifestyles. Pillars, beams, floors that have longer lifespans were taken as one group, and interiors that last relatively short as another (Next 21, 2001). One architectural firm was commissioned for the design of the base building and another 13 different architectural firms designed the 18 housing units (Kendall, 1996). The different floor plans can be seen in Figure 4.2. While reinforced concrete skeleton system was used as the building system, the infill systems of the project were freely designed by each firm. Designers had experimental approaches on energy saving systems, home equipment, household waste recycling, wastewater recycling, and vicinity green activities (Next 21, 2001).

Next 21 project was realized according to the basic plan and design objectives developed by the Next 21 Construction Committee (Kendall & Teicher, 2000). These objectives are summarized by Kendall and Teicher (2000) as follows:

- Using resources more efficiently through systematized construction;
- Creating a variety of residential units to accommodate varying households;
- Introducing substantial natural greenery throughout a high-rise structure;
- Creating a wildlife habitat within urban multi-family housing;
- Treating everyday waste and drainage on site within the building;
- Minimizing the building's compound burden on the environment;
- Using energy efficiently by means including fuel cells; and
- Making a more comfortable life possible without increasing energy consumption (pp.126-127).

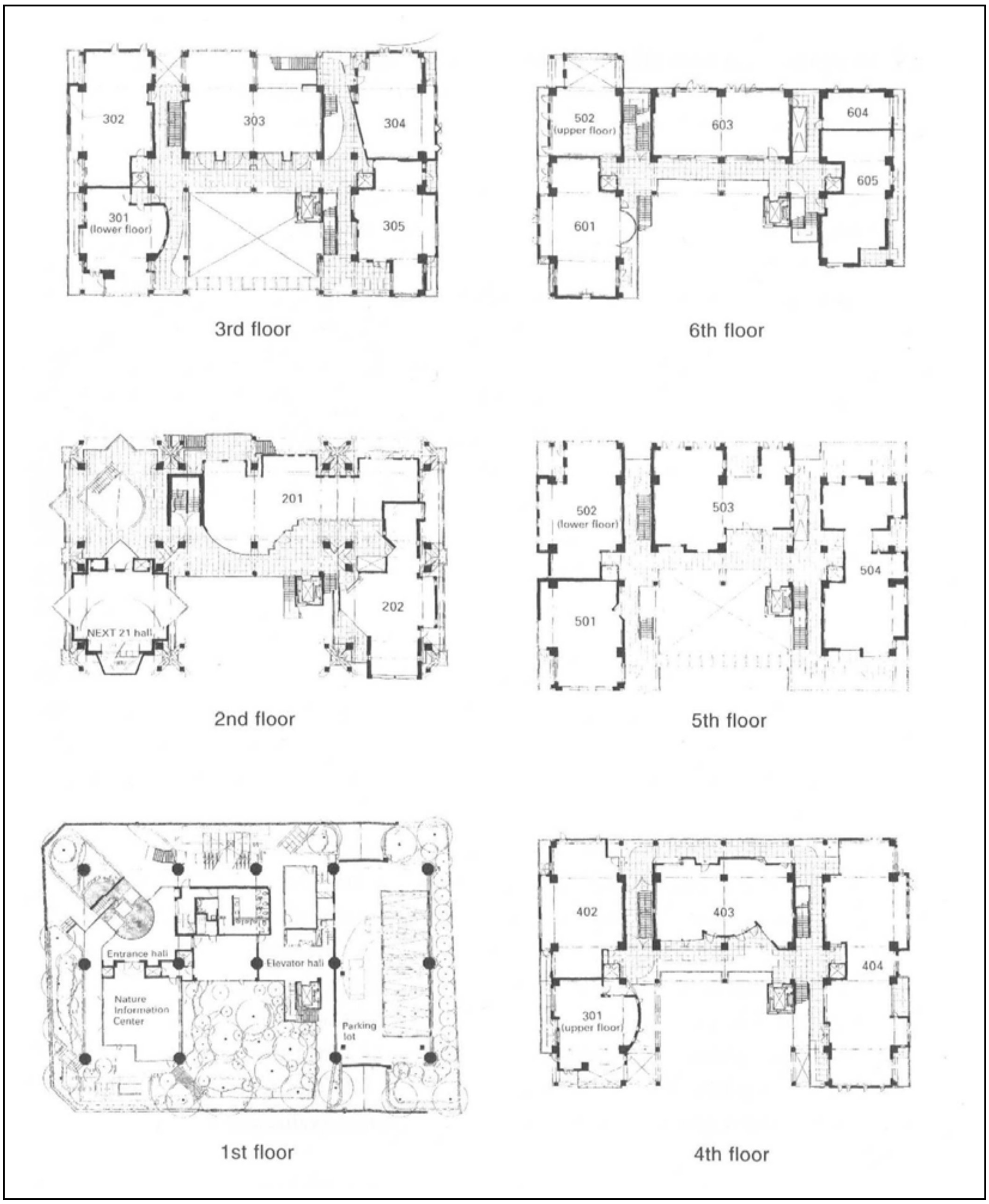


Figure 4.2. Floor plans of Next 21 project (Kendall & Teicher, 2000).

Finally, being designed to test new mechanical systems, recycling waste water and building products and distributing responsibilities (Kendall, 1996), the project successfully reached its aims and "The project continues to explore new methods for building urban housing and experimental infill systems, to accommodate varying lifestyles with reduced energy consumption" (Kendall & Teicher, 2000, p.127).

4.1.2. Voorburg Renovation Project in the Netherlands

"Prinses Beatrixlaan in Voorburg is a typical 1960s social housing estate consisting of three blocks of five storey 'walk-up' flats. The estate has 120 dwellings, enclosed by 13 staircase halls" (Gann, 1999, p.47). In 1989, OBOM research group of the University of Technology, Delft, which undertook a series of research projects on Open Building strategies on postwar housing estates between 1986 and 1989 (Dekker, 1998a), was employed to make feasibility study for the renovation of the estate, by the housing corporation Patrimonium Woningen, which owns the estate; because the housing estate was not able to satisfy residents any more due to the low quality environment and aging of internal facilities (Gann, 1999).

"Improvement measures were investigated on three levels: the residential environment, the support and the new layouts for the apartments" (Cuperus & Kapteijns, 1993, p.7). Patrimonium Woningen decided to renovate vacant residential rental units on a 'one-unit-at-a-time,' 'as-needed' basis, which is different from upgrading all at once (Kendall & Teicher, 2000). A major constraint appeared about the renovation of the systems and individual units. While renewing the units and service systems such as ducts and pipes, the existing ones should be intact because apartments were to be inhabited during the renewal process (Dekker, 1998a).

An important part of the project is that one of the apartments was chosen as pilot project and renovation of it was initiated as a test. The concept of refurbishment using 'Matura

System' was also tested in this pilot dwelling (Gann, 1999). At the end, the estate came out to be the first project which 'Matura Infill Package'[5] was employed (Dekker, 1998b).

Another significant focus of the project is the emphasis on user's choices. After the architects completed their initial studies on the design, they had meeting with the occupants to make them express their wishes; then architects developed their projects according to the needs of the tenants (Dekker, 1998a). During the design process tenants had the chance of determining the places of their kitchens and bathrooms irrespective of the location of the shafts (Gann, 1999). Users also had the opportunity to select a floor plan and a catalogue of equipment (Dekker, 1998b).

The capital problem of differing needs and choices was solved such that external improvements were covered by all users, whereas internal ones were covered by the users who chose the option (Gann, 1999). "Tenants are simply assessed modest additional monthly fees if the equipment and finishes selected exceed the standard adopted by the building owner" (Kendall & Teicher, 2000, p.114).

At the end, the housing was renovated in both individual units and the base building scale, based on the OB principles (see Figure 4.3). In the support level, adding elevators, enlarging balconies, better thermal insulation for roof and outer walls, window renovations and isolation glass were the basic strategies; and the infill level deals with the renovations inside the dwellings regarding the tenants own wishes and

[5] Matura Infill System is a fully prefabricated infill package, with the specific elements of the Base Profile and the Matrix Tile, which includes entire infill of a dwelling unit. The software, MaturaCads supports the whole Matura process from design to cost estimating, using the 10/20band grid developed by SAR (Kendall & Teicher, 2000). Matura Infill system can be mentioned as "the most comprehensive infill system" (Kendall & Teicher, 2000, p.196).

possibility to pay for (Dekker, 1998b). As a result, Voorburg project of the Netherlands is an important OB project with its having innovative approaches of application as well as being mainly a renovation project.

