

REPORT 12

SUSTAINABLE CONSTRUCTION IN SPAIN

**P. ALAVEDRA
M. D. CALVET
M. CASALS
D. GIMENEZ**

UPC
POLYTECHNICAL UNIVERSITY CATALUNYA
Department of Construction Engineering
C/Colom. 11 Edifici TR5
08222 Terrassa - SPAIN
Tel : +34 3 7398153 - Fax : +34 3 7398101
email : alavedra@ec.upc.es

J. BERNIS
Metropolitan Territorial Plan for Barcelona

J. DOMINGUEZ
University of Zaragoza

J. SERRA
General Department of Housing and Architecture

NATIONAL REPORT

CONTENTS

1. INTRODUCTION: THE SPANISH TERRITORY IN A CHANGING EUROPE	3
1.1 Geographical framework	3
1.2 Socio-economic framework.....	4
2. THE SUSTAINABLE CONCEPT IN SPAIN.....	7
2.1 Environmental problems.....	8
2.2 Evaluation criteria	8
3. THE CONSTRUCTION SECTOR IN SPAIN.....	10
3.1 The structure of this sector today	10
3.2 Regional evolution of the construction sector.....	11
3.3 Sustainable construction in Spain: present situation and future prospects	12
4. METHODOLOGY.....	13
5. ANSWERS TO THE QUESTIONS.	15
5.1 Answers to the 5 questions.....	15
5.2 Answers to other questions that arise in Spain.....	18
6. CONSEQUENCES OF THESE ANSWERS FOR CONSTRUCTION IN THE YEAR 2010.....	19
7. CONCLUSIONS AND RECOMMENDATIONS	19
8. GOOD PRACTICE EXAMPLES.....	20
8.1 Territorial planning.....	20
8.2 Construction.....	22

1. INTRODUCTION: THE SPANISH TERRITORY IN A CHANGING EUROPE

1.1 Geographical framework

The organisation of the Spanish territory is an important factor due to the fact that it encompasses a lot of problems and heterogeneity's that keeps Spain at a distance from other countries, and more concretely, from the rest of the European Union.

A common characteristic seen in the varied landscapes of the Peninsula are the strong contrasts between them which creates a diversity unfound in any other country in Europe. Such contrasts in the landscape are a characteristic of the Mediterranean countries in which high mountain ranges alternate with medially high ones, with flat depressions appearing between them which have favoured human settlements. Added to this is the influence of two climatic regions so different from each other as is the Atlantic and the Mediterranean, these contrasts give, perhaps, a higher diversity in Spain than found in any other of the Mediterranean countries.

As you can see in figure 1, the areas where it is possible to establish settlements, that is, those having a slope less than 20%, are scattered over the territory overcoming the problem of the Spanish orography.

Briefly, we can say that the geological relief is articulated around a great central unit, La Meseta, which has a high average height, of 650 m., and is bordered both in the North and the South by high mountain ranges, of 2.500 m.. In the peripheral areas there are medium height mountain ranges such as the *Prelitoral Cordilleras*, as well as high mountains like the *Betic Cordilleras* in the southern sector and *Cantabric Cordillera* in the northern one. The *Pyrenees* mountains, which are situated between the Peninsula and the Continent, have an axial zone where are found the highest mountains, of over 3.000 meters.

In summary, in order to systematise the study of such a diverse and contrasted country, we can high light three characteristic features:

- the massif shape, scarcely cut, of the coastal area.
- the average medium height (only surpassed by Switzerland in Europe).
- the disposition of peripheral outstanding mountains.

1.1.1 The water problem

Spain is situated in the southern extreme of the *arid diagonal*, which crosses the West of Europe. This *diagonal*, which extends from the south-east to the north-east of the Iberian Peninsula separates the two more active zones of the country; and it is in its

bordering areas, where the oasis of urban and industrial development cities such as Zaragoza, Guadalajara and Madrid, appear.

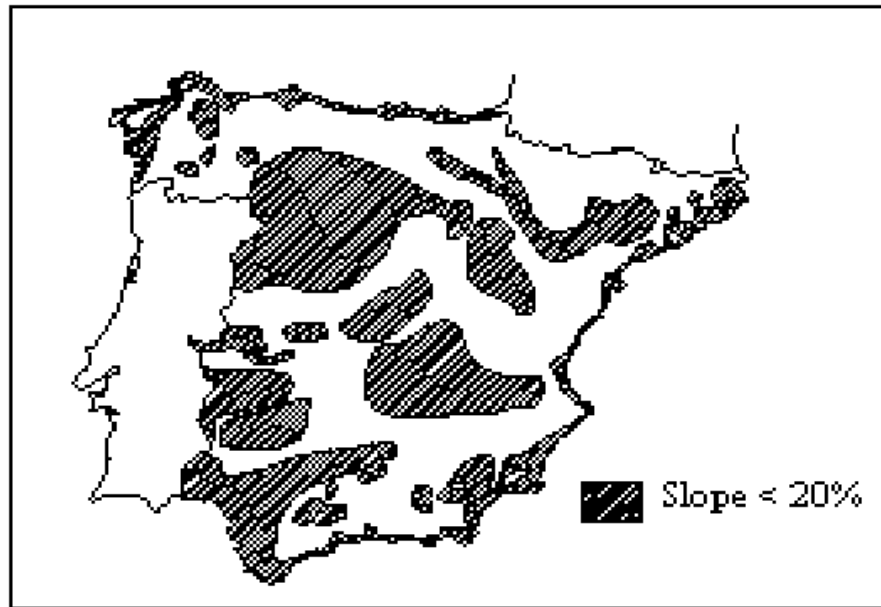


Figure 1: Areas where it is possible to establish settlements

Within the *arid diagonal* we find a common characteristic: scarce rain combined with a high level of evapo-transpiration. Another characteristic from an agronomical point of view is the bad quality of the soil, which makes this region not fit for agriculture development.

