FLEXIBLE DESIGN FOR MASS HOUSING IN TURKEY

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Abstract: The aim of this study is to develop a decision-making approach in multi-storey housing design that will allow for alterations in the layout of the dwellings at the time of the users' initial moving in and/or at later periods of the use, in response to new requirements arising from the users' initial characteristics or any changes in their characteristics in the course of time, and to select the most suitable building plan alternatives for the users. The houses demands of the real user groups with different charactericstics and a variety of lifestyles might usually lead to a conflict between the users and the houses even at the time when they move in. Futhermore, the houses may fall short in meeting demands when the original users move out and other users move in, or as a result of changes that may occur in the family structure, socioeconomic statuts,lifestyle etc. In this study, a multi-storey housing system with a reinforced concrete skeleton structure is being proposed which allows the design of floor plans that are variable to accommodate different family structures. In housing blocks built according to this design principle, the users must be able to choose the plan of their flat according to their own needs and desires, accounting for a higher degree of satisfaction with their living space.

Key Words: Flexible design, Mass housing, Planning, Partition walls, Modular coordination, Dimensional co-ordination.

Türkiye'deki Toplu Konutlar İçin Bir Esnek Tasarım Modeli

Özet: Bu çalışmanın amacı çok katlı konut tasarımı için, kullanıcıların taşınma ve kullanım süreçlerinde sürekli değişebilen ihtiyaçlarına olanak tanıyan bir karar verme yaklaşımı geliştirmektir. Birbirinden farklı sosyal ve ekonomik yaşantıları olan farlı kullanıcı gruplarının istek ve ihtiyaçları düşünülmeden tasarlanan ve üretilen konutlarda kullanıcı ve konut arasındaki ilişkinin doğru kurgulanmaması nedeni ile konutun verimsiz kullanımı ortaya çıkmaktadır. Çalışmada değişik aile yapılarına uygun esnek ve değişebilir plan düzenlemelerine olanak veren betonarme iskelet taşıyıcılı bir çok katlı konut sistemi öngörülmektedir. Kullanıcıların konutu kullanılma sürelerince kullanıcıların sosyo ekonomik durumlarında, aile yapı ve büyüklüklerinde, yaşam tarzlarında vb ortaya çıkabilecek değişiklikler, konutun kullanıcı ihtiyaçlarını karşılayamaz duruma gelemsine neden olmaktadır. Konut tasarlanırken kullanıcısı için esnek mekanlar yaratılacak şekilde tasarımların yapılması elzemdir. Fakat esnek yapı elemanlarının yüksek maliyetli oluşu, esnek olmayan yapı elemanlarının yapım sonrasında veya kullanımları sırasında değiştirilmesi ilave maliyet gerektirmektedir. Konut bloklarının bu tasarım ilkeleri doğrultusunda inşa edilmesine yönelik olarak seçilen blok tipleri üzerinde boyutsal koordinasyon kurallarına uygun plan düzenlemeleri yapılmıştır. Konut mekanları ve mekan grupları üzerinden alan hesabı yapılmış, ıslak hacimlerin alan ve konumsal durumları planlar üzerinde incelenmiştir.

Anahtar Kelimeler: Tasarım esnekliği, Toplu Konut, Bölücü duvarlar, Modüler koordinasyon, Boyutsal koordinasyon.

1. INTRODUCTION

In order to meet the housing demand in urban areas in Turkey, developers used to resort –to a large extent– to mass-housing production. However, these dwellings produced in great numbers have brought with them a set of problems due to their deficiencies in meeting the real demands in terms of both the flat and block.

In this study, dimensions of rooms are determined according to number of occupants. In addition different variations of rooms are also examined by the dimensional characteristics.

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Particularly bathroom and kitchen design variations are studied according to number of occupants. As for the planning stage, formation of floors, structural configurations, partition wall and mecanical shaft positions are examined. In the last part of the study, different housing block plan schemas are studied.

In the process of designing multi-storey housing, for lack of reliable information about the actual users, designers usually base their decisions on the average (standard) characteristics of users rather than taking into consideration the characteristics of the actual users. Consequently, if dwellings are designed and produced without due recognition of the expectations and demands of the actual user groups with different characteristics and a variety of lifestyles; this is likely to lead to discrepancies between the users and the dwellings even at the time when they move in. On the other hand, the dwellings may fall short of meeting demands when the original users move out and others move in, or as a result of changes that may occur in the family structure, socio-economic status, lifestyle, etc., of the same users during the period of their stay. In such events when a conflict occurs or the harmony between the user and the dwelling is disturbed, the user either moves out or is compelled to adapt to the restricting character of the dwelling (Low&Chambers, 1989; Pakdil,1991; Carvalho, George, Anthony, 1997).

The flexibility demands which may arise concerning the dwelling can be met by way of physical building elements. Nevertheless, the users may have to endure some technical and economic impositions as a result of replacing or reorganising building elements. The efficiency of building elements in terms of meeting the flexibility demands of the users is dependent on whether the building elements that are liable to change in the future are determined in accordance with the characteristics of the user, and whether the most suitable alternatives for the users from among alternatives of such building elements are selected by virtue of rational methods (Kendall &Teicher, 2000; Clark& Flowerdew,1982).

The objectives of this study are stated below:

- to give the users the chance to choose, before moving in, the floor plan of the flat they want to live in;
- to enable the floor plan to be adapted to the future users and to the changing needs of families;
- to achieve harmony between the basic structure and the various sizes of dwellings in the long term, in accordance with rising space standards and the possibility of new family members in the future.

Around the world, a great variety of research has been and is being carried out concerning the ideal living area. As a general average, the following living area sizes are regarded as minimum:

- for 1 person a living area of 25-30m^2
- for 2 persons a living area of 30-45m^2
- for 3-4 persons a living area of 50-60m^2
- for 5 persons a living area of 90-100m^2

An examination of the housing blocks erected by one of Turkey's largest public housing companies, Emlak Bank, shows that flat sizes are designed within a wide range, from 35m^2 to 170m^2. On the basis of Emlak Bank housing blocks, the following average sizes were identified (Table I):

Deepening the spaces decreases social control, the level of perception and social interaction. Increasing the depth of spaces in a house leads family members to stay apart from each other by individualizing their activities.