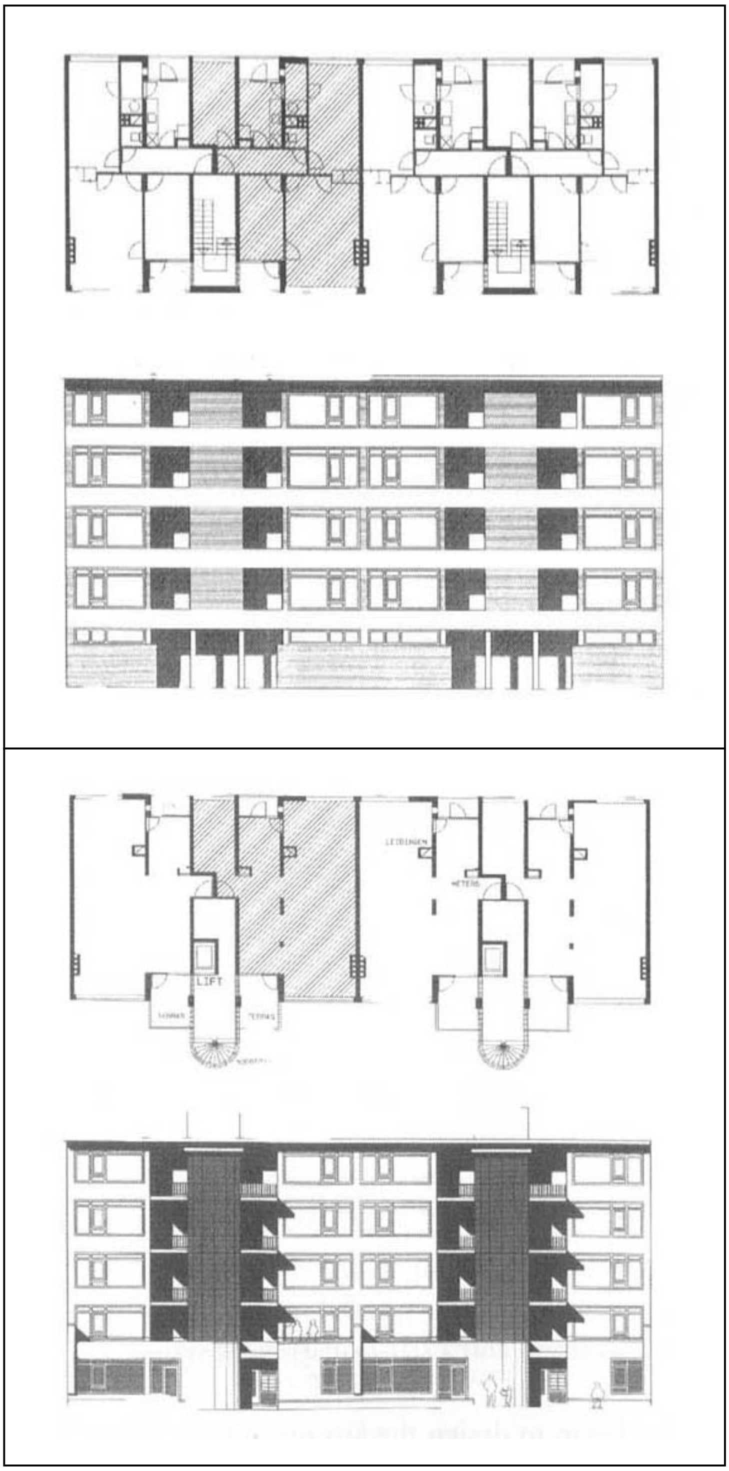


Figure 4.3. Typical building plans and elevations before and after Support renovation (Kendall & Teicher, 2000).

4.2. Comparative Analysis

By using the analytical tool, these two OB projects, which have different priorities in applying OB principles, can be comparatively analyzed, and the more proper strategies of each can be determined according to their appropriateness to Turkey. The results of the analysis are given in Table 4.1 (see Appendix B). The symbols used in the evaluation are as follows:

■	yes
□	no
◘	partially
	not applicable

The explanations for the questions are given below both for Next 21 and Voorburg projects, when clarification is considered necessary.

4.2.1. Explanations of the First Stage Questions

A. Characteristics of Support and Infill

1. Support

a. accommodating different infill designs

	Next 21	Voorburg
1. Are specific support technologies (such as depressed floor slab trenches, flat beam skeleton, inverted slab-beam floor structure, Z-beam structure, etc.) used to support the use of infill systems?	■	□

Next 21: The support includes utility zones in the form of slab trenches and raised floors designed to provide a flexible piping system (see Figure 4.4).

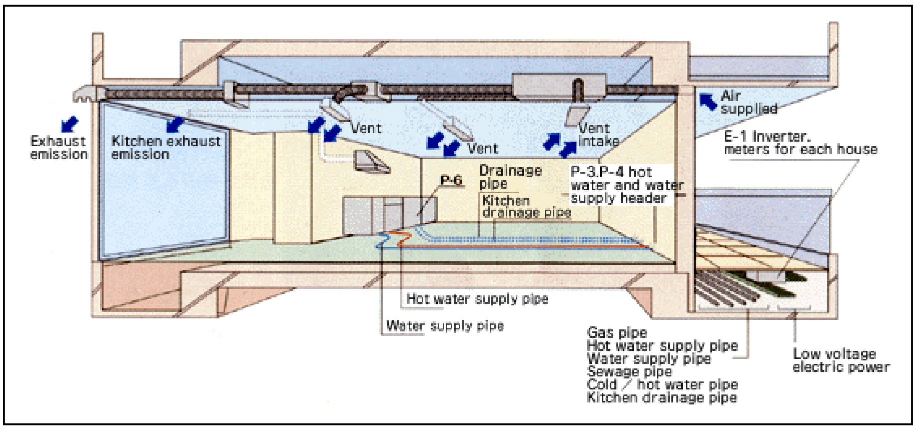


Figure 4.4. Support system providing flexibility of infill (Next 21, 2001).

2. Does the support provide 'open frame structure' to allow a variety of infills and their adaptations?	■	□

Next 21: The support' structure is reinforced concrete and pre-cast concrete/reinforced concrete frame system, which allows free configuration of unit designs (see Figure 4.5).

Voorburg: Since the housing estate was built in 1960s, it is composed of loadbearing masonry walls, thus has some limitations in the infill designs (see Figure 4.6).

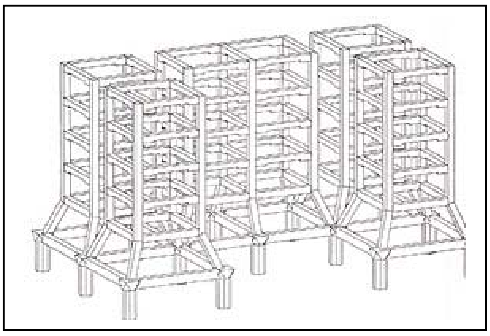


Figure 4.5. Open frame system (Next 21, 2001).

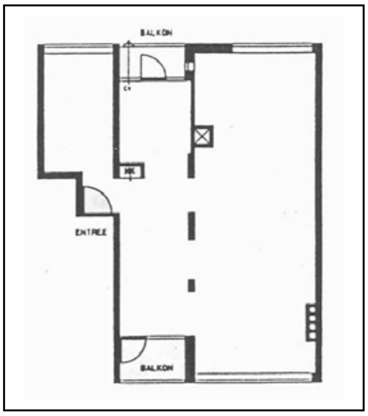


Figure 4.6. Stripped support of Voorburg (Cuperus & Kapteijns, 1993).

3. Does the support utilize specific OB design methods, such as the zoning rules defined in *Variations* to allow for all the desired variations while using a few detachable units as possible?	■	□

Next 21: A system of coordinating rules is employed as the design method of this project (Kendall, 1999).

Voorburg: As Voorburg is a renovation project, its support structure was converted from an old design, not able to satisfy OB design methods.

b. housing all common functions independent of infill designs

4. Is the support totally separated from individually varied infills, including all common functions in it?	■	◘

Next 21: The support is treated as "a vertical, multilevel urban framework that provides sidewalks, gardens and open spaces-a neighborhood that interweaves the individual houses" including all common functions (Next21, 2001).

Voorburg: In this renovation project, interior refurbishment was done only to the units whose tenants' have the opportunity to afford, thus not all dwellings' systems are separated from common systems. But for the renovated units, infill including "the space, the non-load bearing party walls, the technical installations, the equipment and the finishes" (Dekker, 1998b, p.47) is completely separated from the support with common functions.

c. reflecting the architectural style, local market, and the other local conditions

5. Does the support design suit the appearance of the surrounding buildings in terms of: a. roof type and materials, b. façade finishings and color, c. opening proportions?		

6. Does the scale of the building (support) suit the scale of the surrounding buildings?		■

7. Is the support composed of locally available materials in terms of:		
a. structural system,	■	■
b. service systems,	◘	■
c. floors and walls,	◘	■
d. doors and windows		■
e. finishings?	◘	■

Next 21: Some newly developed systems and components are used in the building's service systems such as the aqua-loop system, and in the finishings.

Voorburg: The housing estate was constructed in 1960s, by using conventional construction materials and techniques (concrete slab, masonry bearing walls and wood frame facades with windows) (Kendall & Teicher, 2000).

d. building's being used by all occupants throughout their lives

8. Is 'accessibility for elderly and disabled' thought as a basic criterion for the support design?		■

Voorburg: Although not available in the original design, the new support accommodates new apartments for the elderly and handicapped at the ground level converted from the car boxes (Dekker, 1998a; Dekker, 1998b). Moreover, elevators have been added to the existing building which would make lives of the elderly and handicapped easier.

2. Infill

a. dwellings' being designed on a 'unit-by-unit basis,' and independent from support decisions

1. Are the units designed according to the positioning and dimensioning rules for each subsystem developed for OB approach, such as the 'band grid' utilized by SAR?	■	

Next 21: Design of each unit's exterior and interior layout was freely done by different architects, but according to a system of rules for positioning various elements (Kendall, 1999) (see Figure 4.7).