Although Spain is situated in a temperate zone, its irregular topographical relief implies two great and opposed climatic conceptions. To the north of the *arid diagonal*, we find humid Spain which coincides with one of its most developed regions, in economic terms, whilst to the south of this divide we find dry Spain, which it self is divided in two areas: a very dry zone and a Mediterranean zone.

In surface area terms, the *humid area* represents one third of the country, while the other two thirds belong to the *dry area*.

1.2 Socio-economic framework

One of the socio-economic consequences that becomes evident from the above study of the geographical framework, is the lack of balance in the Spanish Society; this is even more evident when considering the deep differences that there are between the Spanish regions. The regional unbalance shows clearly three significant aspects of facts:

- population
- gross regional product

- income per capita

The population is distributed over the Spanish territory, which exceeds 500.000 square kilometers, with an average density of 76,8 inhabitants per square kilometer, slightly higher than that of Greece, but considerably lower than the rest of the European countries.

The distribution of the population is uneven, with large areas well below the already low national average. This situation implies the existence of some "human deserts" unparalleled in other European countries. There exists high concentrations of populations in the big metropolitan areas opposed to a steady depopulation of the country areas.

The development of the population distribution in Spain is explained in the following study which pays special attention to the creation of employment. Within this study are examined two characteristic periods within the last 25 years, the 1970-1995 period (see figure 2), which shows the evolution of the Spanish economy from the end of the dictatorship until today; the deep crisis of the 70's and beginning of the 80's, and the expansion period between 1985 to 1995, when 1.160.000 jobs were created, however, with paradoxical results. Employment in Mediterranean regions such as Valencia and Catalonia grew by over 18%, while in Atlantic regions such as Galicia and Asturias it fell by over 11%.



Figure 2: Provinces which generate work between 1970-1995

Employment, by industrial sectors, is organised as follows (see Figure 3):

- the primary industry; 10% of the active population works in any of the activities pertaining to this sector ;
- the secondary industry; this sector employs about a 33.1% of the population, 10.6% of which are people employed in the construction ;
- the tertiary industry, or service industry, the rest of the working population is involved with activities in this sector.

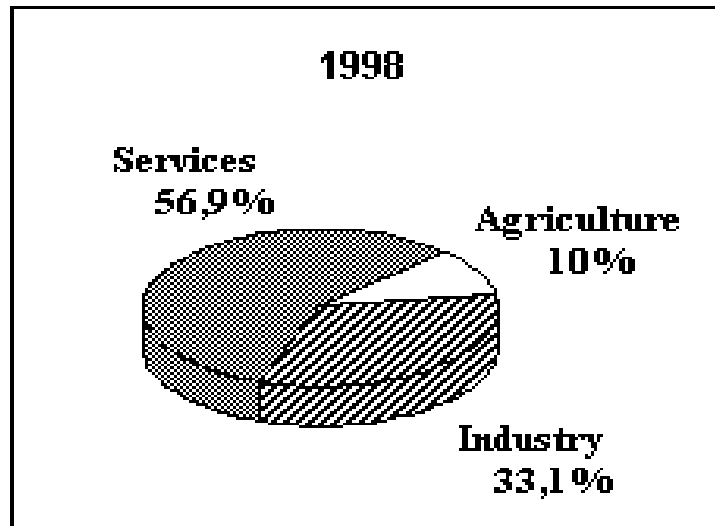


Figure 3: Employment in Spain

Not one of the regions in Spain reaches the European GDP average, even the richest ones, that is, Baleares and Catalonia with 98% and 97% of the European average respectively. On the other hand, economically depressed zones such as Extremadura in the Southwest of Spain does not reach 70% of the average.

If we analyse the income per province we can see that the Vasco-Navarra and Catalonia-Valenciana areas have the highest development, together with Madrid and Zaragoza, while the Southwest and Northwest areas do not reach the minimum income levels of the richer provinces.

In summary, if we draw the above mentioned *arid diagonal* line on the Spanish map we can see the clear division between a poor and depressed Spain in the Southwest angular region, close to the Portuguese border and the southern Mediterranean; and a rich and developed one, in the Northeast regions around the Cantabric coast and the French border.

1.2.1 The Atlantic 'arc' and the Mediterranean 'arc'

European 'arcs' are in fashion nowadays. There is a Mediterranean 'arc' and an Atlantic one, in order to counterbalance the north of Europe.

The Atlantic 'arc' has become an area where poor villages have been waiting for a long time for the central area to give them work. It has also become an attractive 'European' place for certain industrial activities because it has rural areas with available manpower at cheap prices and a high demand of temporary work from unqualified young people.

The Mediterranean 'arc' is the edge of the huge Mediterranean gulf, thanks to it the greater part of the European megalopolis is located in this front. It is a passage territory, completely open; it is not a land of refuge but a circulation corridor as it was in the past with constant comings and goings of Greeks and Romans.

These two 'arcs' seem to have common objectives. In general, both do everything that it is possible to have a permanent employment; they have a desire to have a greater autonomy with respect to the centre, and to develop local companies with less dependence on the decision of foreign firms.

Spain is one of the European countries which is more attractive for foreign firms and also one of the countries which has received more investments in the last few years, which indicates that the Spanish market is interesting and has an importance within the European context. In order to increase the attraction of the country, so that it can reach the levels of richness and employment similar to those of the rest of the countries of the European Union, several steps of great importance must be taken, with respect to transportation infrastructure and a rapid connection between the two mentioned arcs, but within the framework of the sustainable construction.