Table I. Room sizes in public housing

DESIGNATION	NUMBER OF ROOMS	SIZE
Entrance spaces	For single-bedroom flats For 2-bedroom flats For 3-bedroom flats	1-3m^2 3-7m^2 3-7m^2
Corridor	For single-bedroom flats For 2-bedroom flats For 3-bedroom flats	0-1m^2 4-5m^2 4-8m^2
Living room	For single-bedroom flats For 2-bedroom flats For 3-bedroom flats	10-20m^2 25-30m^2 30-35m^2
Kitchen	For single-bedroom flats For 2-bedroom flats For 3-bedroom flats	3-5m^2 7-13m^2 9-13m^2
Bedroom(s)	For single-bedroom flats For 2-bedroom flats For 3-bedroom flats	9-12m^2 2-18m^2 12-25m^2
Children's bedroom(s)	For single-bedroom flats For 2-bedroom flats For 3-bedroom flats	None 8-12m^2 8-15m^2
Bathroom	For single-bedroom flats For 2-bedroom flats For 3-bedroom flats	3-5m^2 5-7m^2 5-7m^2

The integration and dimensions of the living room-kitchen connection and accessibility of certain spaces from the others are attached great importance by the elderly.

Bathrooms are arranged in one of three following ways (Figure 1, Table II):

- **Bathroom with shower:** A bathroom incorporating a shower is the most practical solution when it comes to saving space in flats 50m^2 or less in size. The size of the smallest shower tub is 70x70cm. Considering this, together with the required access space, an area of 90x105cm is sufficient for a bathroom of this type.
- **Bathroom with bathtub**: Bathtubs are available in different sizes, depending on whether or not they allow for full body immersion. The design of such bathrooms is therefore dependent on the bathtub size opted for.
- **Bathroom with shower and bathtub**: Type of bathroom incorporating both a shower and a bathtub.

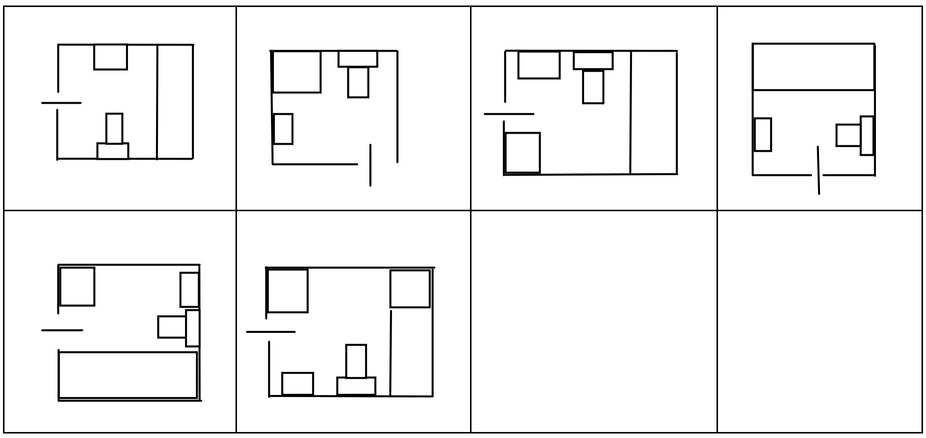


Figure 1:
Variation of different bathroom types

Table II: Bathroom sizes in public housing

Type of family	Shower/tub + toilet + sink
Family w/out children	2.3m^2
Family with 1 child	2.5m^2
Family with 2 children	2.5m^2
Family with 3 children	2.5m^2
Family with 4 children	2.5m^2
Family with 5 children	2.5m^2

According to the shape formed by the individual units, kitchens are designated as I-, L-, H-, U-, or G-shaped (Figure 2):

I- Shaped Kitchen: In an I-shaped kitchen, the units are positioned in a single row alongside one of the walls.

L- Shaped Kitchen: Here the units are positioned alongside two walls in a right angle to form the letter L.

H- Shaped Kitchen: This shape is formed by two rows of units on two opposite walls.

U- Shaped Kitchen: Here the units are positioned in three rows to form the letter U.

G- Shaped Kitchen: This is a variation of the U-shaped kitchen, where one of the opposite rows is squared off inwards, generally for the purpose of forming a dining area.

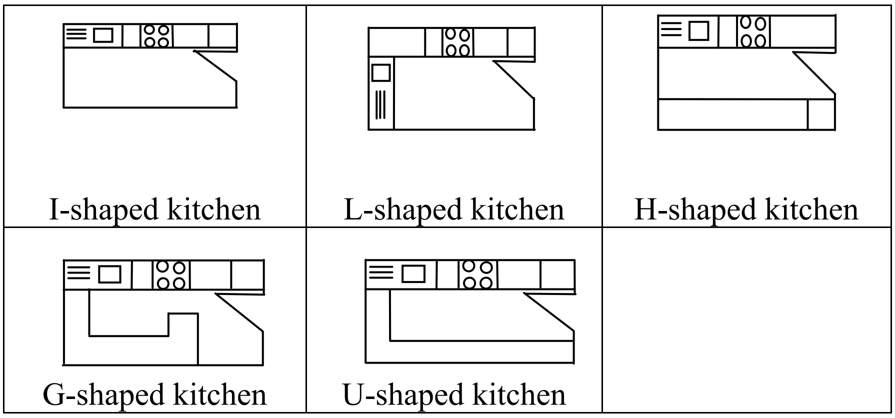


Figure 2:
Variation of different kitchen types

2. FLOOR AREA & GEOMETRY

With increasing floor areas of the individual dwelling units, the number of possible space organisations is also growing. To design various plan alternatives, at least 80-90 m^2 of area are required for a 4-person family flat, and 90-100m^2 for a 5-person family flat. The geometry of the flat's floor area also plays an important role for variability. Generally, flat floor areas are designed in square, rectangular, "L", or "Z" shape. "L" shaped flats are more difficult to divide than square ones (Karni, 1995; Lawrence, 1987). "Z" shaped flat plans are preferred because they make it possible to put in more windows for natural lighting and ventilation, thereby widening the range of indoor planning alternatives. The flexibility of rectangular plans with closed long sides is limited to switching space functions on opposite sides. This is due to the fact that there is an area at the centre of these plans which does not receive any daylight, and the flat is divided into two small areas at the exterior sides of the plan that can be used efficiently. For this reason, square or rectangular shapes are selected for the plan layouts of housing blocks (the rectangle's side - a&b - dimensions must be $b<2a$). The characteristics of these plan layouts are:

- They allow for planning two or three adjoining spaces at facades receiving light;
- The facades which are parallel to each other and at the shortest sides of the rectangle plan are blind (there are no windows);
- The layouts allow a variety of alterations of the area and number of spaces;
- The layouts are more suitable than rectangular plan layouts with blind long side facades in terms of design flexibility (Prins&Plat, 1990).

