PROJECT MONITOR

Commission of the European Communities

- Full height sunspaces provide solar heating to all 45 flats and contribute 32% to the net space heating load of the block.
- Active solar collectors and a heat recovery unit on the waste water, provide 60% of the water heating.
- Communal heating system uses heat meters for individual measurement of consumption and improved control.
- Energy saving measures include high levels of insulation and attention to cold bridging.
- Overall, the block produces an annual saving of around 50% of the primary energy used for space heating in a conventional design.

BARBARICINA

PISA
ITALY

Project Monitor is a series of case studies illustrating passive solar architecture in the European Community

APRIL 1988
Issue 19

- 2 Project Background, Site and Climate.
- 3/4/5 Design Details, Construction, Passive Solar Design, Operating Modes.
- 6/7 Performance Evaluation, Monitoring, User Response, Cost Effectiveness.
- 8 Project Information and Credits.

Project Background

This public housing scheme is a six storey apartment block, curved at one end and originally intended to be one of a pair. The 45 dwellings, which vary in size from 38m² to 80m², are designed for low rent occupancy and accommodate about 150 people.
The project was legally termed an "experimental housing scheme" due to the solar energy features incorporated within it. This entitled the client to special funding to cover the extra costs associated with the package of measures. Construction was completed in summer 1983 and the building was monitored over the 1985/86 heating season.

OBJECTIVES

The building was commissioned by IACP of Pisa (Local Public Housing Authority) for low-income people registered on their lists, mainly families.
The objective of the project was to demonstrate the feasibility and effectiveness of a package of energy saving and passive solar measures in a publicly owned and run housing estate. It was necessary to keep the operating modes simple and manually-controlled to suit the tenants.

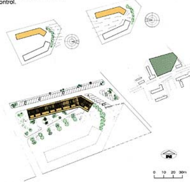
ENERGY SAVING FEATURES

The design aims to maximise useful solar gains in winter and minimise unwanted gains in summer. Natural ventilation is promoted throughout the year whilst unwanted air infiltration is kept to a minimum.
The energy saving features in the block are:

- Full height glazed balconies attached to the living rooms to capture direct solar gains and to provide additional living space.
- Roof-mounted active solar water heating collectors to provide domestic hot water and to preheat water for the space heating system.
- Increased insulation placed in the walls, in the soffit of the portico and in the loft, and the elimination of cold bridging, to reduce fabric losses.
- Draughtstripping throughout and double glazing on the north facade to reduce ventilation and fabric losses.
- Heat exchanger installed to extract heat from "clean" waste water.
- Individual thermostats and energy meters for the hot water supply and space heating system to enable direct payment and to increase occupant awareness and control.

SITE AND CLIMATE

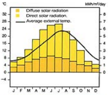
The site is in Barbaricina, on the outskirts of Pisa. The area is flat and only 7km from the sea. To the north of the site, a semi-rural landscape offers a distant view of Pisa's skyline framed by the Appuan Alps.
The climate is characterised by prevailing westerly winds in summer (2.1 m/s) and easterly winds in winter (2.6 m/s). The average maximum temperature in July/August is 27.7°C and the average maximum temperature in January is 2.8°C. There are 1380 degree days (17°C base). There is good solar access with no shading from the surrounding buildings and vegetation. A main road to the south of the plot, however, creates noise problems.



SITE PLAN
The layout chosen for the two apartment blocks would shelter the communal garden from easterly winds in winter, yet expose it to cooling westerly breezes in summer. As yet, only the block to the north of the plot has been built.

Design Details

CLIMATE (Pisa)



PLANNING

The architect in charge proposed a courtyard-like arrangement, based on the client's requirement for two apartment blocks on the same site. The two buildings would face each other along an east/west axis, enclosing a common open area. At the eastern end, the parallel blocks would curve towards each other at the same angle, creating a U-shaped layout to protect the garden from the prevailing winter winds. In addition, a shelter belt of trees would be planted at this end. At the opposite end, there would be no barrier to the summer westerly breezes.

Unfortunately, the entire scheme is yet to be completed; only one block has been built to the north of the plot. This block looks strange because it is set so far back from the main road, and in front of it the land is exposed to the elements rather than sheltered from them.

A decision is still to be made about whether the second building will complete the original design, or whether a conventional building will be erected instead.

DESIGN DETAILS

The building has a portico at ground level in which the boiler room, the communal areas and the three entrances to the residential blocks are situated. The pitched roof is angled at 40° to accommodate the solar collectors. This is unusual in the area and therefore very noticeable.

A continuous transparent skin covers the south facade, creating full height glazed balconies, one for each flat. The elevation is an irregular rhythm of pilasters, the spacing of which corresponds to the different frontage sizes of the flats. The juxtaposition of solids and voids gives order to the facade and helps to define the glazed area of the balconies.

