# Technical Improvement of Housing Envelopes in Cyprus

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ABSTRACT: The main problems in the building envelopes in Cyprus and the actual standards for existing buildings are being identified. The legislative, natural (climatic boundary conditions) and other influencing factors that lead to the standard solution are being described. Also descriptions of the most commonly used refurbishment actions standard envelopes are being discussed with recommendations on how to solve these problems. The impact of the most commonly used refurbishment actions are being described loooking at the technical, functional, social, economical and environmental on the existing buildings. Finally application methods are being described through two different case studies

## 1 INTRODUCTION

### 1.1 *Standard envelopes in Cyprus*

Cyprus gained its independence in 1960 and was proclaimed a Republic. At the period 1960-73 Cyprus went through a fast and almost uninterrupted growth. Despite the breakdown, in the years 1974-75, due to the Turkish invasion and the occupation of 38% of its territory by military forces, the economy recovered soon after and a substantial growth has been achieved. In the years 1975-1993 Cyprus once again witnessed additional economic growth, accompanied by an expansion of social services. Today the people of Cyprus, who live in the Government controlled part of the country, enjoy a high level of education, low unemployment and a good standard of health care. 69% of the population is living in urban areas, which cover 9.6% of the island. The population in 2001, in the area controlled by the Cyprus Government, was 689.565. The total number of units was 286.000 in 2000. Almost 85.000 of these units were built in the period from 1960-1980. Out of the total number of units, nearly 60.000 are apartment blocks and 125, 000 are detached or semidetached houses. The average dwelling area is 189 $m^2$ and the average construction cost is 568 Euros per $m^2$ for the year 2000. The average number of persons per dwelling was 3.23 for 1992 and 3.06 for 2001. In addition to that the number of square meters per person was 49.5 for 1992 and 61 for 2001.
Within the context of the housing policy for the refugees, the government of Cyprus has introduced various schemes and programs like the “Low Cost Government Housing Scheme” that provides houses free of charge to low-income families (5.6% of the total number of households were benefited from this scheme). In addition to that the government provides the “Self-help Housing Program on Government Land” (4.1% of the total number of households), the “Self-help Housing Program on Private Land” and the “Purchase of a House/Apartment Scheme”.

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In the private sector, development and construction companies offer in the free market various types of housing units, mainly apartment or terrace houses. This type of development satisfies nearly 30% of the total demand. A substantial number of families however, choose to build their own detached or semi-detached house, on an individual plot of land, which has an average surface of 520 $m^2$ (68.2% of the total number of households have their own private housing units). Three categories of construction financing have been developed. In the first, a contractor undertakes the construction of the building. In the second, the owner of the property decides to play the role of the contractor-entrepreneur and undertakes the responsibility of constructing and financing the project. He/she usually sells or rents most of the apartments keeping one or two for him/her. In the third (the gradual method of construction), the owner of the property builds one housing unit for the present needs of his/her family, allowing for the possibility of constructing additional apartments in the future to cover the needs of the growing family or merely for investment reasons. The results of this practice are the following:

- Lack of planned connection between housing areas and other areas of the city (educational, commercial, etc).
- Mixed housing areas with industrial or other areas, dangerous for public health.
- Very limited green and open spaces within the housing areas.
- Bad relation between street width and building height.
- Different housing types even in the same street (large apartment blocks adjacent to low houses).
- Unplanned and often unhealthy interaction between the built and natural environment.

Contemporary life and the building industry in Cyprus are greatly affected by the proliferation of apartment blocks in the large urban centres. The apartment house became the symbol of the final stage of urbanisation. And since urbanisation is for certain reason a preferable way of living for the contemporary Cypriot; the apartment model is extensively adopted even in medium size settlements in the countryside.

### 1.2 *Requirements in Cyprus, that enforce a reaction to refurbish envelopes*

The Law (The Minister of the Interior is the Planning Authority), considering the kind of development, specifies the appropriate drawings and any other documents, certificates etc., which they have to be submitted with the application form to the Director of Town Planning and Housing Department and later on to the Municipal Council. Three main issues can be mentioned here. There is not any legal obligation to submit designs or calculations for thermal, acoustic, light and fire performance of a conventional building within the application form. Although civil engineering calculations have to be submitted at the building permit application process, these drawings are roughly checked and the responsibility for any structural failure remains on the civil engineer's side. According to a recent regulation of 2000 all new constructions, renovations and generally any structure, have to be inspected by authorized engineers. Therefore inspections are compulsory for freelance practitioners, though are not compulsory for Responsible Authorities. For this very reason the enforcement of the Planning and Building laws, is not so effective.