"Z" shaped flat floor plans have many advantages. A free choice of orientation, natural light and ventilation can be achieved with such a plan, thus enabling various space organisations and alterations (Karni, 1995; Sarja, 1990). To reach alternative designs of the plan layout, the placing of the partition walls must be planned in connection with the placing of the facade windows (Sarja, 1990; Jackson, 1996).

3. CONFIGURATION OF THE SUPPORTING STRUCTURE

Both the arrangement of columns and load-bearing walls and the possible clear span are important for the efficient use of the dwelling floor areas. To obtain maximum clear space in the plan layout, steel or prestressed reinforced concrete floor systems and components are to be preferred. The ceiling surfaces must be clear, and beams must be hidden in the exterior wall axes or fixed infill wall axes.

- All structural elements must be located at the exterior of the layout to create unobstructed space within the floor plan.
- The plan layout should not foresee room divisions, but rather allow for unlimited unobstructed clear space that can be freely arranged.

Common walls between the dwelling units are non-load-bearing walls. Thus, the dwelling unit floor areas can be arranged independent from boundaries. This solution provides an entirely flexible arrangement of living room and wet room locations in the plan layouts (Rabeneck & Sheppard&Town, 1976; Dirisamer & Kuzmich & Voss & Weber, 1976; Darke, 1982, Deniz, 1999). The most suitable solution to meet the variability and flexibility demands caused by the increasing complexity of requirements in planning is a skeleton building structure.

4. INSTALLATION DISTRIBUTION SYSTEMS AND WET ROOM POSITIONING

The identification of vertical and horizontal positions and locations of pipe-based distribution systems for heating, clean water, waste water, and gas is vital for effortless changes to the dwelling space organization (Owens & Hant & Sontag, 1985; Smith, 1996). Holes in the floor, installation walls, blocks, or shafts are used for pipe-based installations which spread in vertical direction, particularly in high-rise housing. These ducts are put either into different places or central places in the floor. If the vertical pipes are placed into a central duct, the plan will allow more flexible space organization design. Repairs and additions the vertical installation pipes are possible if they are put into a duct of sufficient size. On the other hand, it is very difficult to change the position of such ducts. Therefore, vertical pipe ducts must be considered as fixed building components during the designing of dwelling plan layouts which allow different space organizations and changes in space arrangement (Monray & Geraedts, 1983; Van Der Werf, 1990).

5. VARIABLE FEATURES OF PARTITION WALLS

Partition walls enabling flexible planning must have the following features:

- They must be easily applicable;
- They must be produced in standardized dimensions and not require base coat;
- It must be easy to remove any traces left by demounted partition elements on the adjoining elements, such as floors, ceilings, face walls, and fixed partition walls;

- It must be possible to coat them with different materials and to change colour and texture of their surfaces in accordance with the requirements of the space and the individual taste of the users;
- They must be storable.

6. PROPOSED HOUSING BLOCK

The proposed flexible housing block design is taking different family types into account. These are:

Dynamic families which are likely to have more children in future, and are therefore expected to have continuously changing and increasing needs, thus requiring a high degree of space flexibility;

Stable families who are not going to have any more children, whose children have left home or are too small to leave home, thus requiring a low degree of space flexibility (Friedman, 1994).

Stagnant families who are expected to live in the same dwelling for a long time to come, particularly free-holders, and therefore have sufficient opportunity to benefit from flexible building elements, which provides for lower life-cycle cost of such elements (Hacihasanoglu & Beken, 1989).

A 90-cm base grid module has been used for planning the dwelling. The proposed plan schemes aim at giving users the chance to choose the space organization they want before they move in, and to make the flat layout suitable both to the changing needs of the family and to future users. Suitability to the Turkish family structure has been taken into consideration during the planning of the flats. In particular, living rooms and bedrooms have been separated from each other. For this reason corridors have emerged. Except for the studio-type flats, there is no direct access from the living rooms to the bedrooms.

In dimensioning and designing housing produced with modular load-bearing system elements, variable elements (especially partition walls and face walls) and modular grids (90cm) for load-bearing structural system elements (columns, beams, curtain walls, floor panels) have been taken into consideration.

The structural system chosen is a central-core reinforced concrete skeleton system. Floor spacing has been set at 6.10m, 5.80m, 8.10m, and 6.5m. Floor slabs 20m thick shall be used in the proposed flat.

Columns are placed at the corners and at the middle of the plan. Around the stairs are curtain walls. With this solution it is possible to get a flexible housing plan. 4 different flat types have been proposed in the same plan, and 15 different plans have been designed within those flat types. To enable an arrangement in studio-type flats for the entrance doors to open up in the middle of the space, and to create individual spaces with practical value, the stairs have been placed in the centre and 1m off.

With these plans and systems, flats are created for 4 different family types within the same building. Furthermore, various plan variations have been developed for each family type. The plans given in Figure 4 show how 2-bedroom layouts can be transformed to 3-bedroom layouts, and vice versa, to enable variations of the space arrangement for accommodating increases or decreases in the number of family members. This is achieved simply by changing the position of the partition walls. The windows remain in the same position in each plan. While Figures 5 and 6 show the plan of a studio-type flat plan, a plan variation with 4 bedrooms is given in Figure 7. In the proposed housing, 3-bedroom flats have an area of 88 m^2 (Figure 3), as do 2-bedroom flats, while studio-type flats have 47m^2 or 41m^2 and 4-bedroom flats have 94m^2. The installation systems are bundled in an installation shaft, and conveyed to the wet rooms through ducts in the floor. The planning of variable housing must take into account that partition walls need to be easy to demount and light-weight. The sound transmission values of such walls must be the same as in normal walls. Table III shows the partition walls to be used in the proposed housing block.

7. CONCLUSION

Turkey has been suffering a considerable housing problem since the 1950s, especially in big cities. Various development laws were enacted to solve this problem and to overcome the housing shortages and many methods were tried to meet the housing demand. The final stage reached for this purpose is mass housing construction. Since the existing housing shortage increases by 100,000-200,000 housing units a year mass housing production and construction methods become more important year after year.