2. THE SUSTAINABLE CONCEPT IN SPAIN

Nowadays Spanish cities share many of the problems other European cities have regarding the particular qualities of their individual countries, but added to this are; the hard inheritance received from a long period of strong growth without political freedom and the recent establishment of a Democratic State (1978) with a high federal character; the relative delay and lack of equilibrium with which the industrialisation process and the expansion of the tertiary sector of the country was carried out, coexisting with a high development of the tourist trade mainly in the coastal region.

These singularities determine the own profile of the Spanish territorial and urban reality: the existence of a great territorial reserve which includes a significant percentage of biological diversity; a quite hierarchical system of Mediterranean cities around a series of discontinuous territorial axis and seventeen metropolitan areas.

There has been a certain delay in the consideration of the environmental, local and global problems found in Spain, this was wrongly put aside by the need to face the huge problems inherited from the great migrations from the country to the cities during the decade 1960-1970, as well as the consequences of the subsequent economic crises from 1975 to 1984, and the more recent one which started at the beginning of the present decade.

In order to rationalise the economic situation found within the territorial arrangement, it is important to identify the real problems that may crop up at different levels. At a local level, a lot of questions can be clearly identified; this does not mean that they are simple political questions due to the fact that there are opposing interests at work between different parties. Environmental involvement is not always compatible with urban, industrial or tourist ambition.

2.1 Environmental problems

The most important environmental problems in Spain are:

- natural catastrophes, mainly annually occurring floods and fires.
- continual process of land erosion due to deforestation and creation of deserts.
- problems derived from an inefficient use of the hydrological resources.
- progressive contamination of underground, superficial and sea waters.
- high degree of deterioration of the coastal areas and in the islands.
- progressive soil contamination due to intensive agriculture exploitation, and urban and industrial solid waste disposal.
- growing air pollution found in main metropolitan areas.

2.2 Evaluation criteria

The main obstacle to solve was the establishment of the 'evaluation criteria' with regard to the sustainability concept in urban and local environments, in order to analyse and evaluate the various proposals submitted by several cities.

Three initial general references were established in order to make up the currently found deficiencies:

- implementation of consistent intervention instruments.
- magnitude and integrated character of local management.
- consideration of the efforts carried out by local and institutional bodies.

The areas and basis of thematic evaluation have a more concrete and interesting level of consideration, provided it does not create a segmented perspective of the analysed case which is not compatible with the integrated view required by the kind of evaluation to be carried out. That is to try to envisage several concrete reference values on sustainability of urban policies in order to provide a consistent contrast which regard to the actions to be examined.

Four criteria areas have developed (see Table 1): environmental quality, spatial structure, cohesion and social life quality, and local economy.

Sustainability and urban practices in Spain. Evaluation of criteria areas and thematic values	
1. Environmental quality	<p>Local programs in relation to overall environmental problems.</p> <p>Bio-diversity and local ecosystem preservation, without surpassing the load capacity.</p> <p>Prevention and actions against environmental risks.</p> <p>Minimisation of resources consumption and waste generation: quality of the environmental services and measures in key sectors.</p>
2. Spatial structure	<p>Adaptation of the urban structure to spatial and local environmental conditions.</p> <p>Spatial solution to social needs in respect of the new growth and restoration of the built property, from a rational point of view.</p> <p>Arrangement of urban goods and services and own city space, so as to favour urban transport and pedestrians.</p> <p>Encouragement of wealth, diversity and complexity of urban structure.</p> <p>Adaptation of urban space and construction to environmental requirements and quality of life in the cities.</p>
3. Social cohesion and quality of life	<p>Social <i>backbone</i>, support and cover of basic social needs.</p> <p>Quality of life and availability of a rich, diverse and complex socio-cultural environment.</p> <p>Acces to information, education and participation in local and global policies.</p>
4. Local economy	<p>Scale, equilibrium, viability, stability and a reasonable level of interrelationship with local development.</p> <p>Minimisation of environmental impacts in sectors of the local economy.</p> <p>Encouragement of the ecological economy, that is, the adaptation of environmental aspects within the economic cycle.</p> <p>The sustainability of public finances.</p>

Table 1 (Source : Habitat II)

3. THE CONSTRUCTION SECTOR IN SPAIN

Industrial construction represents about 11% of all of the activities in this sector in Spain. Employment has increased in this sector during the last few years and is now established at around 1.5 Million people. This represents an unemployment rate of between 20% and 25%, which mirrors the exactly the overall Spanish unemployment rate, which is the highest within European countries.

3.1 The structure of this sector today

The Spanish construction sector has lately benefited from a demand that started in the private sector at the end of 1996 and beginning of 1997. In spite of this, the overall decrease in public work demand prevented the sector from having the strong recovery predicted from the general economic situation.

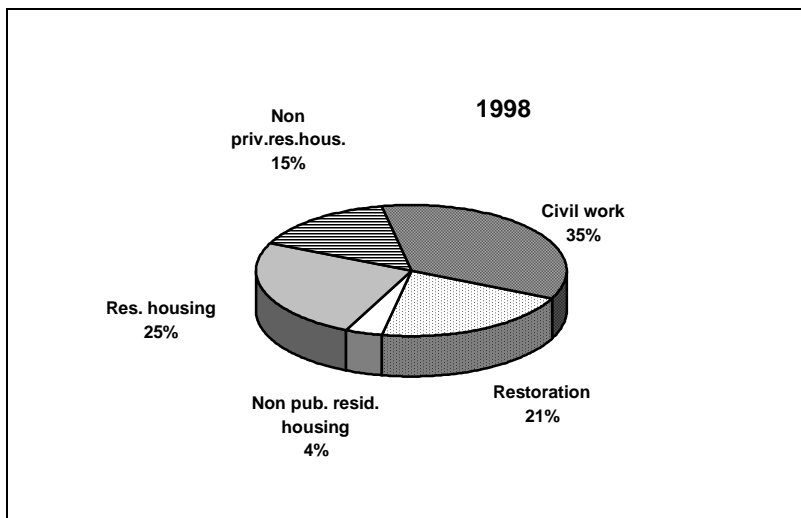


Figure 4: Structure of the construction sector in Spain

After a fall of construction activity of -1% during 1996, there is already a recovery which is reflected in the 1997 statistic and which will be reinforced during 1998 with an estimated growth of 2,8%. Housing is the most dynamic sub-sector of the Spanish construction (see Figure 4) with an estimated growth of 6,3% for this year.