All building modifications require a "building permit" and moreover, the modifications that are regarded as "substantial" require an additional "planning permit" in advance. The specific provision is very vague and therefore depends on the discretion of the respective Town Planning Authorities, to judge whether a modification is substantial or not. The painting of a building for example does not require any permit, simply because is not regarded as a substantial modification. There are no specific data concerning maintenance, renovations, and modifications etc. of building envelopes. Indicative data however suggest that the average Cyprus family does not pay a lot of attention on these matters, that people extent as long as possible the various works needed and that they proceed to the necessary works, only when the performance of their building is intolerable, or dangerous looking always for the absolute minimum expense.

No specific legislation was ever passed before 80's concerning incentives for organized housing complexes. The only regulatory tools were the commonly used town planning restriction which concern plot ratio, plot coverage, maximum height, and maximum number of stories, a general aesthetic framework and some indirect density standards, concerning the minimum surface in relation to the size of housing units. This is actually the very reason that multi-story family buildings were very few till 80's. Some sort of incentives for organized housing complexes up to three stories, were introduced in the revised statutory local plans in 2003.
There are no specific regulations concerning architectural and functional aspects. The authority that is responsible for issuing the Planning Permit, decides whether a certain development rests within the environment of the surrounding area. There are however indirect density standards, concerning the minimum size of housing units. Practice however is much different especially as far as the aesthetic control is concerned. Problems also arise when dealing with the incorporation of small but vital structures, like solar panels, antennas etc.
There are specific rules and regulations for new buildings and public uses according to which accessibility to people with special needs, including access ramps and larger toilets in the ground floors, must be provided.

## 2 SPECIFICATION OF THE TECHNICAL SOLUTION

In general the typical housing construction system in Cyprus is based on the conventional construction system, quite common in this part of the Mediterranean Sea. The system comprises the use of reinforced concrete for the load bearing part of the building, which is completed by masonry walls. Prefabrication systems have rarely been used in the past, mainly by the Government in the construction of some low cost refugee estates in the late 70´s. So reinforced concrete, from foundations to the roof applies for the vast majority of the housing constructions.
Preliminary regulations concerning the calculation of seismic loads were issued in the late 80´s and that detailed construction regulations were adopted in the beginning of the 90´s. Thus all the buildings built before, may sometime in the future, face possible seismic failure.
There is a variety of foundations types according to the type and size of the structure. The most popular are the separate footings with connecting beams and the slab-foundation. The outer skin of a structure, is usually created by the reinforced concrete parts (for the load bearing structure) and a single layer of bricks, (200mm), both coated with three layers of plaster (20-25 mm) and a finishing layer of paint or sprits. The roofs are usually flat concrete slabs, which are covered with light concrete or screed of 50-100 mm for rain-drainage and on top with an asphalt layer of 2-5 mm for humidity insulation. The final touch is given by the use of reflective paints.
The last 10-15 years some buildings appeared to form a different top finish with a complete or partial pitched roof. This is used not so much for insulation reasons, but rather for sales promotion reasons since it gives a touch of more domestic or more humane housing buildings.
As far as windows are concerned, the vast majority of them are single glazed (4-5 mm) with aluminium frames whereas a small proportion of multi-story family houses, especially after 1980, used double glassed windows.

## 3 THE IMPACT OF THE MOST COMMONLY USED REFURBISHMENT ACTION ON SUSTAINABILITY TOPICS

### 3.1 *Technical performance*

#### 3.1.1 *Structural integrity*

Cyprus has already adopted five compulsory standards concerning the quality of cement, sand, gravel, concrete and brick. The enforcement of these standards lies on three Government bodies, which are, the Mines and Quarries Department, the Public Works Department and the Competition and Consumers Protection Service. It is worth mentioning that by the 1st of May 2004, Cy-

prus became a full member-state in European Union, and therefore all the relative European standards (Euro-codes, etc.) have to be established in the respective case-law.