The problem arising in the mass housing units which have been built up till today and their solutions have not been given enough consideration are been efficiently dealt with. The fact that substructure, environmental planing and social facilities in may mass housing units have not been taken into much consideration or have remained unfinished gives rise to the necessity of a study in this respect.

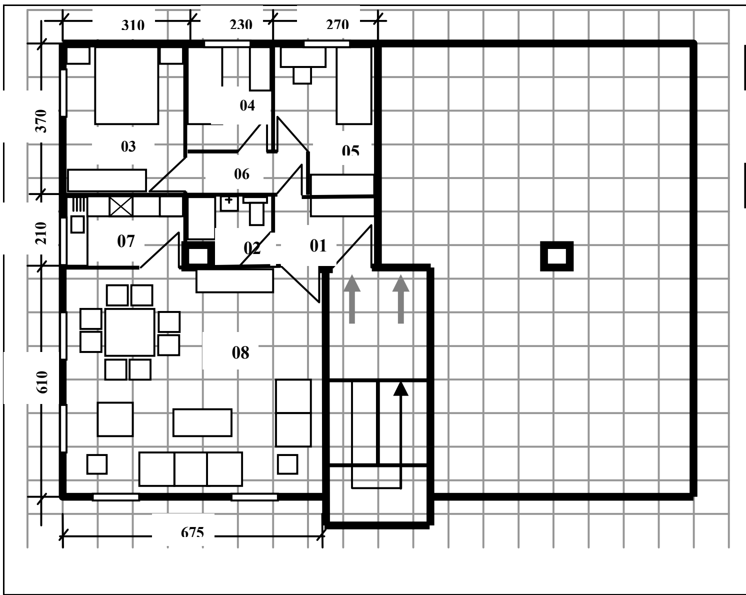
It is possible to follow a design and production strategy based on permanent and variable building components that are configured according to modular coordination rules, thus providing maximum variability in the layouts to meet possible user requirements not yet identified at the design stage.

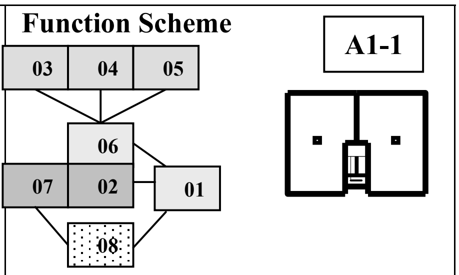
To arrive at variable housing according to the open building concept, all architects and producers must work along common rules, and to agree on a design based on modular co-ordination with respect to the dimensions and positioning of the building components determining the arrangement of space as well as supplementary and complementary spaces (Hacihasanoglu & Beken, 1989).

In this study, a multi-storey housing system with a reinforced concrete skeleton structure is being proposed which allows the design of floor plans that are variable to accommodate different family structures. In housing blocks built according to this design principle, the users must be able to choose the plan of their flat according to their own needs and desires, accounting for a higher degree of satisfaction with their living space.

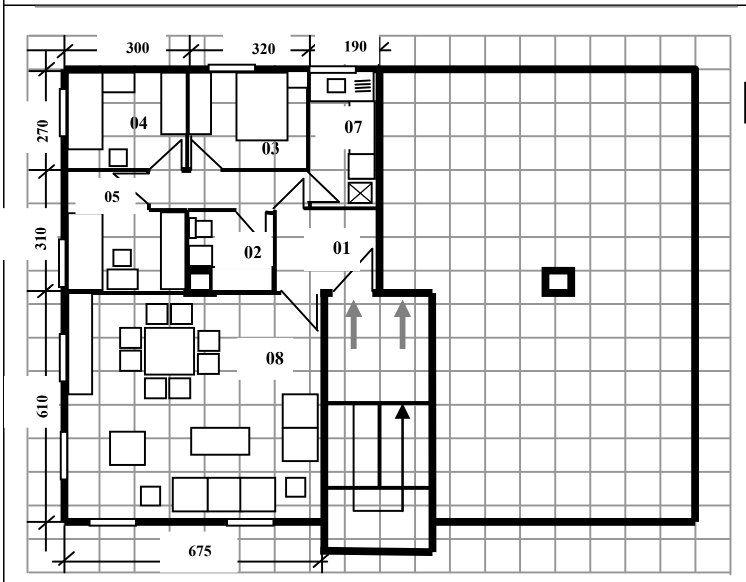
The comparison of the various plan schemes examined in the study rendered the following results:

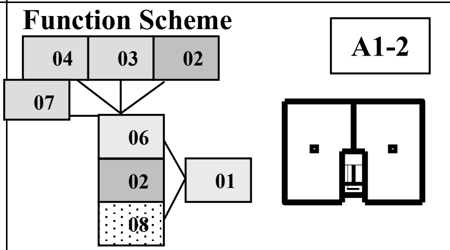
- Single-bedroom plan schemes were resolved within a space of $47m^2$. Due to the lack of available space, only one of the 6 proposals provides for a separate kitchen while the others integrate the kitchen with the living room. Both solutions have proved practical.
- In the 2-bedroom plan types, the living room and the bedrooms are being separated by a corridor. One of the proposals provides for a kitchen integrated with the living room. In recent years, this practice has become more and more common in Turkey, not only for summer houses/flats but also in public housing. In particular where optimum space utilization is desired or where the area available is very small, this solution is resorted to.
- In the 3-bedroom plan types, the living room and the bedrooms are being separated by the kitchen and the wet rooms. This solution is also suitable to the traditional Turkish family structure. The entrance in particular serves to divide living and sleeping quarters.