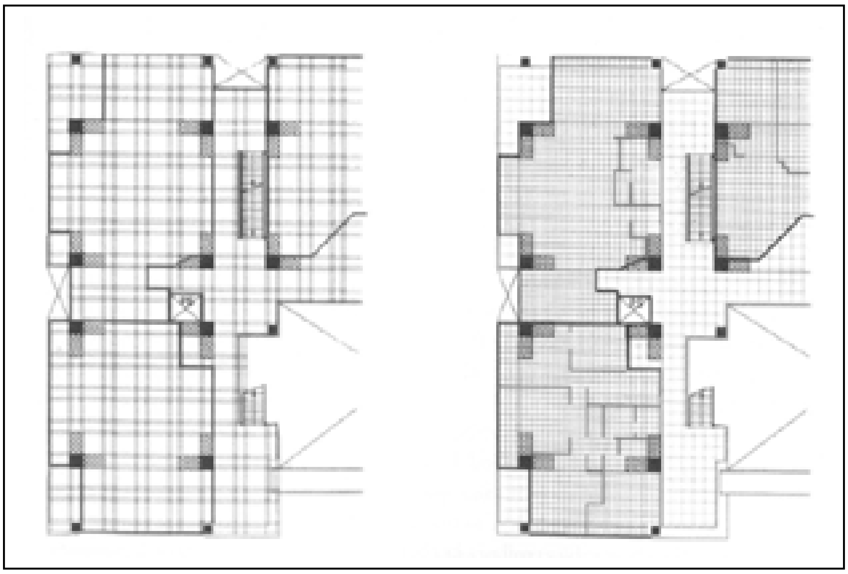
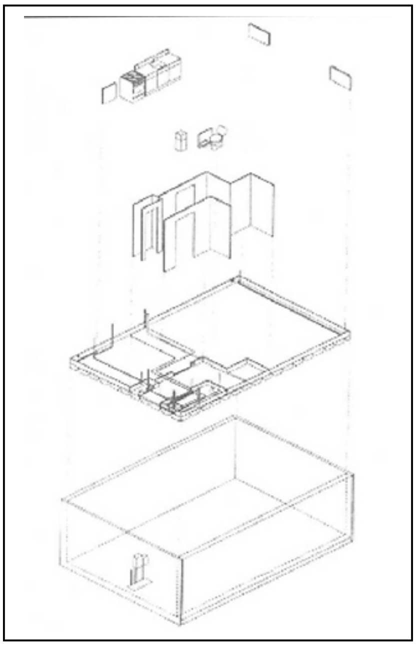


Figure 4.7. Modular grids for coordination (Kendall & Teicher, 2000).

2. Are specific infill technologies, allowing individualization of designs with little or no extra cost, used?	■	■



Next 21: For example, use of access floors allows flexibility in service systems, thus individually designed units.

Voorburg: The Matura infill system which allows unit-by-unit installation is employed resulted in a small increase in rents, and can "compete economically with traditional way of finishing a dwelling unit..." (Dekker, 1998b, p.46) (see Figure 4.8).

Figure 4.8. Matura infill system (Kendall, 1999).

b. infill systems' reflecting the market conditions

3. Are prefabricated elements available in the local market employed to allow quick installation, to eliminate onsite cutting and adjusting dimensions, and thus to save onsite labor costs?	■	■

Next 21: Prefabricated items are used both for exterior walls and other components (Next 21, 2001).

B. Amount of Flexibility

a. flexibility to provide choices in initial design—variety

1. Can users determine the size of their dwellings at the beginning?		□

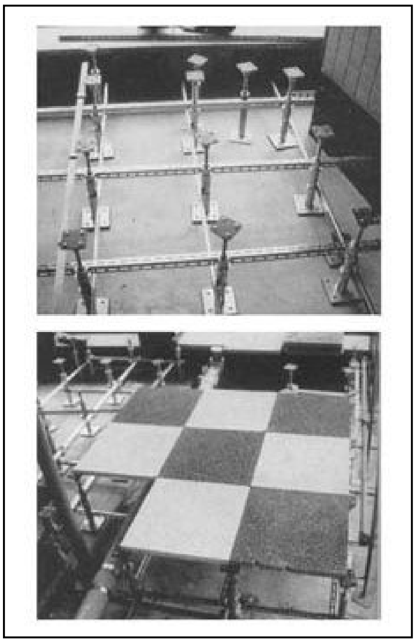
a/b. variety and adaptability

2. Is flexibility allowed for partitions?	■	■

3. Is flexibility allowed for facades?	■	□

Next 21: "…[O]uter walls, kitchens, baths and toilets, and gardens can be moved into or out of one dwelling without disturbing any other dwelling or the common infrastructure" (Kendall, 1999, p.8).

4. Is flexibility allowed for service systems?	■	■



Next 21: The raised floors allow free distribution of service systems inside the units (see Figure 4.9).

Voorburg: While specially designed raised floors offer flexibility for conduits and pipes, the hollow baseboard under partitions allow free configuration of cables (Dekker, 1998b).

Figure 4.9. Raised floor system employed in Next 21 (Next 21, 2001).

5. Is flexibility allowed for the choice of kitchen and bathroom locations and sizes?	■	■

Voorburg: The kitchen and sanitary equipment belongs to infill, thus are chosen according to tenant preferences (Cuperus & Kapteijns, 1993). Furthermore, the location of kitchens and bathrooms are also determined by residents (Gann, 1999).

6. Are different flexibility levels offered in a single project to users with differing participation potentials in terms of economic level, background information, etc.?	□	■

Voorburg: Residents can choose among the 'maximum, built-in, and conventional" flexibility levels according to their affordability potential. They can choose total support-infill separation, partial renovation (only for bathrooms and kitchens), or accept the existing layout (Dekker, 1998a).

b. flexibility to allow future alterations—adaptability

7. Can support and its parts be adapted to varying needs of occupants?		

8. Do the unit sizes have possibility of adaptation for future alterations?	■	□

Next 21: Since the outer walls are movable, it is possible to adapt unit sizes by replacing these walls.

9. Do the selected technologies of infill allow user to adapt their dwellings by do-it-yourself or unskilled labor work, without any expert assistance?		

c. flexibility to enable periodic maintenance, renovation, and upgrading of components, equipment, and systems

10. Is independent distribution of services to units provided to allow the adjustment or replacement of them without disturbing the other dwellings?	■	■

Voorburg: The Matura infill package allows distributing service systems separately to the dwellings (Dekker, 1998b).

11. Are the subsystems totally disentangled so that replacement or repairing of one is possible without disrupting the other subsystems?	■	■

Next 21: "The building frame, the exterior cladding components, the interior finishes and the building services were treated as separate subsystems. The subsystems were designed considering their different life-cycles…" (Tiuri, 1998, p.36) (see Figure 4.10).

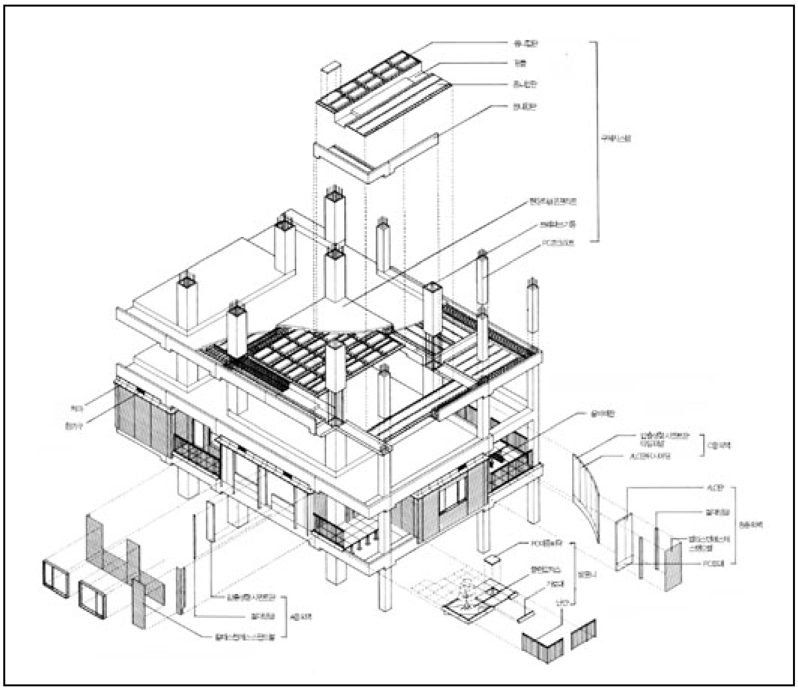


Figure 4.10. Individual components systems of Next 21 (Osaka Gas, n.d.).

d. technical flexibility to fit different locations, climate and ground conditions

12. Does the support design have technical flexibility to be rebuilt in different locations with different climatic and ground conditions by adaptations?		

C. User Involvement in Decision-making Process

a. users' participating the support decisions—users participate collectively in decisions concerning common facilities or common outdoor space

1. Can users participate to the support decisions for the common facilities?	□	■

b. users' deciding the infill—the actual user or future users decide on the infill in their apartments

2. Do experts (architects and interior designers) assist users during the design of their own dwellings?	■	■

Next 21: Four of eighteen units are designed together with the residents. "13 design teams designed the completely different, individualistic 18 dwellings at Next 21. Four of these were designed based on close communication between the designers and the dwellers who related their lifestyles and described their dream home in order to create more satisfactory dwellings" (Next21, 2001).

Voorburg: The new tenants had meetings with an architect to state their desires (Cuperus & Kapteijns, 1993).

3. Are users offered optional plans, if they cannot design interiors of the units?	■	■

Next 21: "In Next 21, 14 residence units offer new and enhanced living environments proposed by Osaka Gas …" (Osaka Gas, n.d.). Some alternatives for the units can be seen in Figure 4.11.

Voorburg: After the meeting between the expert and users, optional floor plans are developed (Cuperus & Kapteijns, 1993), from which the user selects the best one fitting his requirements and preferences (see Figure 4.12).