3.1.2 *Fire protection*

The bearing structure and any stair of a prefabricated building should provide at least 1/2 an hour fire resistance. The "Cyprus Organization for the Promotion of Quality" chaired by the Ministry of Commerce Industry and Tourism plans to establish quality standards and enforce them as compulsory.

3.1.3 *Noise Insulation*

The "Cyprus Organization for the Promotion of Quality" has already specified some recommended Noise insulation (for 500Hz in dB) Walls (45), Roof (45), slab between floors (50).

3.1.4 *Weather and moisture protection*

The most habitual problem that Cyprus faces is the total absence of damp proofing and thermal insulation of the majority of the housing units. This has direct and severe implications on the energy consumption and the discomfort many people experience. In this case certain parts of the building envelopes, like the roofs and external openings, have to attract more of our attention than others. Besides that one could mention of course some other smaller problems like the moisture problems (due to substandard plumbing installations and poor ventilation) and the poor acoustic insulation (due to light building envelopes). Damp regularly appears in several elements of the buildings, causing surface stains, appearance of humidified and watered surface, color weathering and peeling, detachments, material decay, ruptures and cracks, oxidation of unveiled steel bars and mold formation.

3.1.5 *Conductivity (U-value), Heat flow (g-value), radiation, convection*

The "Cyprus Organization for the Promotion of Quality" has already specified some recommended thermal insulation values for conventional buildings, which however are not compulsory. Thermal Insulation (U value in $W/m^{2\circ}K$): Walls (1.7), Roof (2.0), Slab between floors (2.0).

3.1.6 *Durability (service life)*

No information available.

3.2 *Functional / social performance*

3.2.1 *Flexibility*

In an attempt to evaluate some of the current housing habits in Cyprus, two questionnaires were compiled (Lapithis, 2002). From the outcome of both questionnaires, it transpired that most dwellings in Cyprus are constructed with little or no insulation and this is the most likely cause for the high percentage of summer and winter discomfort as well as noise complaints. Most other complaints stated (e.g. poor natural lighting) are the result of unsuccessful bioclimatically orientated design. All this suggests the need for better, more bioclimatically appropriate constructions, with adequate insulation and proper orientation with respect to the sun.

- A high percentage (69%) of the survey participants experience bothersome noises from the outside, probably as a result of poorly insulated wall surfaces and single glazing which not only allow heat enter and exit freely, but also allow noise to penetrate with little difficulty.
- A high percentage of the participants frequently felt cold in the winter (80%) and an even greater number feel warm in the summer (87%).
- There were complains about bothersome cold surfaces (70%).
- Another problem area, which can be minimized by proper passive design, is the need for artificial lighting (64%).

- Participants experience drafts from windows and doors (86%). An element of ventilation that can be exploited in a passive system, if it is designed properly.
- There is a need for a more widespread use of double-glazing windows in order to minimize moisture condensation on windows (65%), and for a better thermal and noise control.
- An interesting fact deduced from the survey is that the overwhelming majority of Cypriots feel safe in and around their house (91%), which makes it easier for a passive solar designer to arrange for ventilation systems requiring frequent openings especially for night time ventilation.
- Another advantage the passive solar designer will have in Cyprus is the fact that the Cypriots seem to appreciate the use of shutters (87%), which have been used in traditional architecture.
- Of the 13% of participants who did not find shutters an acceptable means of controlling indoor temperatures, most attributed it to the fact the shutters do not work properly. This implies the need for shutters to be placed in front of windows more appropriately planned.
- The majority of dwellings have no insulation (66%).
- Of the houses that do have some insulation (34%), it mostly is in the form of double-glazed windows and reflective silver coatings (a waterproofing material, which is misunderstood to act as a thermal insulator) rather than in structural constructions, which implies that most insulation in the surveyed houses was more or less treated as an afterthought.

