ACORDE Project: Adaptable Residential Buildings for a New Social Framework

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Abstract: ACORDE project seeks to maximize buildings’ flexibility, conceiving a residential building made of legally independent functional units that can be connected to or disconnected from each other with easy, plug-in facilities, in a way that permits to purchase exactly what the user need, as well as allows future changes for buildings to be adapted to the needs of their occupants, the user decides how to best utilize the space by acquiring or separating functional units along the years. For this to be possible, in addition to the legally independent modules concept, a diaphanous and very well organized structure is projected as well as a very solid and efficient envelope to ensure durability and minimal maintenance. The efficient occupancy of space leads to an optimal use of energy.

Key words: Adaptability, flexibility, demographic changes, end-uses, plug & play.

1. Introduction

The twenty-first century presents new challenges resulting from the failures of past policies, and major changes in family structure of citizenship, coupled with increasing urban concentration, all point to the need for new methods to confront old problems. This is why we cannot responsibly build housing without cities or build cities without housing [1]. The optimization of efficiency in building must be given by the effectiveness of their systems and enclosures, and through proper use and occupation. Nothing is achieved if energy-efficient homes are built with rigid schemes and occupied inefficiently.

ACORDE project emerges as an exercise of rethinking all key factors involved in a building in order to adapt it to present difficulties, taking into account the better use of resources and energy. During the research process, we detected a number of social and demographic changes; large families are no longer majority, and smaller families, with one or two members, are increasing dramatically. This change in families’ composition should lead to a change in dwellings design; distribution needs are different, as well as its size, while the greater part of new houses in Spain are being built for an outdated family model, without taking any of this into account. Most of new dwelling built nowadays in Spain still are 2- or 3-bedroom distribution, making people buy larger houses than what they really need, which generates residual spaces leading to an inefficient use of environment and energetic resources, as well as a negative impact in their economies.

2. Objectives

The aim of this study is to demonstrate the inefficiency of traditional patterns in the process of planning, design and construction of a residential building, while proposing a new building concept allowing flexibility within the rigid urban regulations of current legislation, to plead for a more efficient system of occupation, which results in an optimization of energy resources both during construction and utilization of buildings.

3. Demographic Issues

Nowadays there is a growing worldwide tendency of one-person households. The increase of people living
alone is still a transformative social experience that changes the way people understand each other and their relationships, transforming the way we build our cities and develop our economies [2]. In 1980 the number of single-member households in Spain represented 8.5% of the total, while in 2007 it reached the 17.6%. In the other hand, families with 5 or more members in the same year were 29.1%, and are currently only 7.3%.

Along the same lines, the evolution of the population pyramid shows a figure not only regressive but, in the short term of the next 10 years, will miss the potential peak of fertility that currently exists in the population between 30 and 40 years old.

On the other hand, dwellings that are designed regarding too rigid urban and architectural regulations do not allow their adaptability to the real needs of the occupants in every moment, who must live in a “standard” housing with two or three bedrooms, which is the most developed distribution in the recent years.

Considering that the stock of studio type dwellings and one or two bedroom houses represents only 13% of the total housing stock and the number of families with one, two or three people -who are supposed to inhabit these types of apartments-, reaches a total of 67%, that creates an obvious gap between the houses and families who live in them.

![Evolution of households](image)

**Fig. 1** According to the INE [3], there is a strong preponderance of households with few members, a fact that will worsen and widespread in the coming years.

![Population pyramid](image)

**Fig. 2** In this 2010 pyramid overlaid with the projection to 2020, appears the population trend indicating the aging of the population and declining birth rates.
Fig. 3  Aggregated data according to the INE Census of 2001 [4], based on the 14 million homes of habitual use.

Fig. 4  Crossing data between housing and families, becomes clear that there are families occupying dwellings much larger than their needs.
This mismatch generates in Spain more than 18,000,000 unoccupied rooms in houses (or at least they are not being occupied with vital uses such as eating and sleeping) and 70% of these dwellings are located in cities. This entails a waste of energy, both for maintenance and for its heating and lighting, equivalent to 2,520 million euros annually in the overall housing built in Spain. Then clearly, people inhabit housing models designed for families of former times.