The structural restoration sector is scarcely developed in Spain. It has an enormous potential but the lack of specialised companies and the use of old-fashioned methodology often turns this activity into localised craftsmanship, the housing sector is an activity strongly influenced by the individual family economic conditions.

The present economic recovery has enabled the new *Plan de la Vivienda 96-99*, Housing Plan for 1996-99, to include restoration and maintenance of buildings as two activities which will get priority attention, particularly focusing in interventions to be carried out in the old nuclei of cities and the improvement of urban structures. It is important for the Spanish restoration sector to grow year after year in order to reach the European levels which represent 34% of the whole market.

3.2 Regional evolution of the construction sector

The evolution of the different indicators of activities in this sector show the construction dynamism of the different autonomous regions. In the first half of 1996 the most dynamic regions were Canarias, Baleares, Valencia, Navarra and Murcia (see Figure 5).



Figure 5: Regional evolution of the construction sector

Nearly 125.000 applications were received requesting for the benefits of the 1996-99 Housing Plan. In absolute terms Catalonia is the region which generated a higher demand with more than 25.000 applications, followed by Andalucía and Valencia. On the contrary, in terms *per capita*, Rioja, Asturias, Murcia, Canarias, Aragón, Catalonia, Valencia and Cantabria exceeded the Spanish average.

3.3 Sustainable construction in Spain: present situation and future prospects

If we concentrate in the area of design and works execution we see, first of all, that the location of the building plays an essential role. It is not always possible to choose the site and, therefore, the most favourable conditions, but the climate, vegetation, topography and urban structure must always be taken into account either if we want to take advantage of them or if we have to protect ourselves from adverse conditions. In this sense it is imperative to be able to influence the urban planning which is where we can really contribute to give the best environmental solutions to urban construction.

3.3.1 Urban planning

If we want to go beyond the limitations of urban planning in order to get an integrated one such as the territorial disposition the following problems arise:

- the existence of several disciplines which have an influence on urban planning and act in a sectarian and fragmentary way.
- the public administration operates in compartments, they carry out sectarian plans which prevent the problems from being solved in an overall comprehensible manner.
- the habit of giving short term solutions.
- limitations of urban planning which regulates the socio-economical activities of a municipal, being incapable of handling the big environmental problems which are of an above municipal nature.
- administrative divisions which restrict urban planning and are an obstacle to the approach of environmental problems.

In the last few years there has been a significant improvement in Spain in the process of overcoming the limitations of urban planning. The laws concerning the regulation of the territory in the autonomous regions have improved in the following aspects:

- simplification in the number of plans. There are now only two or three hierarchical levels. In the first one we find the general rules for the territorial disposition, also called *Plan de Ordenacion del Territorio* or *Plan Territorial General*, depending on each autonomous region. In the second level there are partial rules for the territorial disposition and in the third one the specific programs and sectarian plans of some of the autonomous regions.
- diagnosis of the problems of territorial disposition.
- quickness in the process of planning approval.
- new strategies and co-ordination of actions to solve the problems of territory disposition.
- creation of a permanent information system between public administrations in order to have enough data to work out the disposition plans.
- fix the limits of the territorial units according to environmental values, such as places of ecological, cultural, scenic interest, etc.
- creation of different management areas for non-urban development land.

- incorporation of the analysis of the territorial impact in order to evaluate the incidence that the project activity or installation can have on the territory.

3.3.2 Construction aspects

From the construction point of view there are a series of negative aspects in the current situation:

- increasing occupation of land and transport networks together with incessant extraction of raw materials with the consequential environmental impact.
- presence in the existing buildings of many contaminating substances used in the constructing sector (asbestos, lead paintings, PVC, etc.). Buildings have to be therefore decontaminated before restoring them.
- lack of environmental mentality in constructors, designers and users that hinders the introduction of effective measures which are today both technically and economically possible.

In order to comply with the sustainability commitment in the Spanish construction sector, 3 complementary aspects have to be taken into account:

- economic
- social
- ecological

The economic policy should be directed towards the reduction of the global costs of the buildings, taking into account all the life cycle by using new technologies and building systems, saving energy and using better management. It should also be necessary to state the need to increase investments on restoration and maintenance.

From the social point of view a dignified house, healthy and accessible, must be guaranteed in order to promote social integration and reduce the number of conflicts. Historical buildings and sites must also be preserved as elements of local identification.

The ecological aspect must face the need to use all the planning instruments available to avoid land occupancy and landscape destruction. Also the reduction of CO₂ emissions must be advanced, as well as the saving of non-renewable resources and the avoidance of the use of dangerous materials.

4. METHODOLOGY

One of the basic conditions to write about in the present situation of the Spanish sustainable construction and give some recommendations is as follows, is to consult the different social parties directly related to construction.

We decided to consult three different levels:

- the Administration and the University.

- professionals related to big construction firms.
- autonomous professionals and small firms of building contractors.