### 3.2.2 *Comfort (thermal, acoustical, visual)*

The existing legal framework does not incorporate any objective criteria and indices concerning the technical characteristics (like the thermal conductivity (K), the thermal transmittance coefficient (U), the sound reduction index (SRI) etc), the performance of the building materials and the whole structure of conventional buildings. Therefore in most of the cases the free market, especially the local one, does not provide the necessary technical specifications of the relevant advertised products. So only practice can show the real fire resistance, thermal, acoustic and light performance of any housing unit.

The aspects relating to external mass are of particular significance for Cyprus due to the large diurnal fluctuations (15 to 25 ºC), and the potential possessed by mass for large solar contribution in winter and cooling in summer. This implies that heat admitted during the day in winter could be stored for use during the evening hours and in the summer could be decapitated in the cool night.

Thermal performance of traditional, contemporary and solar houses have been researched in relation to climate and in terms of the various aspects necessary for understanding such performances (Lapithis, 2004). These aspects include architectural design, constructional materials and methods, occupancy patterns and planning. Different architectural and constructional elements and techniques that were used in traditional houses have been studied in relation to their use in passive design today and serve as fine examples of energy-saving architecture. Cypriot traditional houses have proved to be superiorly energy-efficient (243 kWh/m²) when compared to contemporary houses (368 kWh/m²) resulting to the most energy efficient being a passive solar house (121 kWh/m²) due to the thermal performance of all cases based on their architectural design.

Cyprus is within the temperate Mediterranean zone. The thermal comfort zone limits (Lapithis, 2002) are 19.5°C – 29°C as the proposed temperature and 20-75% as the proposed relative humidity. The best thermal comfort is achieved in the months of April, May, October and November. These months need no extra heating or cooling. To achieve thermal comfort conditions, ventilation is required in the summer months (June, July, August and September). In the months of December, January, February and March passive solar gains are used to achieve thermal comfort. It must be noted that steps should be taken to avoid over heating in the summer.

Despite the fact that there are some fine examples of contemporary buildings based on correct design principles and a better understanding of the local climatic conditions, the great majority of contemporary buildings are erected without consideration of the climatic conditions and their influence on comfort and the well being of the occupants. This is mainly because due to lack of knowledge about the thermal performance of contemporary constructional materials and methods and to the shortage of building regulations which govern this aspect of the art of building. In most cases, good thermal conditions are achieved by using (energy consuming external and mechanical methods) air-conditioning systems or split units.

3.2.3 *Health (air quality, TVOC etc., mould & fungus growth)*

No information available. (See also 3.2.1)

3.2.4 *Safety, security*

No information available. (See also 3.2.1)

3.2.5 *Barrier free, accessibility in use*

No information available. (See also 3.2.1)

3.2.6 *Aesthetical perception*

Social and aesthetical aspects are usually forgotten because they are not directly related to primary human needs but rather to comfort and quality needs of the people. Designers and contractors prefer the straight-forward solutions, that satisfy the main humans needs. On the other hand, most of the buyers and tenants prefer simpler and cheaper housing units, than buildings or complexes that accommodate “social spaces”. This is because social places will have an increase on the cost of the buildings or the rents.

3.3 *Economical performance*

3.3.1 *Building costs*

Unfortunately traditional construction methods, techniques , materials etc have been ignored for the sake of fast development and fast profits ( by the building industry) due to the absence of the necessary statutory framework that would guarantee the building quality, but also due to poor awareness of consumers' rights. Due to the age of the buildings many problems are observed. The main problem is their maintenance. The maintenance and the administrative matters of the apartment buildings is entrusted by the residents. In cases where maintenance costs are higher, the agreement of all the residents is required in practice, which often encounters difficulties even in simple administrative matters and often proves to be ineffective in the case of serious repairs or maintenance work on the building.

Therefore a lot can be done in this area. The first refers to the statutory establishment of the necessary standards, (concerning not only thermal standards but also acoustic standards as well as standards concerning the dangerous building materials). Today only prefabricated buildings have to meet certain thermal, fire and stability requirements. The second issue concerns the need for licensing the necessary construction details of the buildings. Finally, a last but not least issue, concerns the enforcement of the various permits provisions by the competent authorities.

3.3.2 *Running costs (heat losses, cooling, cleaning, inspection, maintenance, etc.)*

No information available.