From all the information and figures above we do not have to conclude that from now on only small dwellings should be designed and built, but flexibility and adaptability can be chosen: residential models where the occupants can decide how to inhabit, which surface they need at every moment and what spatial configuration suits best their lifestyle, either when purchasing their house, as throughout their life.

We have also studied other countries like France, Poland, Turkey, Colombia, Chile, Uruguay and many more, and the demographic tendency is similar.

4. Proposed Solution

When we began developing this initiative, we set a fundamental objective: to study the different building types, changing the approaches under which they have been studied so far, and build spaces designed to fit people real needs.

Fig. 5 A standard typology of central core and double orientation that serves to only two housing, creating party walls between the different units, which does not allow variation over the life and evolution of families, resulting in under or over occupied spaces.
Fig. 6 The scheme proposed provides a central corridor that serves a number of independent legal modules, which allow full adaptability of spaces as families change.

We have endured decades of construction without taking into account the evolution of the protagonists of housing, the people who live in them. Therefore, it is necessary to switch sides and build housing to suit the needs of people. The proposed system appears as an exercise of rationality for the future of society through a smart specialization of a well-known asset: housing, which nowadays is designed under the standard of
immobility. This approach was approved for decades, and must now be questioned. The current distributions of housing are rigid, resulting in overcrowded or under-loaded spaces if the course of the household composition changes. In the current conditions of regulations and design standards, no extra spaces can be rented or sold separately.

This research project presents a new type of housing that since its genesis incorporates concepts of flexibility and adaptability, making the dwelling fit the natural evolution of the families. The innovation project ACORDE proposes a legal and functional modularity that allows buying, selling or renting what is really needed. At the same time, it may improve the life cycle of buildings, optimizing the previous phases of design and construction, -where the structure, facilities and enclosures can endure forever-, while extending its utilization phase with interior distributions that may be modified at any time.

For this to be possible, each legally independent unit has to have the possibility to open directly to the central corridor, its own facilities so that it can be transformed to any use, as well as natural sun lightning.

Fig. 7 The spatial configuration of the residential building is open, both at the time of construction and during the life of the building.

Fig. 8 The addition or segregation of legal modules allows different residential programs, on initial sale phase, and in the future changes that may need the inhabitants.
Fig. 9  Depending on the occupation of the apartment, it may be generating income rather than expenses.

An ACORDE building offers the possibility of selling or renting the unused space of the apartment, obtaining an additional income to the household economy. For example, taking into account the average pension, renting a 45 sqm. apartment (two legal units) segregated from a greater 90 sqm. apartment (four units), would mean an increase for the owner's income equivalent to 40%

Similarly, a young couple with no children might consider buying more modules than they initially need, and keep the unused portion for rent, but at the moment they have children, they can occupy the four modules apartment. Then, re-rent it again once the children leave the house.

5. Facilities

To make all of this possible, the facilities distribution should be rational to allow quick and easy transformation of the interior spaces, and the structure should be well-organized to make possible any interior configuration, with perimeter pillars, and last but not least, a solid and energy efficient enclosure to ensure durability, minimal maintenance and optimum insulation. At the same time, in order to achieve optimal energy consumption, many other factors must be studied, such as the disposition of façades and windows, orientation, thickness of insulation, but above all, the air renewals.

We have developed prototypes of a facilities system with "plug & play" concepts. This means that, for the full adaptability and transformability of the different units, those should be able to connect or disconnect each legally independent space: on the one hand, from or to general networks, but on the other, to be joined or segregated from each other.
6. Acorde Buildings

ACORDE system is being used to design many projects all over the world, proving that this system not only adapts itself to the needs of the inhabitants, but also to the different regulations in the different countries. Since we are showing a conceptual project, not a defined module, we can adapt the units to the needs of each different scenario, so that it can have many different sizes depending on the needs of the plot, local regulations, budgets, etc… ACORDE concept is adaptable as well to the characteristics of the project; it can be used for social housings as well as for luxury dwellings, it depends on the material projected, the size of the unit, and every other customizable quality of dwellings.