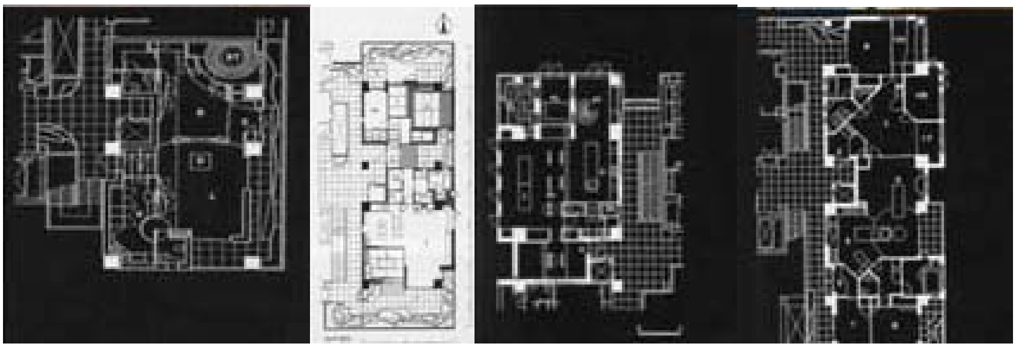


Figure 4.11. Unit plan alternatives of Next 21 (Next21, 2001).

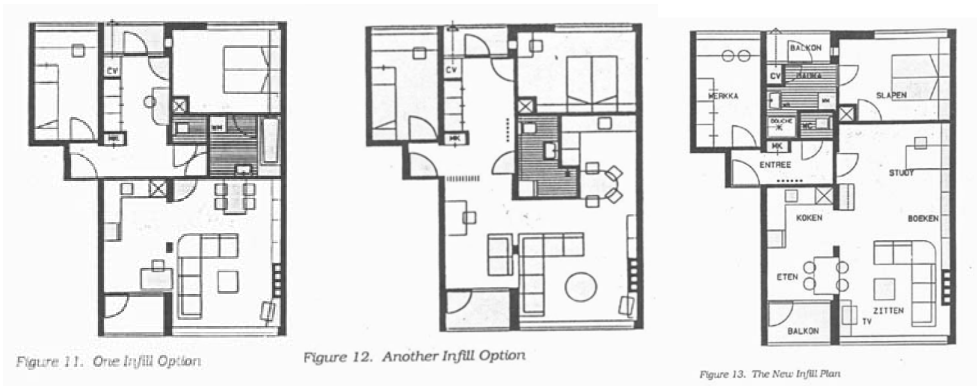


Figure 4.12. Infill options developed for Voorburg, and the selected infill of the pilot project (Cuperus & Kapteijns, 1993).

4. Is it possible to calculate the cost implications of alternative choices during infill design?		■

Voorburg: The costs of infills differ according to "… the level of equipment and utilities available and the technical quality of Infill components" (Dekker, 1998b, p.47). The costs of different interior designs are determined by the 'assessment method,' developed specifically for the system applied in Voorburg (Dekker, 1998b).

a/b. Support and infill decisions

5. Are specific user participation tools (mock-up models, CAD technology) available to assist users during design process?		

D. Sustainability

a. site and land use

1. Does the design take advantage of orientation, form, shading, color, and landscaping?		

b. energy efficiency

2. Are passive heating and cooling methods, and renewable energy sources considered during the design period?	■	

Figure 4.13. Solar cells (Osaka Gas, n.d.).

Next 21: "The roof is mounted with solar cells (monocrystal silicon type; surface area: approx. 70 m2)" (Osaka Gas, n.d.) (see Figure 4.13).

c. materials

3. Are the 'green building' materials used?	■	□

Next 21: The materials used in the project are environmentally friendly. For example, paint components are inorganic and have no effect on human body. Flooring is made of pure oak. “Since no plywood is used, no harmful substances such as formaldehyde are discharged to air” (Osaka Gas, n.d.).

4. Is ease of maintenance of the selected building components or systems considered during design?		

d. indoor ecology

5. Does the design focus on minimizing the impact of the external environment through the use of good insulation, controlled ventilation (esp. passive, i.e. user controlled), and economic use of space?	■	■

Next 21: The project features airtight, high-performance insulation, which minimizes the energy loss in heating and cooling of rooms (Osaka Gas, n.d.).

Voorburg: The project aimed at providing better thermal insulation for roof and outer walls, as well as minimizing the thermal loss by the use of isolation glass for windows (Dekker, 1998a).

e. waste reduction

6. Can building components be reused or recycled to decrease energy and material waste?	■	■

Next 21: “By standardizing and using pre-fabricated items for both exterior walls and other components, components can be easily replaced or moved. Both exterior walls and other components can therefore easily moved or recycled” (Osaka Gas, n.d.).

Voorburg: The design of the Matura infill system allows the reuse of the components.

7. Is treatment of drainage within the building considered?	■	□

8. Is everyday waste of household treated in the building in terms of pre-separation, composting, etc.?	■	□

Next 21: "The NEXT 21 complex is equipped with devices that process perishable refuse and miscellaneous waste water generated in the building. Perishable refuse and waste water are sent from each residence unit to the basement floor. Liquids are treated by microorganisms in the same process used by sewage treatment facilities, and solids are decomposed into harmless gases, CO_2 and N_2, and water by a wet-type oxidation catalytic method. The wet-type oxidation catalytic method was developed with Osaka Gas's proprietary technology, and uses a catalyst to oxidize and decompose solids under 260_C and 120 atmospheric pressure. The intermediate water produced by this process is reused for watering the plants and as toilet water in the building" (Osaka Gas, n.d.) (see Figure 4.14).

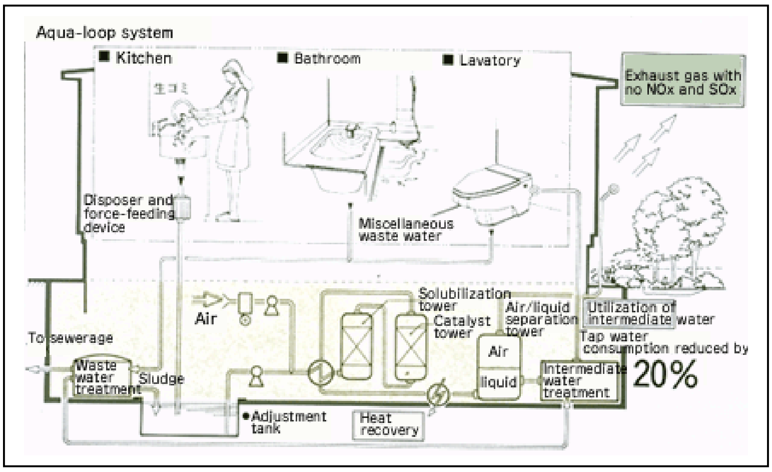


Figure 4.14. Waste (Perishable Refuse/Drain Water) processing in Next 21 (Osaka Gas, n.d.).

9. Are industrial building components (dry-construction techniques) used to decrease waste in site?	■	■

Voorburg: In this project, the parts forming the infill are packed by the company, considering the order of installation and transported to site ready to be installed.

4.2.2. Explanations of Second Stage Questions

A. Characteristics of Support and Infill

1. Support

1. Is the support composed of either the available industrial building components in Turkey, or traditional building materials? (BC)	◘	■

Next 21: The structural system of support is made up of pre-cast concrete and reinforced concrete, which are available and widely used in Turkey. However, "while the project is an experimental one, designed to test new energy saving mechanical systems, waste water recycling, recycled building products…" (Kendall, 1996, pp.11-12), it would not be possible to build the same support system by using the available industrial and traditional building materials and components in Turkey.

Voorburg: The traditional materials used in the support are also available in Turkey.

2. Do the selected materials satisfy the fire-resistance requirements for d. party walls, e. slabs, f. facades, d. roofs? (FSC)		

3. Are the determined common uses belonging to support suitable according to the common property regulations? (FOL)	■	■

Next 21 and Voorburg: In both projects, the common areas such as the entrance area, corridors, staircases, etc.; the common service systems outside the units; and the building components such as the roofs, chimneys, and the other service shafts belong to the support level, satisfying the Flat Ownership Laws in Turkey.

4. Does the support satisfy the environmental compatibility requirements defined by the municipalities in terms of a. roof type and materials, b. façade finishings and color, c. building height, d. opening proportions? (B.Cd. of the specific municipalities)		

5. Does the support design satisfy the accessibility standards of Turkey? (TS 9111 [ANSI 117.1])		
a. Are the staircases suited to the codes in terms of widths and step dimensions? (see also B.Cd., FSC)		
b. Does the support have the essential elevator(s) with the required dimensions? (see also B.Cd., EB)	■	
c. Do the doors (entrance, service spaces, etc.) satisfy the minimum widths? (see also B.Cd.)	■	
d. Are the corridors suitable in terms of wheelchair widths, and turning space dimensions,	■	
e. Are the finishing materials of corridors non-slippery and not obstructive for the movements of handicapped and elderly?		

Next 21: The necessary dimensions for the evaluation are provided from the floor plans of the project (see Figure 4.2).

2. Infill

1. Is the used infill system able to be constructed either by using the available industrial building components in Turkey, or by conventional methods? (BC)	☐	☐

Next 21: Because of the trial of new systems, the infill of the project cannot be constructed within the limitations of Turkey.

Voorburg: Some components of the Matura Infill system, such as the specially produced polystyrene matrix tiles and the L-shaped base-board channels, are not locally available in Turkey (see Figure 4.15).