3.3.3 *Increased rent potential vs.vacancies through building action*

There are many questions on the social aspects that the economical performance of the buildings is affected. Few of these questions need to be answered wit a thorough research:

- Owned property vs. rented.
- Cost of building construction vs. renting (years of payoff of rent or build or buy).
- Developers vs. clients vs. renting.
- Prices depending from the location (town or suburbs).
- Cost of maintenance- façade, services.
- Every how many years is maintenance needed. Lack of investment in building maintenance/conservation vs. high degradation level of facades.
- Different owners of a building resulting with serious problems in putting money together.
- Old building rental policy plays a role in insufficient execution of maintenance work by the owner.

3.4 *Environmental performance*

3.4.1 *Use of resources (non renewable, renewable)*

With the exception of solar energy, Cyprus has no other energy resources of its own and has to rely heavily on fossil fuel imports.

3.4.2 *Energy consumption (non renewable, renewable) - production / assembly - heating / cooling*

The energy consumption is predominantly oil based. The contribution of solar energy to meet the primary energy needs of the country is estimated to be 5.9%. (Synergy Program, 1995) Thus, more than 94% of the total primary energy is supplied by imports. The cost of imported energy represents 63% of the domestic exports. Due to the developmental nature of the economy of Cyprus energy consumption is increasing at an average annual rate, for the last ten years, at about 6.9%.

The total annual energy consumption (electricity included by the domestic sector) in Cyprus comprises of 15.1% with electricity at 34%. Based on consumption by households, a rate of growth of 4.6% is indicated yearly. Breakdown of residential energy consumption in terms of final energy used shows its large share of electricity consumption. In terms of end-use of energy in households, water heating holds the highest place being half of the total consumption, and more than half of the electricity.

The present construction trends indicating distinct preference to private, detached houses over apartment flats (60% prefer private detached houses), coupled with higher standard of living (70% of houses are built with central heating) imply a larger energy saving potential in this particular type of dwelling (Ministry of Commerce and Industry, 1994).

3.4.3 *Environmental impacts, (GWP global warming potential, AP acidification potential, NP nitrification potential, EP eutrophication potential, ODP ozone depleting potential, POCP photochemical ozone creation)*

No information available.

3.4.4 *Waste and recycling and re-use potential*

Not applicable in Cyprus.

## 4 CASE STUDY

### 4.1 *Case study 1: Low Energy Building*

The construction was decided to be a concrete frame and floors and roof (constructed as the typical Cypriot contemporary buildings) (Lapithis, 2002). Typical concrete foundations are used for the anti earthquake calculations. The design demonstrates that with an understanding of the principles of environmental physics, appropriate use of available technology and judicious use of materials and resources, it is possible to achieve comfortable living conditions and low energy use.

Hourly temperature and relative humidity readings were taken all year round. The indoor temperature remained steady at around 22$^{o}$C. Overall, the 24-hour indoor measurements indicate a variation of 0-2ºC temperature swing. Taking into account that the external temperature swing is 10-15ºC, this shows that a constant temperature is preserved throughout the day. The building rewarded the inhabitants with a low winter and summer utility bill, considering that no air conditioning system is required. There is an energy saving of 85% comparing the contemporary building with the low energy building.

In the construction of the low energy building 13 methods of wall construction and 3 methods of roof construction were taken under consideration. Upon further examination of all viable options for an efficient passive solar building, the chosen type of wall construction is type 6 and for the roof construction is type 1 (Figure 1 and Figure 2).

For a passive solar building the walls need thermal mass in order to retain heat. With that in mind, type 11 and 13 listed below are immediately rejected in the case of the low energy building. Types 11 and 13 can be used for passive buildings as long as the walls will not be used as thermal mass. Since the U-value of the wall is an important factor, types 1, 3, 5, 7 and 9 are rejected since they have an unacceptable U-value. Type 10 and 12 have an acceptable U-value, but the high manufacturing cost does not make them cost efficient. The types 2, 4, 6, 7 and 8 are viable options. Type 6, 7 and 8 seems to be the best of at of the 25cm thickness of the concrete frame of the building (beams and columns). A better architectural design is achieved by avoiding the 5cm gap between the external walls and the columns and beams. With these comparisons in mind, the chosen type of wall construction for the low energy building is type 6, since it effectively insulates the whole structure and avoids thermal bridges where the columns and beams occur.