Based on the work of Cas Richter a questionnaire was formed whereby the collaboration in three areas was requested:

1. ecological principles, where answers related to maintenance, recycling, quality or economy were given.
2. sources, where water and money as limited sources were of great importance.
3. construction phases, where all construction aspects from planning to maintenance or demolition were taken into account.

If we make a short review of the different opinions obtained in each level of the questionnaire we can see different approaches.

In the first level of study, we spoke with professionals related with the Administration and the University. Generally, they understood sustainable construction to be that which is environmentally respectful.

In this level they agreed that the most important agents for a change in this regard are:

- house owners, landlords, other investors in housing and residents.
- politicians, planners, local government representatives and the educational system.
- representatives from the agencies responsible for the provision of energy and water, and the discharge of wastewater, solid waste and recycling.
- representatives of the construction industry: professionals, contractors and consultants.
- social housing organisations.

According to these agents, the most important areas of intervention will concern:

- urban planning, that guarantees sustainable cities, that is, integrated urban structures, re-use of the existing cities and adequate densities in the individual territory.
- reduction of transport demands, with adequate policies.
- water savings, including systems for the collection and use of rainwater and local drainage of rainwater.
- energy savings, including incentives to encourage the use of renewable, alternate energy sources.
- refuse handling, including the reduction of refuse production, selective demolition and recycling of building materials.
- indoor climate improvements, including the evaluation of building materials, construction and maintenance.
- development of social processes, which are required to obtain sustainability in the housing sector, by means of a participation in the planning and management processes.

At a second level, where we find professionals related to big construction firms, they considered sustainable construction as the construction of the future, and for them the most important areas of intervention are:

- maintenance and adaptation of existing housing.
- use of sustainable new building materials with lower environmental impact.
- free movement of building materials.

At the third level, autonomous professionals and small firms of building contractors identified the sustainable construction concept with sustainable development and with distribution of wealth. One of the most general comments among designers was the life-cycle of buildings. According to them, life-cycle analysis varies according to the technology, information and habits of each country; and construction materials have a very important local component contrary to bigger industrial products.

In the next section we have synthesised the experiences of the different levels in order to find an answer to the basic questions which will make us understand the sustainability of the construction at the beginning of the new century.

5. ANSWERS TO THE QUESTIONS.

5.1 Answers to the 5 questions

5.1.1 What kind of buildings will be built in the year 2010 and how will we adapt the existing buildings?

In such a traditionalist sector and with a short time view, there will not be radical changes, but the introduction of solutions focused on decreasing the environmental impact is expected. The main foreseeable advances include:

- The use of environment friendly materials (with attention to the analysis of their life cycle).
- Buildings more compatible with the deconstruction process.
- Greater flexibility and capacity to adapt buildings to diverse uses.
- Increasing the energy efficiency (especially in areas of lighting and air conditioning) by means of:
 - ◊ Incorporation of automatic control in some lighting and air conditioning systems. The optimal results are obtained by using integral management systems .
 - ◊ Taking profit of the solar power (solar heating and cooling).
 - ◊ Improvements in insulation techniques.
 - ◊ The use of new and more efficient technologies (illumination by electronic ballast for instance)
- A better management of waste materials and water .

Many of these solutions can be progressively implanted within existing buildings giving satisfactory results, although better results are obtained if all these factors are taken into consideration during the design phase of the building. The simplest and more economical solutions to be adapted to existing buildings are:

- Improvements in insulation systems. It is relatively cost effective and fast to repay.
- The use of low environmental impact materials, in the retrofit of existing buildings.
- Changing the current lighting and air conditioning equipment by more efficient systems whenever they need to be replaced.
- Considering building retrofit instead of demolition and new construction.
- To use recycling criteria when a building is demolished.

5.1.2 How will we design and construct them?

One of the main points to be considered is the need to develop a methodological process focused on integrating environmental considerations into the processes of design and building. These considerations must be incorporated into the project from its outset and carried on throughout the project phases till the final occupancy of the building. It is also important to bear in mind the possibility of the changing use assigned to a building during its lifetime, so it is necessary to endow the building with the quality of being adaptable to diverse uses.

Another basic premise in the design of a building is its correct adaptation to the environment it will be located in. Important aspects as the climate, the topography, the noise, the ground state or the visual impact the building causes, cannot be neglected.

Finally, the first measure, that we are faced with in the approach towards sustainable construction, is to design the building using a interdisciplinary approach that adopts preventive measures instead of applying corrective ones once the work has been finished.

5.1.3 What kind of materials, services and components will be used there?

As said before, the construction sector is reticent to the entrance of new materials and technologies. Probably what we will often see, from now to year 2010, will be adaptations of already existing materials to the new requirements of sustainable development. Either new or adapted, the most recommendable materials to use are those that produce low environmental impact within the different phases of their life cycle:

- the extraction of the raw materials
- processing or manufacture of the product
- their installation in the building (in phase of construction or rehabilitation)
- the operation phase
- the elimination or substitution of the product (disposal, incineration or recycled)

As far as the use of equipment as well as the ease of use of equipment is concerned, it is advisable to use standard components in order to make easy their subsequent

maintenance, repair or substitution. This is especially important in standardised services like water provisions, gas and electricity.

Probably the most foreseeable innovation in the short-term will be the use of automatic control technology. The computer and sensor technology used to control the main systems of the buildings will enable improved occupation comfort as well as to increase the efficiency and capacity of lighting, air conditioning, ventilation and security systems.