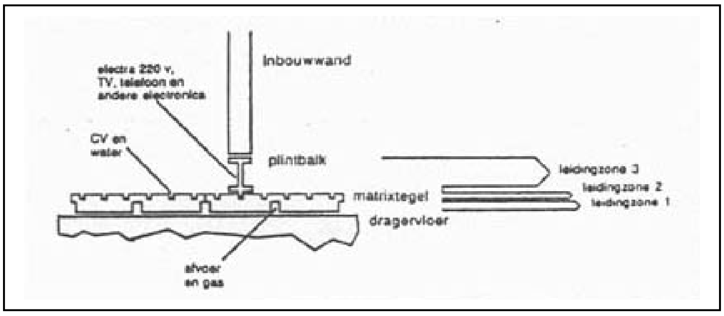


Figure 4.15. Components of the Matura infill system (Cuperus & Kapteijns, 1993).

2. Do the selected materials satisfy the fire-resistance requirements for e. interior partitions, f. façades, c. slabs? (FSC)		

B. Amount of Flexibility

1. Do the infill units have all the required functions which dwelling should have according to B.Cd., although they are designed separately?	■	■

Next 21 and Voorburg: The dwellings of both projects include a living-room, one or more bedrooms or bed niches, a cooking area, bathroom and WC. Thus, they satisfy the minimum functional requirements of a dwelling unit to be built in Turkey.

2. Do the spaces satisfy the minimum dimensional requirements, while providing different layouts according to varying needs? (B.Cd., TS 9111)		

3. Do the openings (door, window, and other facade openings) always satisfy the necessary horizontal distance between each other in all different infill designs? (FSC)		☐

Voorburg: The distances between the windows are less than 100 cm., the necessary horizontal distance for fire protection.

4. Do the areas of the window openings satisfy the allowable areas? (TIR, B.Cd.)		☐

Voorburg: The window areas exceed the 12% of the exterior wall surface area in dwelling units, thus are unable to satisfy the Turkish regulations.

5. Do the individually designed units care for the ventilation and lighting requirements for spaces? (B.Cd.)	☐	■

Next 21: Although one living room and the bedrooms of dwellings should benefit from natural ventilation and daylight, some bedrooms of the units do not satisfy this regulation (see Figure 4.16).

Voorburg: The optional plans developed for the new tenants satisfy the ventilation and lighting requirements.

6. Does the support have the required areas for service shafts (light wells and ventilation shafts)? (B.Cd.)		

7. Are the chimney necessities satisfied in each unit in terms of both dimensions and numbers? (B.Cd., FSC)		□

Voorburg: The chimney requirements are not satisfied for kitchens.

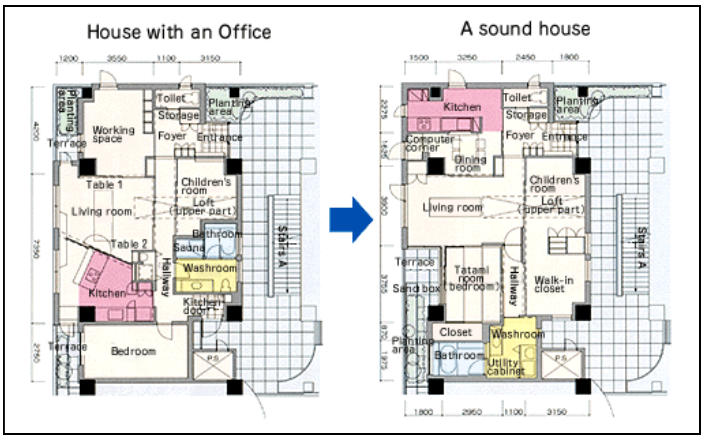


Figure 4.16. Plans of a unit before and after renovation, both unable to satisfy the lighting and ventilation requirements of Turkey (Next 21, 2001).

8. Does the design care for the allowable changes in floor heights, e.g. for bathrooms, while achieving the desired flexibility level? (B.Cd.)		

9. Does the support design satisfy the thermal insulation regulations in Turkey? (TIR)		

10. Is the support's structural system suitable for the seismic design limitations in Turkey? (DPA)		

C. User Involvement in Decision-making Process

1. Are the employed user participation tools available in Turkey?		

D. Sustainability

1. Can the used building elements easily be maintained by the use of available technologies and local skills?		◘

2. Do the used building elements have the required industry of reuse and recycling in Turkey?	◘	◘

Next 21 and Voorburg: Some of the building components, such as reinforced concrete, timber, steel, etc. have the necessary industry for reuse and recycling.

4.3. Discussion of the Results

This section deals with the discussion of the results achieved due to the comparative analysis of the OB projects, Next 21 and Voorburg, based on the analytical tool developed in the previous chapter. A brief comparison is done for each category of both the first-stage and the second-stage analysis, according to the defined goals. Although it was not possible to accomplish a complete evaluation because of the limited information, some of the results leading to the selection of better issues are mentioned below.

4.3.1. First-Stage Analysis

- **Characteristics of Support and Infill:** For the **support** level, Next 21 is better in accommodating different infill designs, because of the technologies used in support design, providing an 'open frame system,' and employing specific OB design methods which allow individually designed infills. Whereas, the support of Voorburg employs locally available materials for the building systems, thus it constitutes a better example in terms of material selection criteria for supports. From the **infill** design point of view, both Next 21 and Voorburg projects are successful, since specific infill systems are tried to allow individually designed units, and prefabricated building components are selected to decrease installation time, and also to save onsite labor costs.

- **Amount of Flexibility:** The 'flexibility' principle is considered in both designs, and a wide range of flexibility is offered to users. The basic advantage of Next 21 is the possibility of unit size adaptation by the movable outer walls. Whereas, in Voorburg project, users had the chance of choosing between the infill and traditional options, as the flexibility levels (conventional and maximum flexibility) according to their affordability potentials.
- **User Involvement in Decision-Making Process:** Considering the user involvement factor in design, Voorburg project is better in terms of providing the chance of participating to the common support decisions, and proposing a tool for the calculation of cost implications of different layouts.
- **Sustainability:** When the 'sustainability' category is examined, Next 21 achieves a more 'open' degree by giving priority to the environmental sustainability issue and the trial of new strategies and technologies to provide a sustainable building. Using 'green' materials and solar cells contributes to the building's sustainability for the energy efficiency goal. Also, treatment of drainage and household waste in the building is considered for waste reduction in Next 21. However, both projects achieve the goal of decreasing waste in site, by the use of prefabricated components.

4.3.2. Second-Stage Analysis

- **Characteristics of Support and Infill:** In the second stage of the analysis, although sufficient information to compare the support decisions is not available, Next 21 indicate a match with the Turkish standards and regulations, in terms of accessibility.
- **Amount of Flexibility:** Even though the amount of flexibility provided in Next 21 is more than Voorburg according to the first stage of the analysis, the design decisions of Voorburg are better in satisfying the building codes, according to the plan layouts. However, the infill systems of both projects cannot be constructed by using the available prefabricated components, or traditional methods. Thus, none of them is suitable for Turkey.
- **Sustainability:** Since Voorburg project uses mostly locally available materials, which are also accessible in Turkey, the selection of materials seems more appropriate for ease of maintenance, reuse and recycling potentials in the Turkish context, when evaluated for the 'sustainability' category.

This comparison of the two OB projects is done not for selecting the best OB projects appropriate for Turkey, but to demonstrate how the tool operates, and how it can be employed to draw conclusions as a result of the comparative analysis. The suitable OB design decisions can only be determined and selected by the designer when the evaluation is done for a particular project to be realized in Turkey based on the OB principles, within the context of that project with the local limitations and the priorities defined by the decision-makers involved in the building activity, a process not dealt with in this study.

5. CONCLUSION

In Turkey, there is a housing problem, which can be defined in terms of quantity and quality. Quantity related issues result from the migration of the rural population to urban areas, and the earthquakes which cause great amounts of housing demands. On the other hand, quality problems originate from the standard dwellings provided to occupants, which are unable to satisfy the needs of variety and adaptability. In this study, the ‘Open Building’ (OB) approach is proposed as a solution to the existing problem. The OB approach, providing a building process based on the principles of adaptability, variety, and sustainability within the framework of ‘levels’ theory, was thought to have the potential to constitute an alternative to the current building process in Turkey, which is not successful in satisfying user preferences and needs.

Having proposed OB as a solution to the housing problem in Turkey, this study developed an analytical tool for the evaluation of previous OB projects according to their success in applying OB principles, and appropriateness of the employed OB methods and strategies’ within the Turkish context. The analytical tool is to be used during the design phase of the building process by the architects and interior designers who aim to apply OB principles for the housing designs in Turkey.

The developed tool has two stages: The first stage evaluates the OB projects to determine their ‘openness’ according to the criteria which OB solutions should have, and in the second stage, suitability of these project’s decisions are assessed within the limitations of Turkey, in terms of legal restrictions and technical availability. At the end of the two-stage evaluation, user of the tool determines the best OB projects, whose decisions are also applicable to Turkey; and selects the appropriate strategies and methods to apply his own project, considering also the specific project constraints.

After development of the tool questions, two projects, Next 21 Experimental Housing and Voorburg Renovation Project, are analyzed comparatively according to their 'openness,' and their decisions' suitability to Turkey, but a complete evaluation was not possible due to the limited information about project decisions. However, the aim was not selecting the best project, but to demonstrate the operation of the analytical tool, and some of the results to be achieved. Thus, the simulation was sufficient to explicate the purpose and benefits of the tool. It can also be concluded from the evaluation that the legal and technical context of Turkey does not yet support the application of some OB issues. This mismatch between the OB theory and practice has always been a problem of this approach in other countries where OB principles are tried to be applied. Furthermore, the comparative analysis of the projects also indicate a necessity to find solutions specific to the Turkish case for successful implementation, or the need for adaptation of some decisions to provide ease of application.