Taking into account the advantages and disadvantages of the passive solar system it is concluded that the best systems which can be used for the low energy buildings are Direct Gain, Thermal Insulation and Thermal Storage (Interior Mass). The simplest heat storage approach is to construct the building of massive structural materials insulated on the exterior, to couple the mass of the indoor space. Double-glazed with low emmisivity film and argon-filledare the best windows to use. Shading can be easily controlled for the non-heating season taking into account solar control by use of orientation and shading devices. Natural Ventilation is applied by the use of cross ventilation, stack effect, night ventilation and ceiling fans.

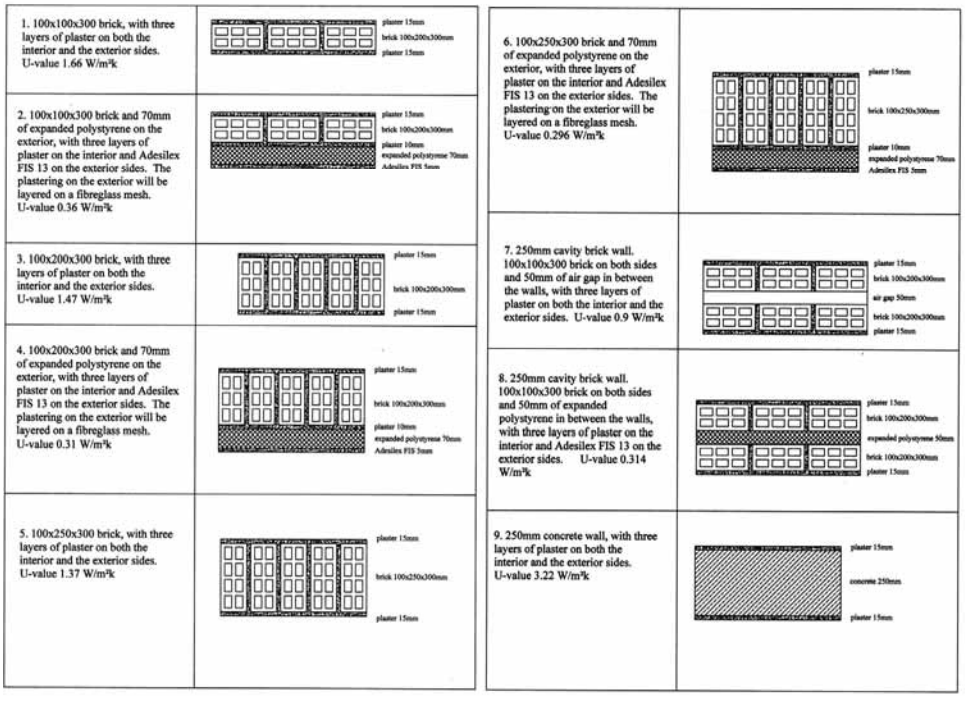


Figure 1. Wall construction consideration methods

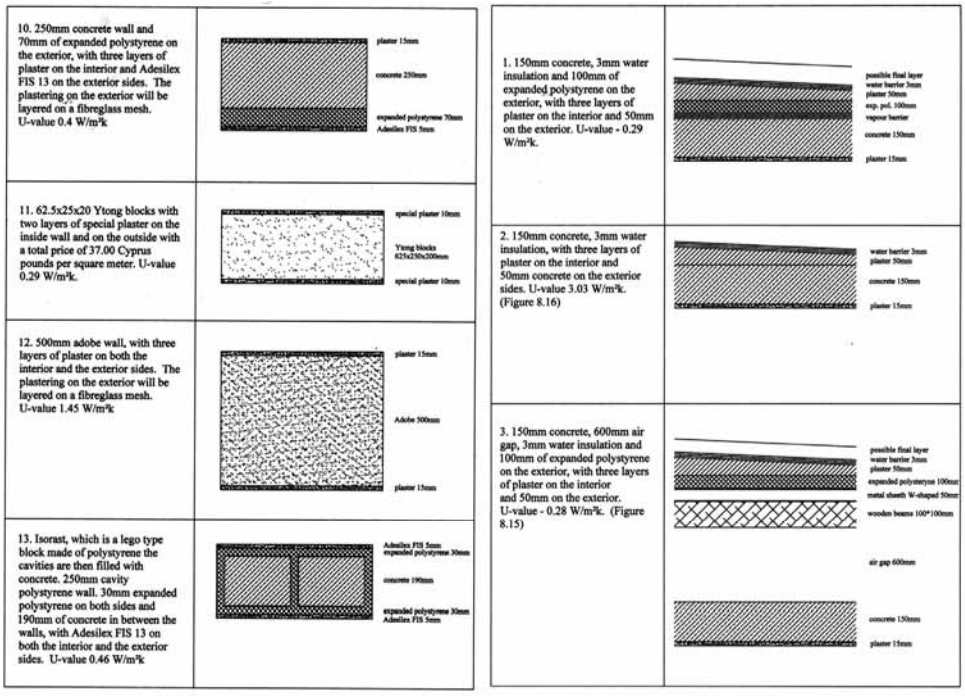


Figure 2. Wall and Roof construction consideration methods

### 4.2 *Case study 2: Government refugee estate ΄΄Archbishop Makarios III΄*

The Government refugee estate ΄΄Archbishop Makarios III΄ is situated in Limassol town, just 3.5 Km from the central area. It comprises two phases (Figure 3 and 4). The first one was build in 1979-80 and the second in 1984-86. It has a total number of 378 housing units, out of which 138 are apartments in three-floor family houses built during the first phase.

Buildings followed a simple "cubic form" for functional, economical and practical reasons. No efforts for differentiations were made during the primary construction phase, although some effort were being made during the on going renovation phase.

All the multi-story buildings of the estate followed the typical flat slabs concrete structure, filled with plastered bricks as described above. The reconstruction of the buildings was based on typical and conventional techniques and materials. The construction safety was the main issue of this case study. The vast majority of the renovations are related to the construction safety and the stability against earthquake actions. A lot of unnecessary loads, like surrounding walls on top of the buildings or balconies, were removed.