5.1.4 What kind of skills and standards will be required?

The 'eco-labelling' may foster the implantation of technical improvements, that will decrease the environmental impact produced by the construction sector, promoting the use of products that have the smallest environmental cost. The 'eco-labelled' products will fulfil strict requirements related to:

- The use of recycled materials.
- The use of low environmental impact products.
- Energy efficiency (insulation, high efficiency lighting, the use of solar energy).
- Environmental considerations during the construction phase (noise, waste generation)

Another premise that should be fulfilled by the future buildings is the capability to be deconstructed allowing the reuse of its materials and components.

In relation to the construction techniques it would be advisable to use standardised elements as well as the use of modular construction techniques. The construction elements made in the factory cause less waste and are easier to be recycled than the ones produced on the construction site.

5.1.5 What kind of cities and settlements we will have then?

Radical changes are not foreseen from now to the year 2010 because these changes are developing slowly.

Current tendency analysis in Spain indicates that the trend is to slow down the growth of large cities, even a small amount of recession in many cases, and a sharp increase in the growth of small and medium cities located in metropolitan areas.

From territorial planning point of view, several important objectives should be considered:

- Keeping construction densities between reasonable limits to prevent its dispersion, incompatible with urban character as well as increasing congestion.
- Avoid land occupation:
 - ◊ In areas with great landscape, ecological or cultural worth
 - ◊ In specially fragile areas: coasts, salt marshes, un-evennesses, etc.
 - ◊ In dangerous areas : floods , landslides.

- Minimise imbalances that take place around the large metropolitan conglomerations.

5.2 Answers to other questions that arise in Spain

5.2.1 What must be considered in special in the case of Spain?

The Spanish climate presents some peculiarities that make it different from most of the European countries. To Begin with, is the rain regime, and followed by the temperatures, these climatic peculiarities have a strong influence in the Spanish constructions characteristics that distinguish them from the ones formed in the North European countries.

Socio-economic factors should also be considered :

- ◊ low investment in investigation to solve the environmental problems
- ◊ strong industrialisation of some zones
- ◊ pressures that tourism exerts along the coast

5.2.2 How to take advantage of the Spanish climate peculiarities?

The bio-climatic construction in the South of Europe might produce savings up to the 70% of the heating energy consumption.

The passive solar design, for lighting and thermal control (heating, cooling and thermal storage), and the active solar uses of all types, especially with respect to hot water preheating and the photo-synthesis applications, providing in Spain a remarkable roll in the way towards a greater power efficiency.

5.2.3 How do we overcome the difficulties that the Spanish climate causes?

Especially, an effective water management system is necessary in Spain to help counter the effects of the small amounts of rainfall. We can go towards this in four different areas.

- Installation of rain water collection and water re-use systems in buildings.
- Protection of water supply areas
- Suitable management of sewage treatment in order to improve the quality of the water in the river system.
- Develop territorial planning with attention to the dangers of flooding.

5.2.4 How can the main socio-economic obstacles in Spain be overcome?

The need for an economic, technical and cultural evolution of the building sector is becoming evident.

Although investments in sustainability are " profitable " over the long term, the construction industry needs to obtain profit from its investments in the short term.

Therefore the efforts must be focussed on marketing of the most sustainable products by means of the eco-labelling and also increasing social sensibility towards environmental subjects.

6. CONSEQUENCES OF THESE ANSWERS FOR CONSTRUCTION IN THE YEAR 2010.

It is very clear that construction technology needs to evolve with the use of lower environmental impact solutions, so as to become more sustainable.

Several environmental factors must be considered in order to improve the environmental quality of construction.:

- Design phase:
In this phase it is very important to foresee the solutions that will allow the carrying out of its subsequent phases with the smallest ecological footprint. This objective requires a multi-diciplinary approach.
- Construction phase:
Several new solutions will be adopted, such as modulated construction, prefabricated elements with the use of recycled or low environmental impact materials. Other interesting techniques are focused in the reduction of noise and waste levels, and the consumption of water.
- Operation phase:
The main goal in this phase is to improve the efficiency of power and water consumption. In this sense, the new automated systems focused on the integral management of the building will be of great help. But it will only be possible to reach a good efficiency level if the previous phases have been carried out correctly.
- Deconstruction phase:
In this phase re-using materials and components will reduce the waste generation and the consumption of new raw materials.

7. CONCLUSIONS AND RECOMMENDATIONS

The goals to achieve in the diminishing of the negative environmental impact caused by the construction industry are:

- to protect natural resources and bio-diversity
- to reduce water and energy consumption
- to decrease air, water and sonic pollution

- to reduce solid, liquid and gaseous waste
- to promote the use of recycling.

The following recommendations are presented in order to fulfil these ecological objectives:

- Promoting the eco-labelling of the buildings, based upon:
 - ◊ the environmental quality of the materials used in construction with attention to the life cycle analysis
 - ◊ a energy efficiency certification in new constructed buildings
 - ◊ other considerations like the environmental impact in the construction phase (generation of noises, rubbish)
- Reducing the environmental impact of the construction waste through its minimisation and recycling.
- Taking into consideration the impact on the health, comfort and security of the users, during the design phase of the building.
- Promoting maintenance and rehabilitation of buildings as a strategy to enlarge their period of use.
- Increasing the degree of environmental education of technicians in order to introduce these criterias into the sector.
- Accelerating the integration of ecological constructive solutions in the construction companies by means of including them in the administration promoted constructions.
- Promoting investment in the environment by means of fiscal deductions and/or eco-tax that burden the process of contaminating or consuming.

8. GOOD PRACTICE EXAMPLES

There are a lot of good practice examples that have been developed in Spain. The following are some cases which reflect progressive integration of ecological solutions in the construction sector.

8.1 Territorial planning

Although the initiatives of territorial planning that take into consideration the sustainability principles, are numerous, the future Metropolitan Territorial Plan for Barcelona has been chosen as an example because it is the multi-section proposal that includes the most extensive territory.