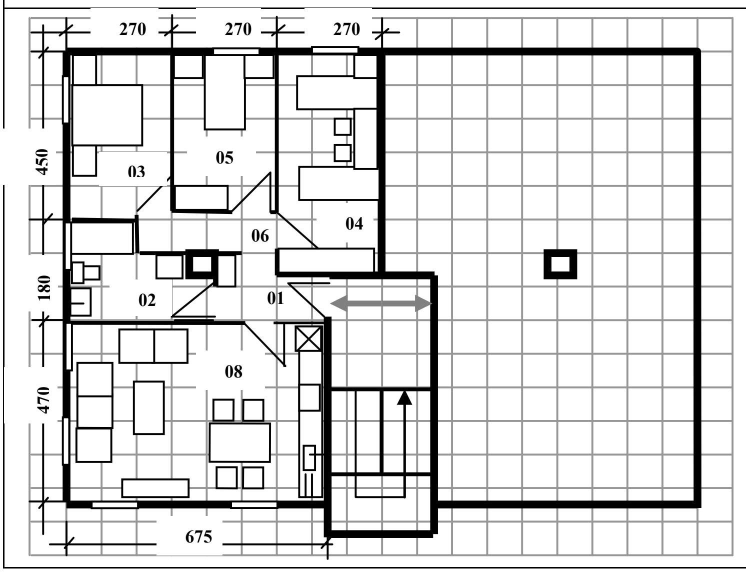


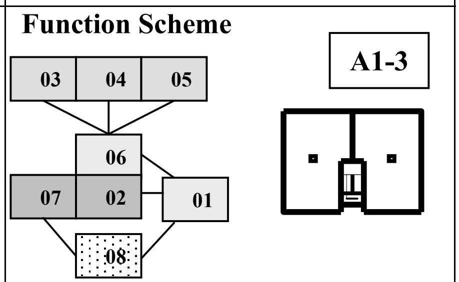
Space Codes - Names	m^2
0.1. Entrance	5.57 m^2
0.2. Bathroom	4.86 m^2
0.3. Master bedroom	11.10 m^2
0.4. Children's bedroom	6.44 m^2
0.5. Children's bedroom	9.64 m^2
0.6. Corridor	3.42 m^2
0.7. Kitchen	6.20 m^2
0.8. Living room	41.10 m^2





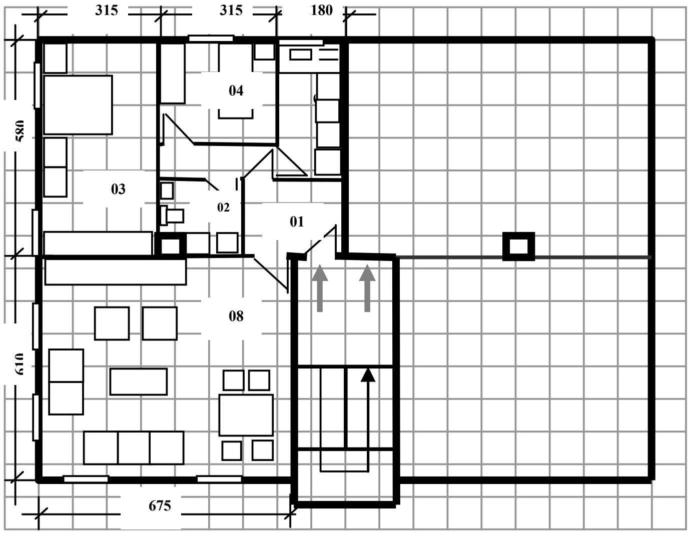
Space Code - Names	m^2
0.1. Entrance	5.70 m^2
0.2. Bathroom	4.80 m^2
0.3. Master bedroom	8.64 m^2
0.4. Children's bedroom	8.10 m^2
0.5. Children's bedroom	8.80 m^2
0.6. Corridor	4.00 m^2
0.7. Kitchen	6.86 m^2
0.8. Living room	41.10 m^2



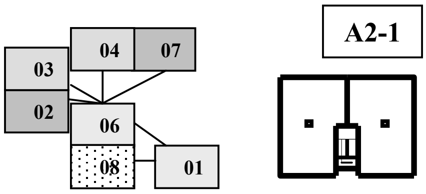


Space Codes - Names	m^2
0.1. Entrance	4.32 m^2
0.2. Bathroom	8.30 m^2
0.3. Master bedroom	12.20 m^2
0.4. Children's bedroom	15.70 m^2
0.5. Children's bedroom	11.60 m^2
0.6. Corridor	3.96 m^2
0.8. Living room	31.80 m^2

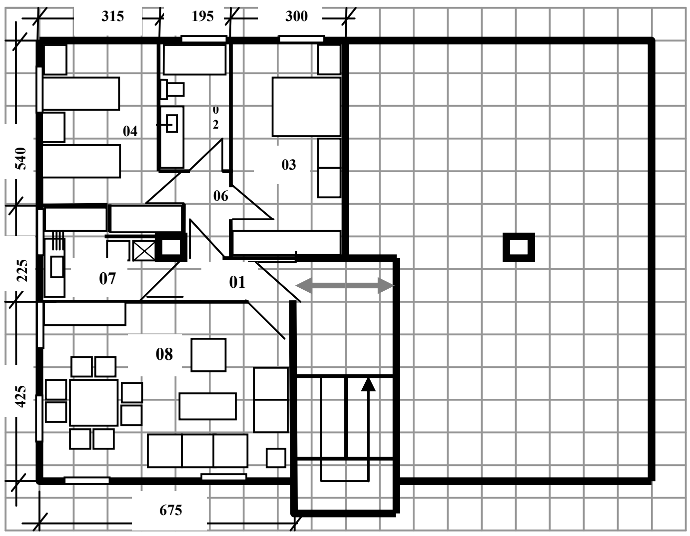
Figure 3:
Three-bedroom flat plans - total area 88m^2



Function Scheme



Space Codes - Names	m^2
0.1. Entrance	5.00 m^2
0.2. Bathroom	4.49 m^2
0.3. Master bedroom	18.27 m^2
0.4. Children's bedroom	8.50 m^2
0.6. Corridor	3.30 m^2
0.7. Kitchen	6.84 m^2
0.8. Living room	41.17 m^2



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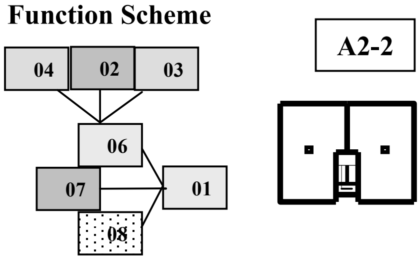
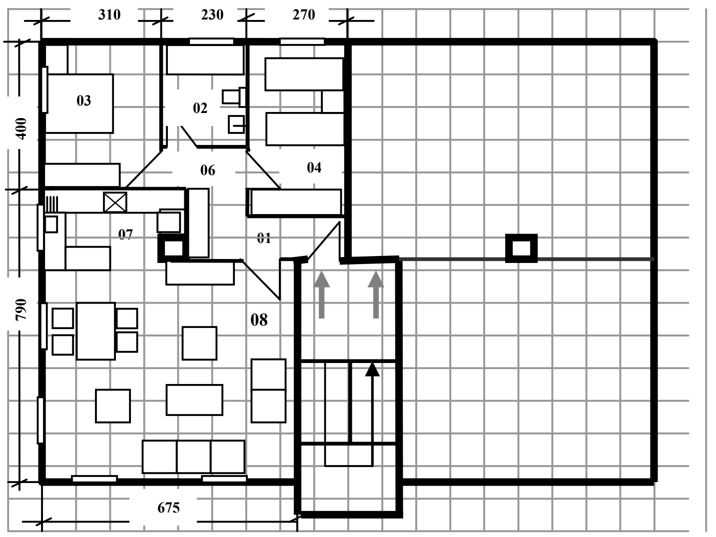