The walls were plastered and painted while the roof was damp proofed. No thermal insulation was used either on the walls or on the roof. No specific studies were carried out concerning the building physics. There is no doubt that the general living conditions have been improved a lot. However newly installed air–conditioning units can be seen on some renovated buildings. This indicates that expensive renovations cannot do miracles in a problematic old housing estate and that air split units were reinstalled, after the completion of the renovation works. The average construction cost of the estate (according to 1979 values) was 130 Euro/$m^2$ and the renovation cost (according to 2003 values) is estimated to reach 170 Euro/$m^2$. There is no doubt that direct comparisons may be misleading and that feasibility studies carried out so far, had already taken into account the inflation rate, the cost of living and the final product.

Figure 3. A typical three storey building in refugee estate and typical interventions by the residents to gain some space.

Figure 4. A typical three storey building in refugee estate and typical interventions by the residents to gain some space.

## 5 CONCLUSIONS

Most building in Cyprus are constructed with little or no insulation, thus causing a high percentage of summer and winter discomfort. The low energy building is designed in accordance to comfort zone calculations so as to ensure the maximum comfort of its occupants. The wall and roof construction plays a significant role in the insulation of the building. The application of the science and art of passive solar architecture to reduce the demand for thermal energy in a building represents a growing area. Retrofitting existing buildings and novel designs of new buildings to this end are a major technical challenge to the near future for Cyprus.
At this time, it can be argued that passive design is experiencing a maturity of design applications in which solar energy is utilised in heating, cooling and daylighting buildings. The message here to advance this important beginning, it is that passive design is a sophisticated process to reach simple solutions. Therefore the innovations to look for in the years ahead will be first the development of design methods to enable building professionals to identify balanced and practical solar designs, and second the development of variations of passive solar techniques suited to local climate and resource conditions. This could result to a clearer vision by everyone involved of how passive design is the most cost-effective strategy available in creating an environmentally sound habitat in the climate of Cyprus or any climate of the world. Because of Lefkosia climate, passive solar architecture works to its full capacity, meaning that a passive solar building has 100% energy saving potential.

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