In this study, the developed analytical tool deals with the OB approach under four major categories: Characteristics of Support and Infill, Amount of Flexibility, User Involvement in Decision-making Process, and Sustainability. These categories can be said to encompass nearly all OB criteria to be satisfied by designers during housing designs; and the legal and technical issues specific to the Turkish context, which can be effective on the application of these criteria. One difference of this categorization from the previous definition of OB characteristics is its more emphasis on the sustainability issues, according to the OB's newly emerging focus on the sustainable development concerns as well. The objectives of sustainable architecture, such as design considering site and land use, energy efficiency, selection of environmentally sensitive materials, efficiency in indoor ecology, and waste reduction are underlined within the primary goals of OB approach. In the analytical tool, the 'subsystems disentanglement' principle is examined under the other OB objectives, such as the service flexibility criterion. Perhaps, a classification concerning this principle as an independent category would be clearer, by indicating all OB objectives separately.

This study was the one of the first attempts to encourage the OB principles applicability to Turkey, by development of a tool for designers focusing on the legal and technological framework. Moreover, first stage of the tool can be employed independent of the second stage, as a checklist to evaluate all OB projects worldwide for their technical aspects. Nevertheless, further research is necessary to study the cultural compatibility of the decisions to the context where OB principles are applied. The appropriateness of some OB strategies should be examined within the cultural context. For example, the level differences in the plan layout (e.g. in bathrooms) was demonstrated not to damage the lifestyle of Japanese people, but to disturb the occupants in Europe. Such problems may also occur in Turkey, thus it is also necessary to define the cultural compatibility criteria of the OB strategies and methods. Especially for the second stage of the tool, the affect of cultural factors on the suitability of OB decisions to Turkey is required to be studied, besides the technical issues. Moreover, the economical viability of the OB approach in Turkey, which was not dealt with in this thesis, should be examined in following research studies. Furthermore, organizational models for the decision-makers, rather than the designers, who are involved in this process need to be developed to support the utilization of OB principles in the building process within the Turkish context.

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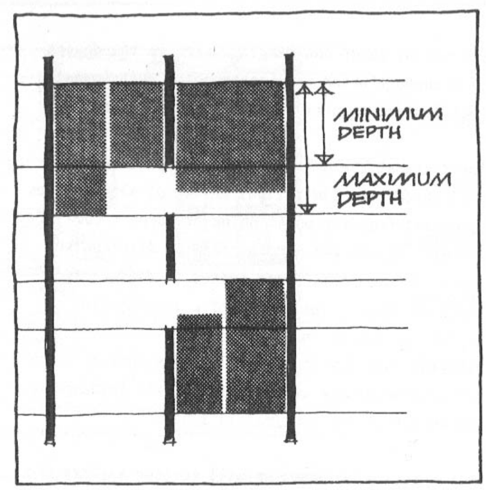
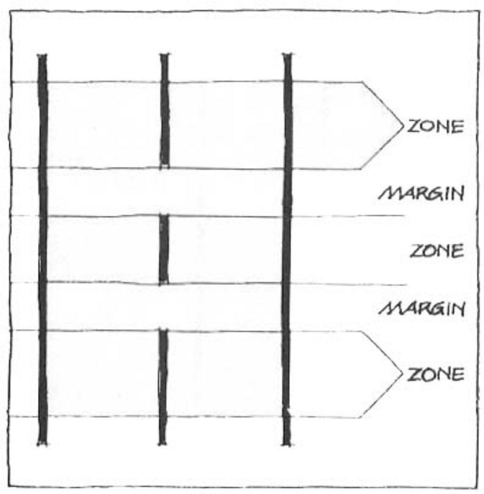
APPENDIX A

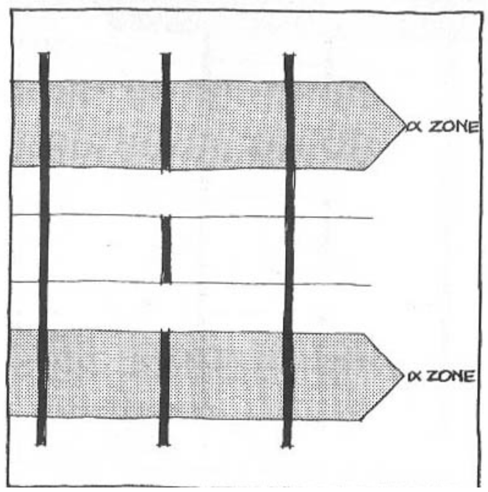
Variations: The Systematic Design of Supports, by N. J. Habraken, J. T. Boekholt, P. J. M. Dinjens, and A. P. Thijssen[6]



Within a support two areas can be distinguished: one on the perimeter and one totally internal. Each of these is suitable to a different purpose. ... Two lines can be superimposed on the plan of support indicating the minimum and maximum depth of ... rooms. These lines define an area within which a certain kind of room can be located (p.52).

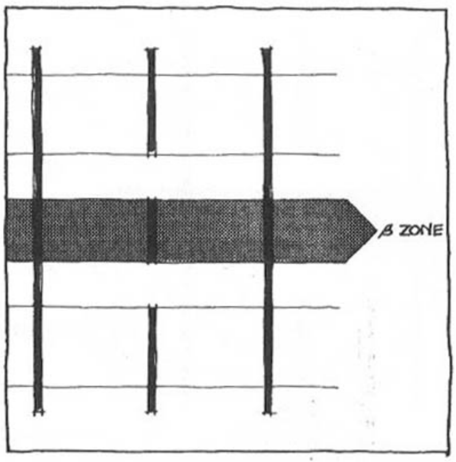


… [A] room behind the façade will never be shorter than the width of the first band, and never longer than the width of both bands together. … The areas described by these lines are called zones and margins. These are areas within a support in which certain kind of spaces are located according to specific rules (p.53).

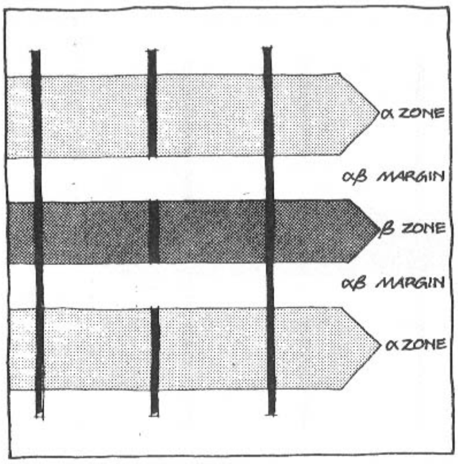


The zone adjacent to the façade is called the alpha zone. … There are three basic characteristics to an alpha zone:
it is an area within a dwelling unit
it is an internal space
it is an area which is adjacent to an external wall.
… it is part of a larger private area, that is the whole dwelling unit and is distinguishable from the public are in which the unit is located (p.53).

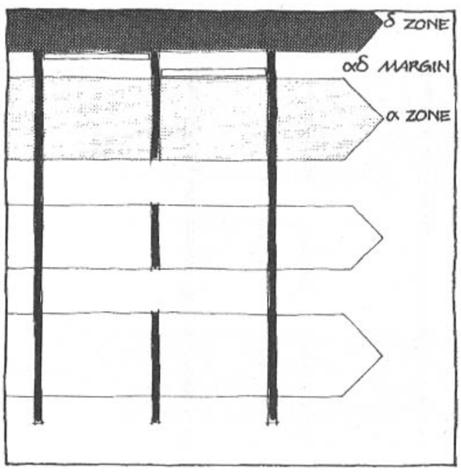
[6] In this section, some parts of the book *Variations* are presented to explain the rules for the support design of OB approach, based on the zone/margin system. The basic diagrams and their explanations are chosen to demonstrate the basic concepts of a support design, which guide the designers through the positioning and dimensioning methods of OB.



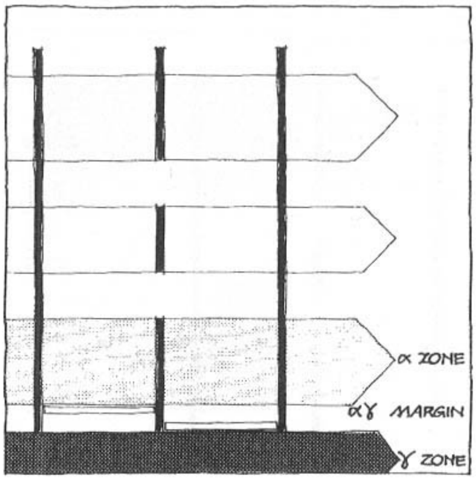
The second area that can be identified in the illustration is that which has no direct relationship to the outside. This area is called the beta zone. ... A beta zone is an internal area, intended for private use, and is not adjacent to an external wall (p.53).



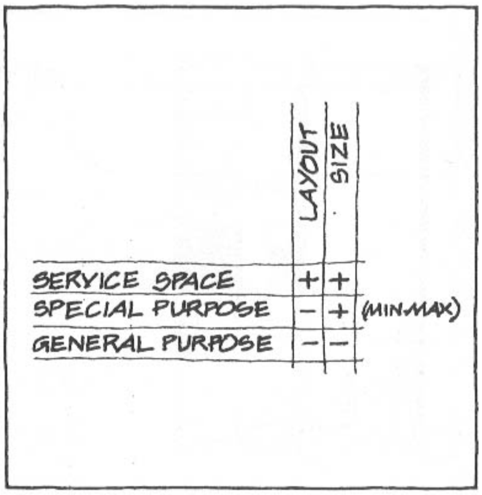
Between two zones there is always an area called a margin, which is defined as follows:
A margin is an area between two zones, with the characteristic of both these zones and taking its name from them (p.54).