Space Codes - Names	m^2
0.1. Entrance	3.65 m^2
0.2. Bathroom	7.20 m^2
0.3. Master bedroom	18.20 m^2
0.4. Children's bedroom	17.80 m^2
0.6. Corridor	2.60 m^2
0.7. Kitchen	8.90 m^2
0.8. Living room	29.68 m^2



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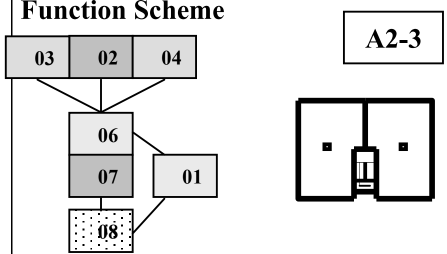
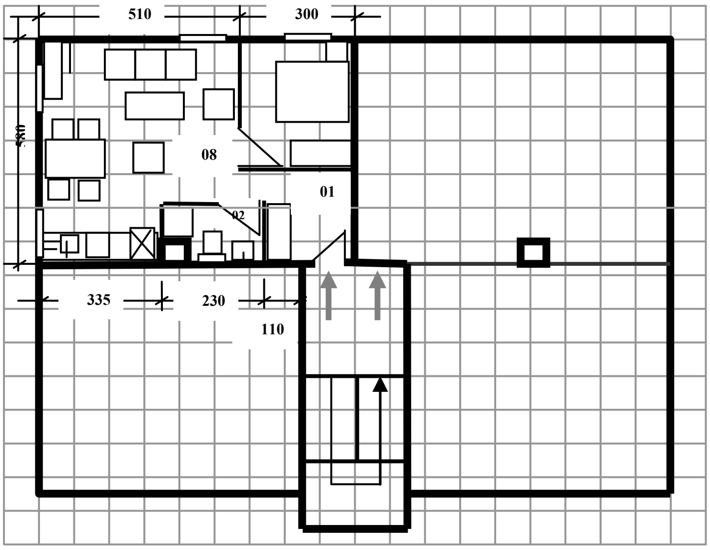


Space Codes - Names	m^2
0.1. Entrance	3.67 m^2
0.2. Bathroom	6.40 m^2
0.3. Master bedroom	12.96 m^2
0.4. Children's bedroom	12.50 m^2
0.6. Corridor	3.40 m^2
0.7. Kitchen	7.90 m^2
0.8. Living room	41.17 m^2

Figure 4:
Two-bedroom flat plans – total area 88 m^2



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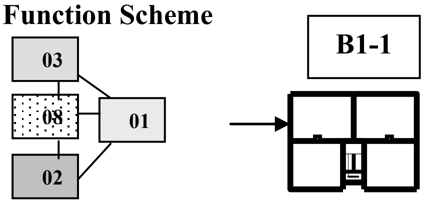
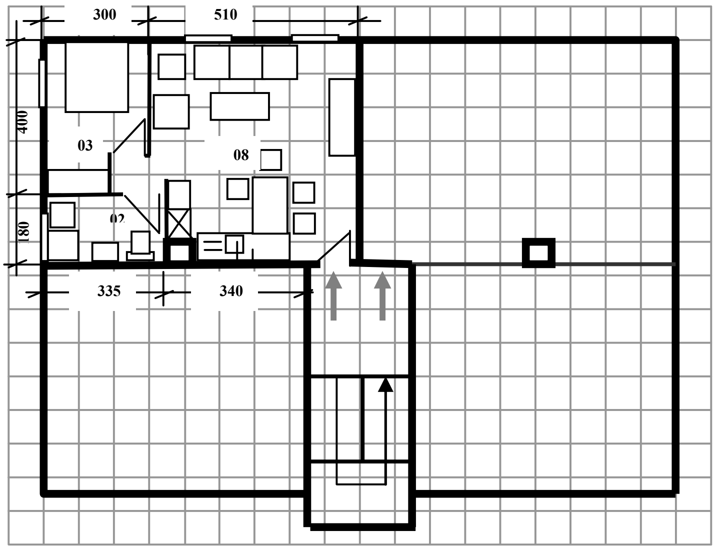


Space Codes - Names	**m²**
0.1. Entrance	5.52 m^2
0.2. Bathroom	4.32 m^2
0.3. Master bedroom	10.80 m^2
0.8. Living room + kitchen	26.36 m^2



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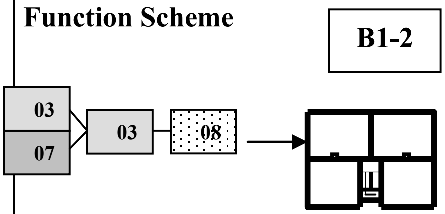
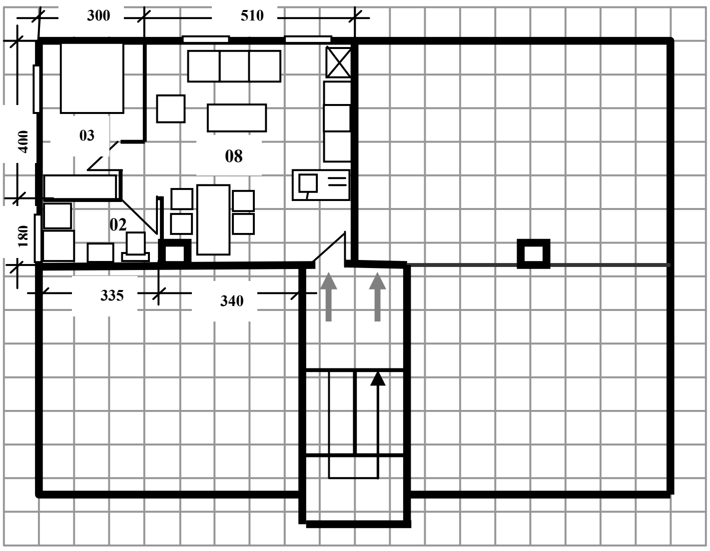
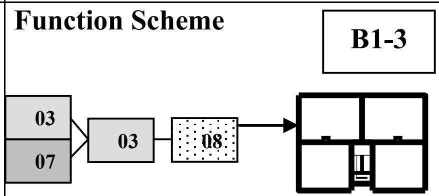