Metropolitan Territorial Plan for Barcelona

This Plan, that has not yet been ratified, tries to avoid the habitual and not desirable situation that is generated in the surroundings of large cities. In these peripheral areas, the territory is occupied in a dispersed uncontrolled manner, while in the old city centres, a great degradation and congestion has been produced. The objective is not to

obtain a geometric or static balance but the homogenisation of the living quality and the preservation of low or high value areas.

In order to be able to offer a high quality services and communications, it is necessary to avoid the mentioned situation of disperse land occupation added to the congestion of specific zones. The Plan proposes a solution based on distributing the territory in a system of "open spaces ", and " metropolitan islands ".

The " open spaces " must constitute an integrated assembly with its own value, beyond the mere addition of dispersed pieces of more or less protected areas. In these "spaces ", construction will be very limited but not always non existent, in order to respect existing environment situation. Its main function is to avoid that urban sprawl invades the zones that do not have to be occupied. These spaces will include the areas with great landscape, agricultural or forestall worth, as well as the areas needed for the operation of the hydrological system. They will also include zones that must be protected due to their special weakness, for example salt marshes and the lands with great slope.

The " open spaces " will be connected through a system of connector-separators that the Plan denominates as " filters ", whose mission is to avoid that these " spaces " became isolated and surrounded by densely occupied zones.

The "metropolitan islands" will be areas of high construction density. These " islands " will contain the areas of the territory with a effective provision of services and mobility as well as a fixed infrastructure of public transport.

Obviously, mainly the existing cities and settlements will be included in these " islands " that will have clearly enough defined contours to avoid yielding to the pressures of growth.

Another interesting proposal of the Plan is the system of segregated roadways, structured as a homogenous and orthogonal network, that will canalise the *passing through* traffic. This system is complemented with a net of "civic" thoroughfares and service corridors that will channel the inter-metropolitan short distance transport flows and serve, at the same time, as a backbone for the different main service networks (water, electricity, gas, telephones...)

Other interesting *good practice* examples are:

- General Urban Development Plan for Sabadell, Barcelona.
- Performance of a City Plan for Girona.
- Integral Management of water and urban waste in Navarra.
- An example of participation and urban rennewal: the district remodeling in Madrid.
- Ciutat Vella, integral restoring the historical center of Barcelona
- the application of a strategic plan in Alcobendas, a city within the Madrid metropolitan area
- Alternative home policies in Andalucía.

8.2 Construction

8.2.1 Dwellings.

A block of six flats with solar conduit in Horta, Barcelona

The building consists of three floors and a parking storey that has been equipped with bio-climatical solutions to fulfil the requirements of ventilation, air conditioning and lighting. One of the most novel characteristics of this building is the incorporation of a solar conduit for the illumination of the kitchens, that is used at the same time to provide natural ventilation (see Figure 6).

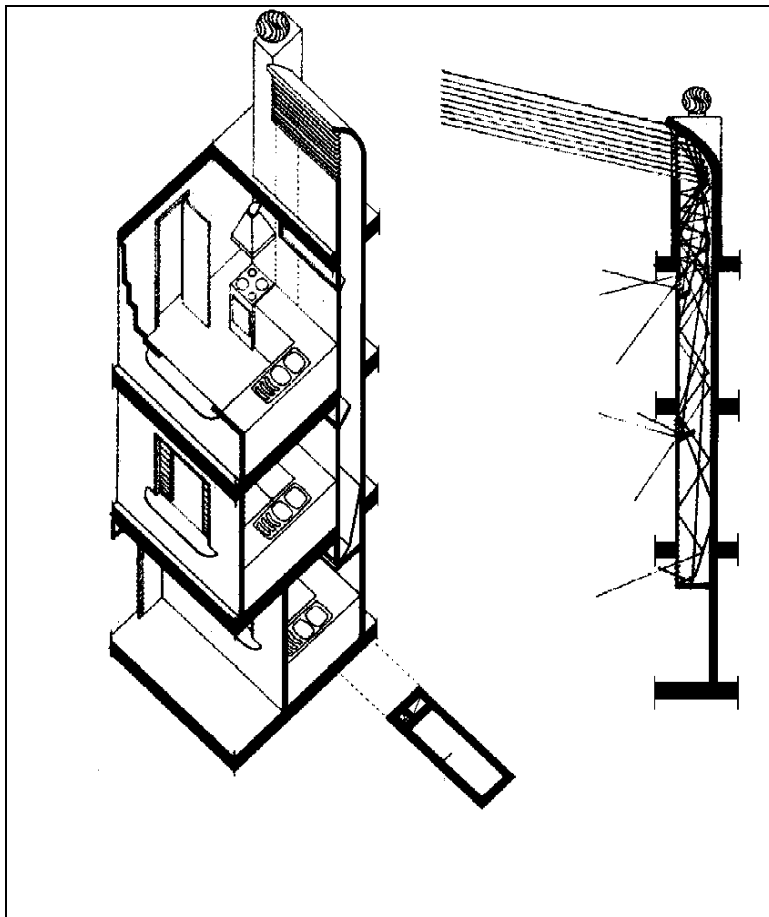


Figure 6: A block of six flats with solar conduit in Horta, Barcelona

Other bio-climatic measures have also been applied to this building. The ventilation and illumination of the parking have been arranged by using a skylight, also used in the lighting of the stairs. One of the main areas that have been taken into consideration is

energy saving in heating. The walls have HD polystyrene to improve thermal inertia. In the main facade, oriented to the Southeast, there are 53.2 m² of double glazed windows, whereas in the rear facade there are 14.5 m². The improved solar lighting, reduces the thermal losses and allows crossed ventilation in the summer.