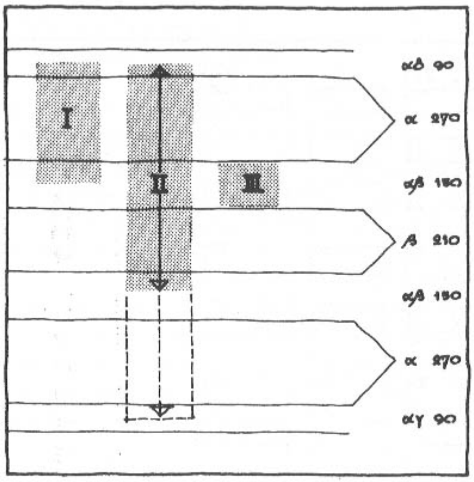
The support … could have space for balconies or porches, outside spaces that are really part of the dwelling unit and are intended for private use. These are called delta zones. … Between the alpha one and delta zone is the alpha/delta margin. The separation between inside and outside occurs in the alpha/delta margin, in other words, the façade is located here (p.54).



In the illustration, the area on the other side of the dwelling unit provides public access to the dwelling. This zone is the gamma zone, thus:
A gamma zone can be internal or external, but is intended for public use (p.54).



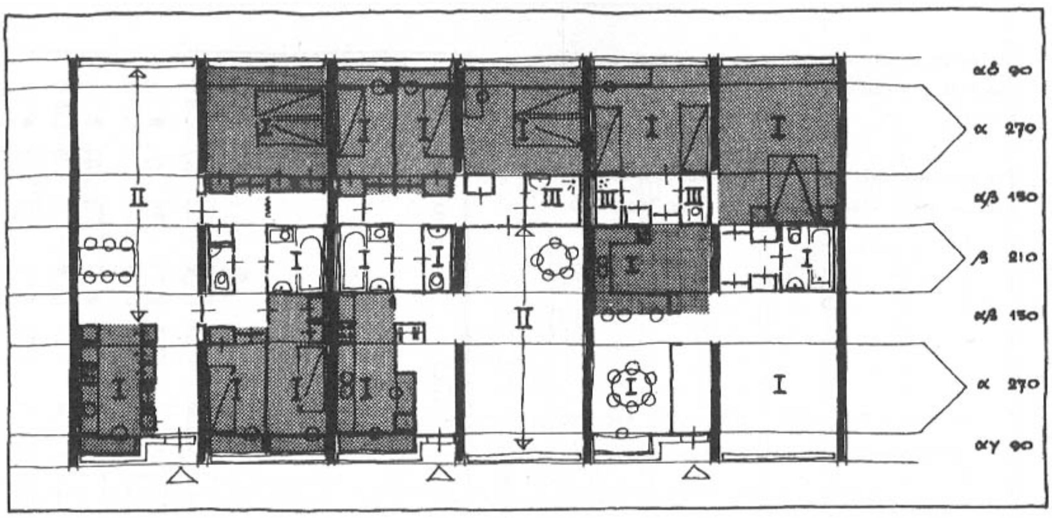
All spaces with determinate functions can be divided into three groups. … The first kind of spaces that can be distinguished in a dwelling are special purpose spaces, such spaces are intended for particular activities over a certain length of time, they include bedrooms, kitchens, studies, etc. … The maximum and minimum size … can be determined on the basis of an analysis of its function. … The second kind of space that can be distinguished is the general purpose space. … A general purpose space s a space that allows a combination of specific activities that cannot always be determined in advance. … [Thirdly] service spaces are meant for short term occupancy, are utilitarian in character, the size and layout of which can be determined on the basis of an analysis of their functions (pp.56-58).

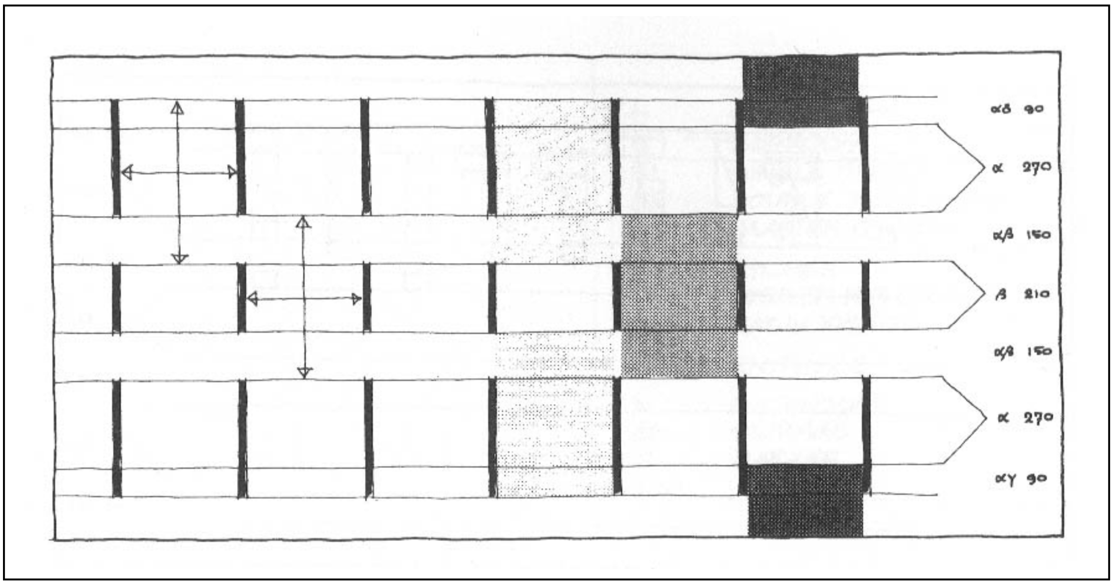


In every zone distribution three primary positions can be distinguished:
Position 1: A space which overlaps the zone and ends in the adjacent margin.
Position 2: A space which overlaps more than one zone and ends in a margin.
Position 3: A space which begins and ends in the same margin.
All three positions conform to the general rule: spaces always end in a margin (p.62).

	I	II	III
GENERAL PURP. SPACES	●	●	
SPECIAL PURP. SPACES	●		
SERVICE SPACES	●		●

Special purpose spaces will usually be located in position 1.
General purpose spaces will usually be located in either position 1 or position 2.
Service spaces will usually be located in position 1 or 3 (p.64).



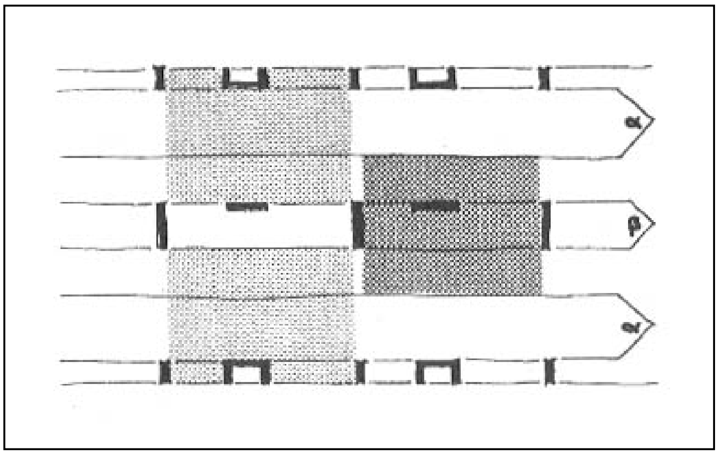


Because zones are generally long strips they have only one fixed dimension, the width. When the size of a zone is determined, it sets only one dimension of spaces, the depth, but in designing spaces the width must also be taken into account.