7. The Prototype

The first building in which the ACORDE system has been used entirely is a development of social housing in Pamplona (Spain), by designing a building with the best energy performance, high environmental awareness and a strong social conscience: incorporating a clear ground floor with communal equipment, releasing most of the plot and separating adjacent buildings in order to interfere as little as possible in the sun lighting of neighboring plots.
The building was initially designed with 10 social housing units, being the vast majority 3 bedroom apartments. However, the building configuration allows a maximum of 18 apartments with 1 bedroom, and can also become 2-bedroom dwelling by changing the unit’s aggregation. The final configuration of these units depends on the selling process and the real demand of the users.

8. Other Acorde Projects

Acorde concept is being used to design many different projects, as well as to compare traditional projects already designed to what they could have become, by using our concept optimizing the use of it, showing its advantages.

9. Optimization Study in Chile

We studied a project in Talca, Chile, where we counted on the demographic data of the future owners. In the given project, there were 264 empty rooms, and we offered a solution of optimization. Considering that this particular building was conceived for very disadvantaged people, the optimization of space claims even more meaning; buyers will not have to pay for what they do not need. 12% of the total families were families with one member, 70% of them were families with two or three members and only 18% of the total were bigger families that actually needed a three-bedroom dwelling. Acorde proposal had exactly the dwellings that were needed, but was able as well to be readapted in the future to whatever change in family’s composition. In this particular case, Acorde units were symmetric so than future transformations would be as inexpensive as possible.
Fig. 16  One, two and three bedroom houses distribution.

Fig. 1  Study of empty rooms in their project in the left side and ACORDE solution where the distribution of apartments fits the needs of the inhabitants and the optimization of sqm. is total.
10. Social Apartments in Bilbao, Spain

This project was designed entirely with Acorde concepts, for an architecture competition in Txurdinaga, Bilbao, that has not yet been awarded.

The building was designed using two different units or modules, responding to two different needs. Part of the program needed to be one space apartments, and the reminder one or two bedroom dwellings. Regardless on the composition needed at the moment, the composition can be changed in the future to suit the owner’s needs. Acorde project, also offers the opportunity to the owner, (in this case the government of the Basque Country), once the use of housing is no longer needed, it can be changed into another use, such as a student residence, a hotel, or even an office building with easy, and fast adaptation works.
11. Housing in Warsaw, Poland

This first project in Poland is an exercise of adaptation to polish regulation. The plot is located in Wilno, a new development designed to become a fully self-reliant estate in Warsaw. Sun lighting and orientation are key factors; each façade must receive 4 hours sunlight without shadows.

In Poland, it is important to distinguish between what is customizable in the interior and what it is not. Our Acorde project fits perfectly in this concept for we design units absolutely customizable, allowing any interior arrangement, thanks to a very well organized structure, with perimeter pillars, and well organized facilities as well. The developer differentiates inside each dwelling between “walls with the possibility of demolition” and “undetachable walls”

12. Dwelling Tower in Bogota, Colombia

Using Acorde completely adaptable concepts as well, we designed a dwelling tower in Bogota, adapting our units to Colombia regulations, designing a central lobby illuminated and ventilated so that sun light would reach every floor in the inside, as demanded in their regulations.

The future users of this building are politicians or business men spending a time in the city, so the apartments must be high standing quality, and mostly for one or two users. The apartments are located surrounding a spacious lobby with a little patio through which the garden vegetation appears. In the highest floors, a large space is reserved for a meeting room and another for an extended gym. And the flat roof of the volume that does not reach the same height than the other serve as a large terrace with great views towards Monserrate Sanctuary

13. Energy Efficiency

The building's energy efficiency is based on the application of the BREEAM sustainability international protocol both in the design and the choice of materials or construction systems. Following the guidelines of a proven design guide allows quantifying and assesses the real scope of the required sustainability strategies. In these methodologies should be developed and implemented, through an energy modeling or engineering design, a plan for measuring and verifying the energy demand and consumption.
Fig. 20  North elevation. General view of the buildings.

Fig. 21  Typologies type: 2, 2a and 3a using 2 or 3 units. This scheme shows how the disposition of structure and facilities leaves the distribution of the dwelling up to any change. Floor plan of one of the volumes.