Thanks to the gains obtained from the passive solar pick up and the good insulation, the degree of energy saving in heating has reached 68%.

Other interesting good practice examples:

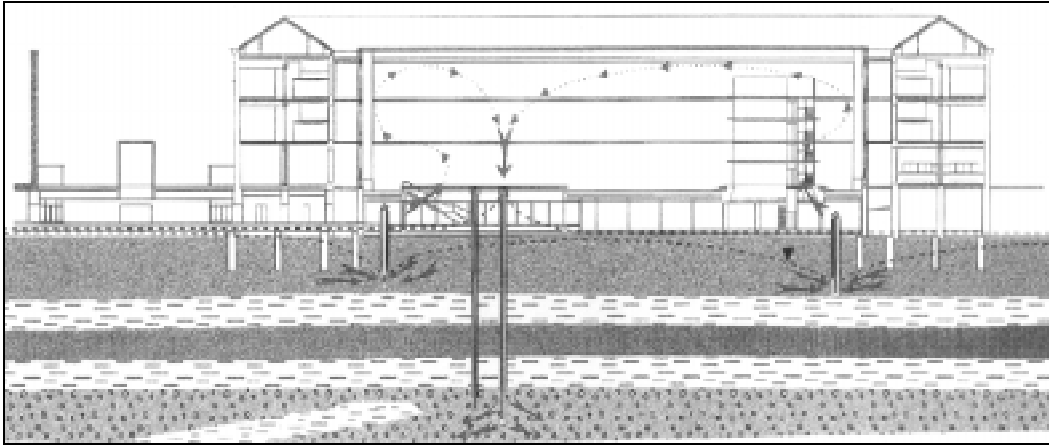
- An experimental block of forty nine bio-climatic flats in San Pedro de Alcántara, Málaga
- A sixteen flat block in Pedrajas de San Esteban, Valladolid.
- A twenty flat block including glazed atrium in Aguilar de Campo, Palencia
- A sixty four flat block in Mendillorri, Pamplona, (included in the Thermie program).

8.2.2 Public buildings

The air conditioning system in a building in the Universitat Pompeu Fabra, Barcelona

The "Jaume I" building in the "Universitat Pomeu Fabra" is the result of remodelling the old military barracks of the "Parc de la Ciutadella". The "Àgora Jordi Rubio" is located in the underground of one of the lateral streets and it will be linked with the "Roger de Llúria" building. The characteristics of the subsoil forced measures to be taken to protect the underground plant from the negative effects of the water level. The necessity of underground water pumping to maintain the water level 30 cm below the basement was considered. As a result of this a continuous pumping system was projected to protect the building against water filtration and floods.

The building has strong air conditioning requirements . During most of the year, a simultaneous provision of cooling and heating is needed. Taking in consideration the water volume extracted by the pumps which control the water level, the possibility of installing water condensed machines, that enable optimal power consumption to be obtained (because they provide cold and warm water simultaneously), was studied. After a hydrologic study of the zone, the existence of two water-bearing levels were determined, the higher one located between a depth of 6m and 12 m and the lower one located between a depth of 30m and 35m, both of them separated by an impermeable layer. It was decided that water would be taken from the higher one , and once used, inject into the lower one. With this solution the water of the subsoil can be controlled and its level maintained such that it does not endanger the building, while, at the same time, water is injected in the lower water-bearing contributing to regenerate it from the marine intrusion.



Other solutions adopted in this building are: the use of the free-cooling system, cold and warm radiating ground, individualised air conditioning system for each space and management of the air conditioning and lighting systems based on presence detectors and computer control.

Commercial buildings

System of management of the facilities in a large commercial building in Barcelona

In the Barcelona-Glòries commercial centre a control and management system has been installed. This system allows to control, in unified and efficient way, the electrical consumption, the lighting system, the air conditioning, the low voltage distribution, the ventilation, the garden watering, the electricity-generating groups (used in the rush hours from consumption as auxiliary generators) fire-protection systems, cesspools and the elevators.

This centralised management system is helped by other more usual solutions: low solar factor glazing, free-cooling system to diminish the heat pumps operation at intermediate weather, the installation of time-lag switches in the auxiliary premises.

All these systems allow a power saving of 25% in relation to the electrical consumption initially forecast.

Thermal- photo-voltaic building, the Pompeu Fabra Library in Mataro, Barcelona.

The building that houses the Pompeu Fabra Library in Mataró has been designed with attention to reaching an optimal balance between energy saving, comfort, lighting, aesthetic and economy.



In order to achieve this objective photo-voltaic panels, formed by prefabricated multifunctional modules of great surface were integrated in the building.

This project has been given a subvention by the *Joule II* program. The project has served to show the possibilities that the European photovoltaic industry offers, and to show the different technologic possibilities using mono-crystalline cells, polycrystalline cells and of amorphous silicon cells in their opaque and semitransparent versions.

The infrastructure is formed by a photo-voltaic system installed in the facade. This system is made up of a semi-transparent multi-functional photo-voltaic modules, formed out of solar photo-voltaic polycrystalline silicon cells, and four rows of 37° inclined photo-voltaic skylights installed in the roof.

The building absorbs or gives energy to the network depending upon if its power consumption exceeds its power generating capacity or if its power generating capacity exceed its power consumption.

Another feature of the project is the use of the hot air obtained in the chamber formed between the solar modules and a transparent glazed wall. This hot air is used in winter as preheated air in the conventional heating system of the building as well as it is expelled outside of the building in summer. This thermal system allows a power saving upper than the 30%.

Other interesting good practice examples:

- Hospital of Vielha, Lleida.
- Dispensary of Perales de Tajuña, Madrid
- Music school in Almería.