Space Codes - Names	**m²**
0.2. Bathroom	6.00 m^2
0.3. Master bedroom	10.20 m^2
0.8. Living room + kitchen	30.80 m^2
0.6. Corridor	2.00 m^2



Function Scheme



Space Codes - Names	**m²**
0.2. Bathroom	6.00 m^2
0.3. Master bedroom	10.20 m^2
0.6. Corridor	1.80 m^2
0.8. Living room + kitchen	29.80 m^2

Figure 5:
Single-bedroom flat plans - total area 47 m^2

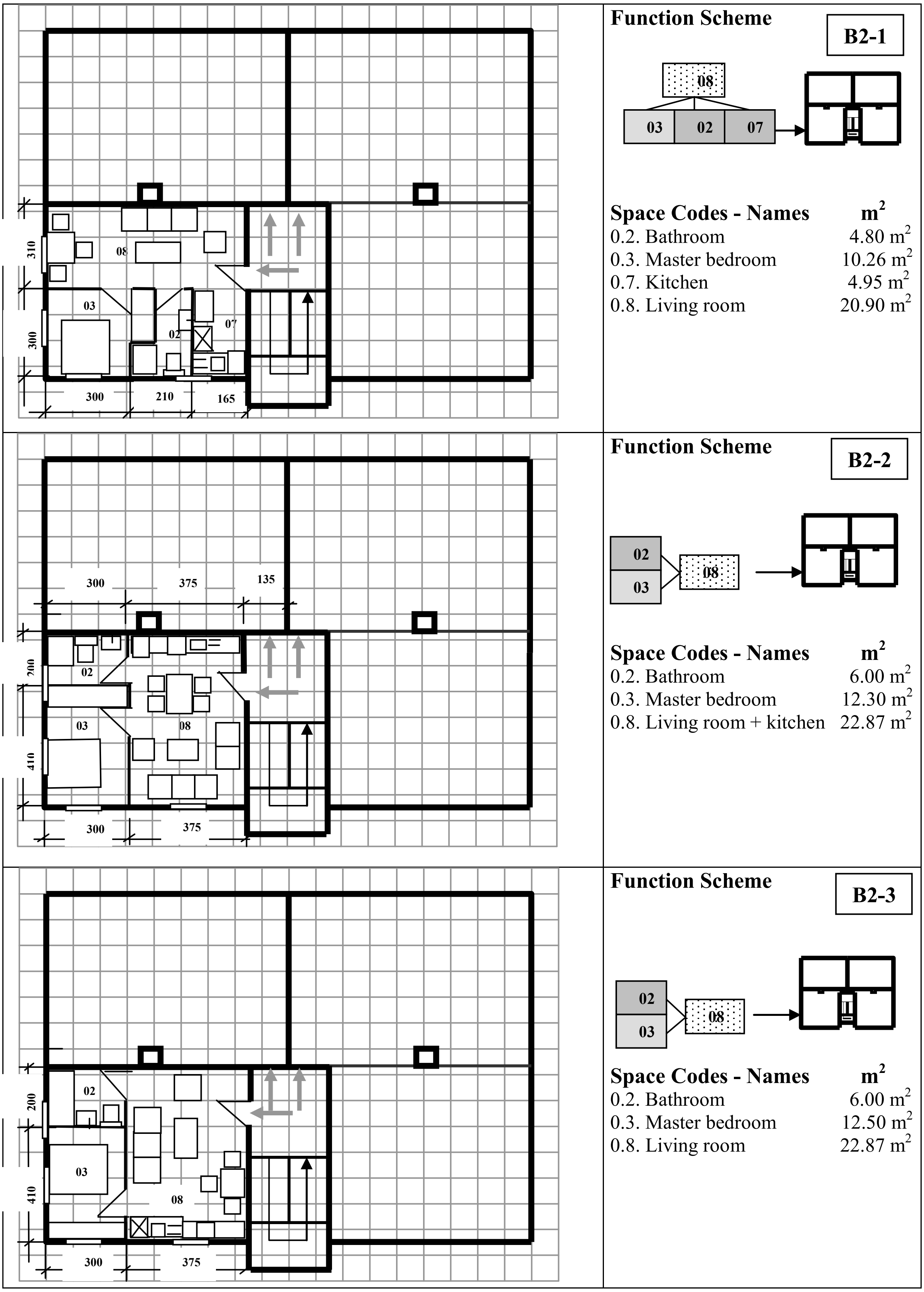
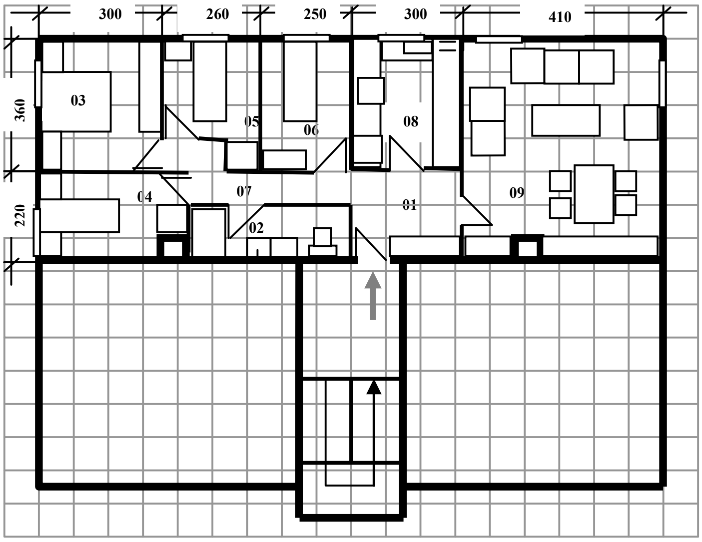
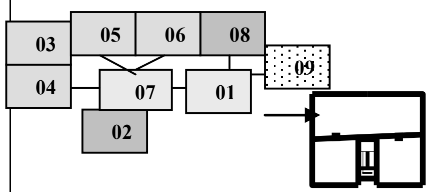