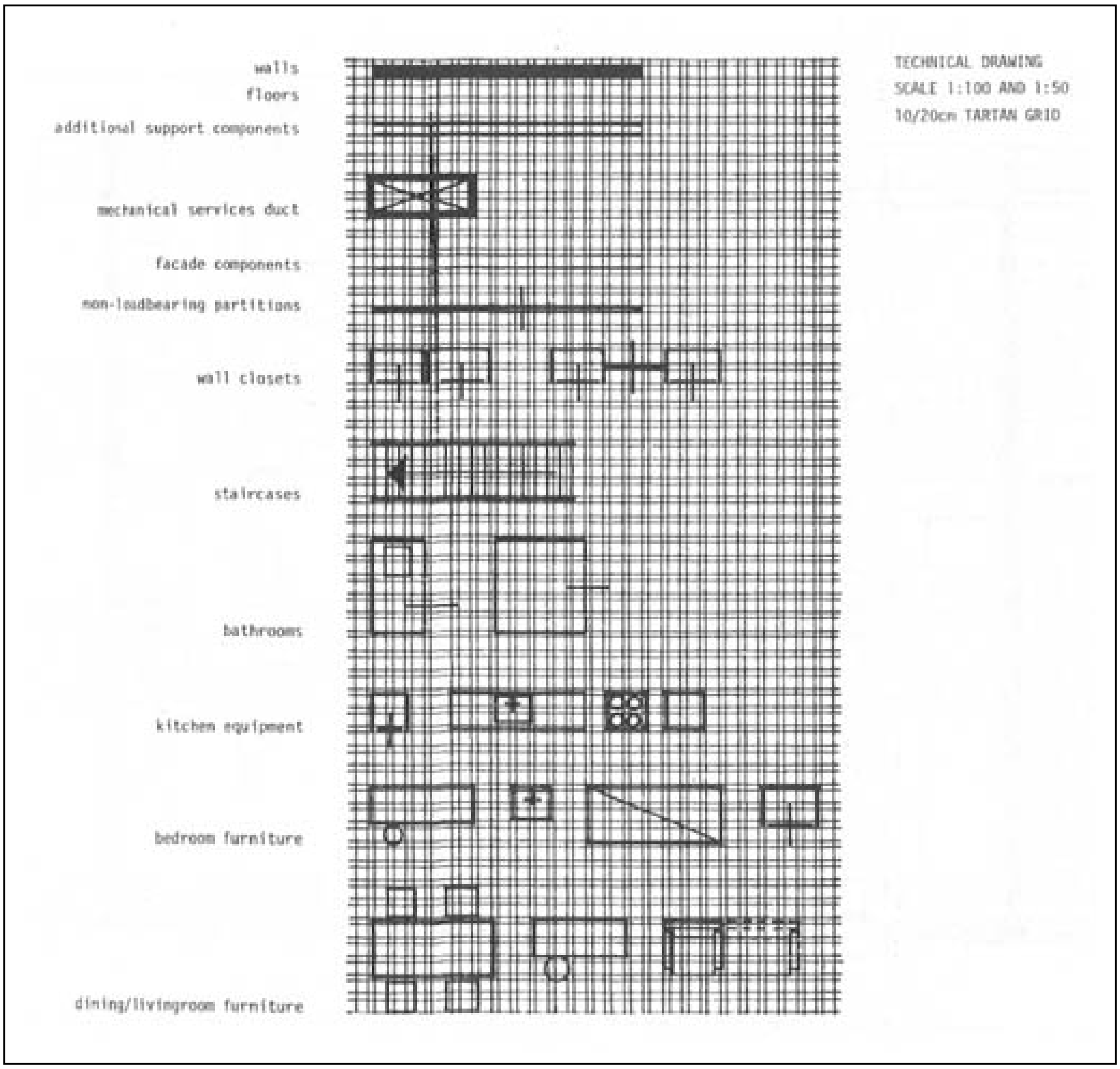
Structural components will often cut across zones. In analyzing various layout possibilities, the utility of that part of a zone between structural members has to be evaluated. This portion of a zone in called sector.

...

A support in combination with a zone distribution can be considered as a series of sectors. The same sectors can be conbined in many different ways, thus different supports can be created from the same set of sectors (pp. 66-68).



The designer is free to divide the area in a spatial structure into sectors whatever way is best. The intention is to divide the total area into parts in order to analyze the possible layouts (p.68).



In the development of supports and detachable units the location of components must be clearly defined. … Thus, a location grid must be drawn in which the distances between the grid lines represent an agreed module. … The location grid discussed here is referred to as a 10/20 tartan grid and consists of horizontally and vertically alternating bands of 10 cm and 20 cm. …

In a tartan grid, all dimensions can be stated in terms of the main module. Thus, in the 10/20 tartan grid all dimensions will be related to the 30 cm module (p.95).

APPENDIX B

Table 4.1. Comparative analysis of Next 21 and Voorburg projects.

I. FIRST STAGE QUESTIONS A. Characteristics of Support and Infill **1. Support**	Next 21	Voorburg
1. Are specific support technologies (such as depressed floor slab trenches, flat beam skeleton, inverted slab-beam floor structure, Z-beam structure, etc.) used to support the use of infill systems?	■	□
2. Does the support provide 'open frame structure' to accommodate and outlast infill changes?	■	□
3. Does the support utilize specific OB design methods, such as the zoning rules defined in *Variations* to allow for all the desired variations while using a few detachable units as possible?	■	□
4. Is the support totally separated from individually varied infills, including all common functions in it?	■	◘
5. Does the support design suit the appearance of the surrounding buildings in terms of: a. roof type and materials, b. façade finishings and color, c. opening proportions?		
6. Does the scale of the building (support) suit the scale of the surrounding buildings?		■
7. Is the support composed of locally available materials in terms of:	■	■
a. structural system,	◘	■
b. service systems,	◘	■
c. floors and walls,		■
d. doors and windows	◘	■
e. finishings?		
8. Is 'accessibility for elderly and disabled' thought as a basic criterion for the support design?		■
2. Infill		
1. Are the units designed according to the positioning and dimensioning rules for each subsystem developed for OB approach, such as the 'band grid' utilized by SAR?	■	
2. Are specific infill technologies, allowing individualization of designs with little or no extra cost, used?	■	■
3. Are prefabricated elements available in the local market employed to allow quick installation, to eliminate onsite cutting and adjusting dimensions, and thus to save onsite labor costs?	■	■
B. Amount of Flexibility		
1. Can users determine the size of their dwellings at the beginning?		□
2. Is flexibility allowed for partitions?	■	■
3. Is flexibility allowed for facades?	■	□
4. Is flexibility allowed for service systems?	■	■
5. Is flexibility allowed for the choice of kitchen and bathroom locations and sizes?	■	■

Table 4.1. Continued.

6. Are different flexibility levels offered in a single project to users with differing participation potentials in terms of economic level, background information, etc.?	□	■
7. Can support and its parts be adapted to varying needs of occupants?		
8. Do the unit sizes have possibility of adaptation for future alterations?	■	□
9. Do the selected technologies of infill allow user to adapt their dwellings by do-it-yourself or unskilled labor work, without any expert assistance?		
10. Is independent distribution of services to units provided to allow the adjustment or replacement of them without disturbing the other dwellings?	■	■
11. Are the subsystems totally disentangled so that replacement or repairing of one is possible without disrupting the other subsystems?	■	■
12. Does the support design have technical flexibility to be rebuilt in different locations with different climatic and ground conditions by adaptations?		
C. User Involvement in Decision-making Process		
1. Can users participate to the support decisions for the common facilities?	□	■
2. Do experts (architects and interior designers) assist users during the design of their own dwellings?	■	■
3. Are users offered optional plans, if they cannot design interiors of the units?	■	■
4. Is it possible to calculate the cost implications of alternative choices during infill design?		■
5. Are specific user participation tools (mock-up models, CAD technology) available to assist users during design process?		
D. Sustainability		
1. Does the design take advantage of orientation, form, shading, color, and landscaping?		
2. Are passive heating and cooling methods, and renewable energy sources considered during the design period?	■	
3. Are the 'green building' materials used?	■	□
4. Is ease of maintenance of the selected building components or systems considered during design?		
5. Does the design focus on minimizing the impact of the external environment through the use of good insulation, controlled ventilation (esp. passive, i.e. user controlled), and economic use of space?	■	■
6. Can building components be reused or recycled to decrease energy and material waste?	■	■
7. Is treatment of drainage within the building considered?	■	□
8. Is everyday waste of household treated in the building in terms of pre-separation, composting, etc.?	■	□
9. Are industrial building components (dry-construction techniques) used to decrease waste in site?	■	■

II. SECOND STAGE QUESTIONS **A. Characteristics of Support and Infill** **1. Support**	Next 21	Voorburg
1. Is the support composed of either the available industrial building components in Turkey, or traditional building materials?	◘	■
2. Do the selected materials satisfy the fire-resistance requirements for a. party walls, b. slabs, c. facades, d. roofs?		

Table 4.1. Continued.

3. Are the determined common uses belonging to support suitable according to the common property regulations?	■	■
4. Does the support satisfy the environmental compatibility requirements defined by the municipalities in terms of a. roof type and materials, b. façade finishings and color, c. building height, d. opening proportions?		
5. Does the support design satisfy the accessibility standards of Turkey? a. Are the staircases suited to the codes in terms of widths and step dimensions? b. Does the support have the essential elevator(s) with the required dimensions? c. Do the doors (entrance, service spaces, etc.) satisfy the minimum widths? d. Are the corridors suitable in terms of wheelchair widths, and turning space dimensions? e. Are the finishing materials of corridors non-slippery and not obstructive for the movements of handicapped and elderly?	■ ■ ■	
2. Infill		
1. Is the used infill system able to be constructed either by using the available industrial building components in Turkey, or by conventional methods?	□	□
2. Do the selected materials satisfy the fire-resistance requirements for a. interior partitions, b. façades, c. slabs?		
B. Amount of Flexibility		
1. Do the infill units have all the required functions which dwelling should have, although they are designed separately?	■	■
2. Do the spaces satisfy the minimum dimensional requirements, while providing different layouts according to varying needs?		
3. Do the openings (door, window, and other facade openings) always satisfy the necessary horizontal distance between each other in all different infill designs?		□
4. Do the areas of the window openings satisfy the allowable areas?		□
5. Do the individually designed units care for the ventilation and lighting requirements for spaces?	□	■
6. Does the support have the required areas for service shafts (light wells and ventilation shafts)?		
7. Are the chimney necessities satisfied in each unit in terms of both dimensions and numbers?		□
8. Does the design care for the allowable changes in floor heights, e.g. for bathrooms, while achieving the desired flexibility level?		
9. Does the support design satisfy the thermal insulation regulations in Turkey?		
10. Is the support's structural system suitable for the seismic design limitations in Turkey?		
C. User Involvement in Decision-making Process		
1. Are the employed user participation tools available in Turkey?		
D. Sustainability		
1. Can the used building elements easily be maintained by the use of available technologies and local skills?		◘
2. Do the used building elements have the required industry of reuse and recycling in Turkey?	◘	◘