Fig. 22  General view of the tower from west side.
The prototype building is being developed under BIM methodology BIM (Building Information Modeling) since its inception, under the All-plan platform. The energy efficiency analysis was developed with Energy Plus (v.6), and modeling has been made with the Design Builder. The operating conditions (calendars, set point temperatures high and low, sensible and latent occupations, lighting, equipment, summer and winter ventilation) are taken from the "Conditions of acceptance of alternative procedures for “Calener”&“Lider”, annexes to the IDAE (Institute for Diversification and Energy Saving). LEADER is the application that allows checking the requirement established for Energy Demand Limiting established on the national Technical Building Code (CTE-HE1) and is sponsored by the Ministry of Housing and the Institute for Diversification and Saving of Energy (IDEA). This tool is designed to perform the geometric description, constructive and operational for buildings. The CALENER software is a tool promoted by the Ministry of Industry, Tourism and Trade, through the IDEA, and the Ministry of Housing, which determines the standard of energy efficiency for a building.

From this analysis can be deduced that the variables of materiality and insulation thickness of the entire enclosure, the size and solar factors of glass for windows, etc., can generate, at best, some advantages equivalents to 10 to 20 Kw/h/sqm. per year or, in other words, an improvement between 15 and 30%. However, regarding the air renewals and uncontrolled infiltration, the differential regarding to the minimum posed by regulations can reach 30 Kw/h/sqm., especially if placed mechanical ventilation systems with heat recovery. This implies, for the actions in the enclosure, about an average of 15 € per person / year by energy savings, and about 30 € per person / year by the control of infiltration and air renewals, considering full occupation of the building.

The building is developed considered mainly passive strategies for energy efficiency. It was decided to be used industrialized building systems with large insulation thicknesses and an optimal solution of singular points, avoiding thermal bridges. Regarding the active equipment, solar panels are placed for the domestic hot water and heat exchangers for ventilation and air renewal. The building reaches the energy certification "A" and is designed taking into account the protocols BREEAM –Spain.
Fig. 24  It is passed from a grade "D" to an "A", the maximum scoring according to local regulations.

14. Conclusion

This system serves to demystify the urgent need in recent years has been given to the double orientation and cross ventilation as a paradigm of sustainability, showing that it is much more efficient the rational use of spaces and systems technologically adapted to the user, where more effective and plausible energy savings can be achieved. In addition, if the building guarantees the possibility of full occupation, the impact of any action in the envelope will have most direct impact to occupants, and the economic return will be more immediate. Therefore: the building will be better if it could be best used and occupied.

This requires deep reflections both in terms of planning and ownership regulations, as in the parameters that are usually considered for energy certification. This will require an open approach to the calculation of housing density in urban and territorial, where everything must be thought "per home", but can be done by "habitable rooms", by residential modules, per sqm. (like in other uses as commercial and office buildings) or, even better, "per person". In the same way, reflect on the impact this has on factors such as calculation of the number parking lots linked to the number of apartments, common areas impact, the facilities (connections, accountants, interior layout, etc..), thinking everything to be done really putting the person first, which is the one who actually inhabit the spaces.

In this model, legally, functionally and technologically patented, every space can adopt different uses and configurations, in contrast to rigid, standard models in which the different spaces eventually become over- or under-occupied. With the possibility of quick, economic changes in building configuration, the user decides how to best utilize the space by acquiring or separating functional units. This provides economic benefits to the user through increased energy performance and optimal use of space.

The efficient occupancy of space leads to an efficient use of energy, minimizing maintenance costs and
ACORDE Project: Adaptable Residential Buildings for a New Social Framework

preventing the heating and cooling of unused rooms. In order to achieve maximum levels of versatility, ACORDE buildings allow for possible future changes in configuration, even in the main use of the building, while at the same time taking into account the technology available at each moment in order to achieve the most efficient management. The principles developed by ACORDE represent a new, efficient philosophy within the open-building framework, consisting of maximum flexibility and adaptability of spaces, all of which translates into the following benefits:

- Optimization of land use and long-term building occupancy
- Flexible, a la carte options for customers
- Reduction in unoccupied spaces
- Increase in economic benefits for occupants
- Reduction in maintenance costs
- More efficient use of energy and resources
- Improved stability of social circles
- Enrichment of the demographic composition of buildings
- Promotion of intelligent cities and buildings
- Quick, easy conversion of spaces
- Better access to technology for users

Acknowledgments

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References

[3] Data from INE (National Statistical Institute) for whole Spanish territory.
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