Figure 6:
Single-bedroom flat plans – total area 41 m²

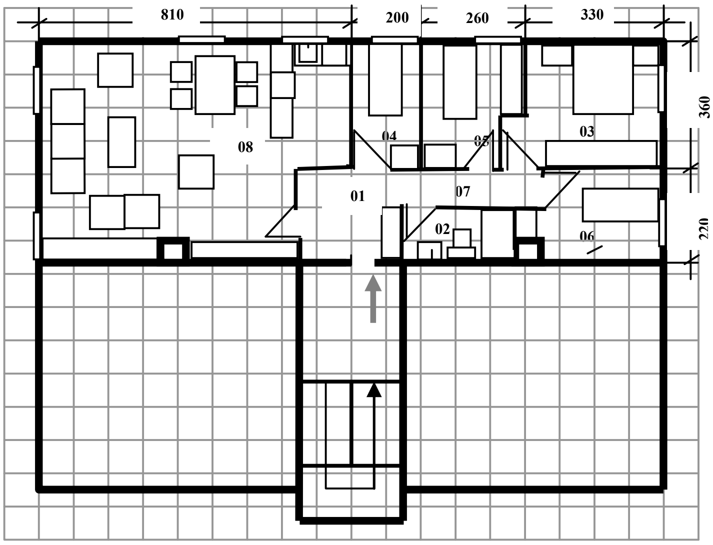


Function Scheme

C-1

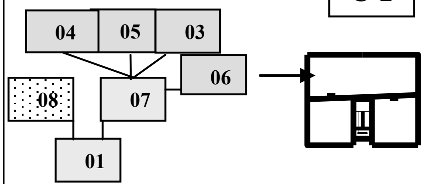


Space Codes - Names	m^2
0.1. Entrance	7.50 m^2
0.2. Bathroom	6.70 m^2
0.3. Master bedroom	12.96 m^2
0.4. Children's bedroom	7.92 m^2
0.5. Children's bedroom	8.10 m^2
0.6. Children's bedroom	9.72 m^2
0.7. Corridor	5.94 m^2
0.8. Kitchen	10.80 m^2
0.9. Living room	24.36 m^2

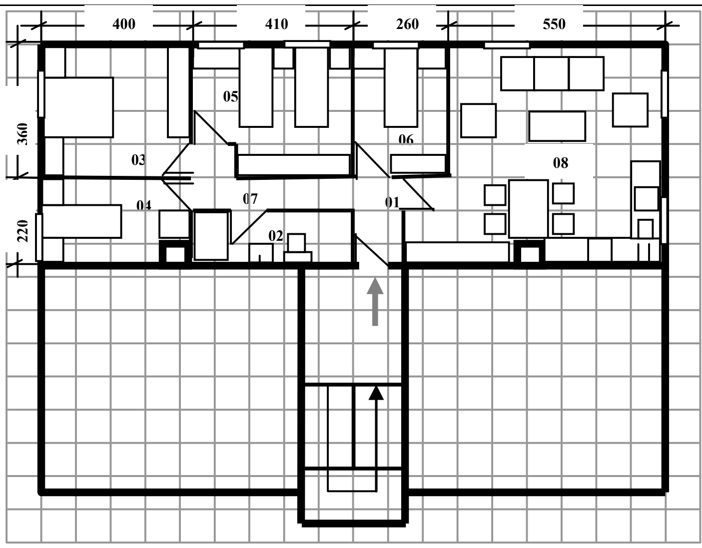


Function Scheme

C-2

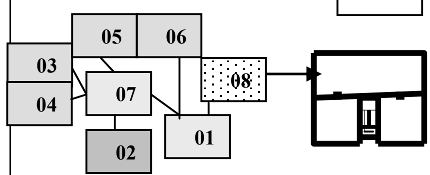


Space Codes - Names	m^2
0.1. Entrance	7.50 m^2
0.2. Bathroom	6.70 m^2
0.3. Master bedroom	12.96 m^2
0.4. Children's bedroom	7.92 m^2
0.5. Children's bedroom	8.10 m^2
0.6. Children's bedroom	9.72 m^2
0.7. Corridor	5.94 m^2
0.8. Living room + kitchen	24.36 m^2



Function Scheme

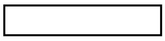
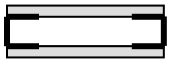
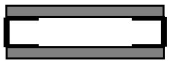
C-3



Space Codes - Names	m^2
0.1. Entrance	5.40 m^2
0.2. Bathroom	5.90 m^2
0.3. Master bedroom	13.40 m^2
0.4. Children's bedroom	8.80 m^2
0.5. Children's bedroom	14.20 m^2
0.6. Children's bedroom	9.30 m^2
0.7. Corridor	6.40 m^2
0.8. Living room + kitchen	32.94 m^2

Figure 7:
Four-bedroom flat plans – total area 94 m^2

Table III. Characteristic features of partition walls

Variety of partition wall	Shape	Thickness (mm)	Panel layers					Heat transmission $m^2hC/kcal$	Acoustic insulation (dB)
Gas concrete		150	Gas concrete					1.08	40
Metal framed panel with gypsum board		100	Gypsum board (12.5mm)	+	Glass wool insulation panel (30mm)	+	In situ installed metal frame profiles estab-lishing 600mm space	1.5	45
Wood framed panel with wood board		90	Plywood board (10mm)	+	Glass wool insulation panel (30mm)	+	In situ installed wood frame components establishing 600mm space	1.5	45

The study develops a decision-making approach in multi-storey housing design that will be helpful in the determination of the building elements capable of meeting the changing characters and requirements of the users after construction or during use, as well as in the selection of the technically and economically most suitable solutions for the users (Aydınlı et al, 1996; Priemus, 1986; De Chiara & Koppelman 1975).

On the basis of the data for design, it is possible to follow two different design strategies, depending on the predictability of flexibility demands as well as the level of information compiled about the flexibility demands that may arise in the future during the users' stay in the dwelling unit, for the design of the infill building.

- In case of uncertainty, i.e. if the users' flexibility demands cannot be predicted, "a design strategy for uncertain flexibility demands",
- In case of certainty, i.e. if the user's flexibility demands can be predicted, "a design strategy for flexibility demands predetermined".

The feasible alternatives of building elements liable to change in the future are all the available alternatives that have the property values expected from the element within the range of the constraint limits. Since property values of some available potential solutions or alternatives do not meet the requirements of various laws, regulations, standards, etc., or the expectations of designers and users, such alternatives are not taken into account in the evaluation process of the building element in question.

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