The north facade, with limited openings, is very distinctive due to the stepped arrangement of the windows in the stairwells. The plan is very compact, and the narrow elongated shape of the building increases the solar exposure and allows good solar penetration into the living spaces. The living room and principal bedrooms are positioned on the south side, with kitchens and bathrooms to the north. Internal insulating roller blinds are fitted to the north facing bedrooms and kitchens. All the flats have double exposure apart from the smaller ones immediately opposite the stairs and lift block. These have windows only on the south side. In addition, the landings, which are separated from the 'cold' stairwells, are designed to act as buffer spaces.

CONSTRUCTION

Traditional methods of construction were employed. The load bearing column and beam structure is concrete and the north, east and west perimeter walls are made of

Fully glazed south facade creates balconies for each flat across the full width. All the windows have pre-coated red steel frames and are draughtstripped.

Design Details

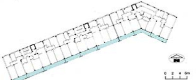
concrete panels with an external insulating layer of 40mm rigid polyurethane boards. This form of cladding is easy to assemble, reduces thermal bridging, particularly along column/beam structures and around openings, and has the effect of maintaining the thermal inertia on the inside of the dwellings.

The first floor is on pilotis so there is increased insulation in the soffit to reduce downward heat flow. The loft space also has extra insulation to reduce heat losses from the flats on the top floor. The concrete slab floors have a thermal break where the floor of the balcony is in contact with the internal floor of the flat.

In winter, the flats immediately above the portico were not warm enough; more insulation was needed in the floors. On the top floor, the flats had problems with water penetration from the walkway running parallel to the solar collectors. The smaller flats (three per floor) gave rise to many complaints particularly in summer. In these, the absence of windows in both the kitchens and bathrooms leads to poor cross-ventilation and makes the flats stuffy and hot. Condensation problems occurred in the unheated stairwells, giving rise to mould growth.

The spacing of the pilasters on the south facade corresponds to the different frontage sizes of the flats.

The arrangement of the windows in the stairwells gives the north facade its distinctive character.



The plan is very compact, and the narrow elongated shape increases solar exposure and allows good solar penetration into the living spaces.

View of the apartment block from the north east, the main part of the building is just visible on the left. The 40° roof pitch to accommodate the solar collectors, is most unusual and very noticeable.

PASSIVE SOLAR DESIGN

The building has been developed along passive solar principles and the integration of sunspaces is fundamental to the design. Each flat has a sunspace across its full width created by a wall of single glazing over the entire south facade (640m²). The sunspaces are all 1.2m deep, but vary in length according to the flat size.

Between the living room and the

sunspace, the glazed doors are fitted with PVC roller blinds. The external sunspace glazing is full height (2.7m), the lower part (ie. the balcony parapet) is wired glass whilst the upper part has sliding windows. Reflective venetian blinds are mounted internally.
The depth of the balcony allows the full penetration of winter sunshine into the living spaces, but reduces solar penetration in summer. Natural lighting is good due to both the extensive area of transparent surfaces and the limited depth of the rooms. Glare can be controlled with the roller blinds and the venetian blinds.
The space provided is a habitable extension to the living/dining room throughout the year. However, because of its narrowness, it is mostly used for drying laundry and to provide emergency storage space, in much the same way that balconies are used throughout Italy.

AUXILIARY HEATING SYSTEM

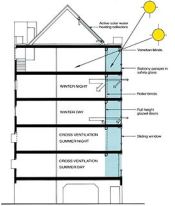
A heat exchanger has been installed to recover heat from "clean" waste water from the kitchens and baths, and there is an active solar system which consists of 180m^2 of roof-mounted solar water panels. Thus three sequential heat exchanges can be used in the production of domestic hot water. These are:- with clean waste water collected in a tank; with solar-heated water in a storage tank; and finally with the boiler. Water for the space heating system is preheated by solar-heated water if any is available. There are two gas oil fired boilers for the apartment block for both the space and water heating, with an overall capacity of 160kW. Heat meters in each flat measure the energy consumption.

Roller blinds are fitted to the glazed doors onto the sunspace, and reflective venetian blinds are mounted behind the external glazing. Both can be used to reduce glare.

Initially, excessive hot water consumption by the residents (approximately 20% higher than predicted) further reduced the already small contribution from the active solar system to the space heating demand. Through discussion with the tenants, this situation has improved.

OPERATING MODES AND CONTROLS

The passive controls are extremely simple, the occupants merely open or close the windows, lift or lower the roller blinds and regulate the venetian blinds. These operations are all manual.



Section showing operating modes

Performance Evaluation

MONITORING

Monitoring took place over the 1985/1986 heating season (November to March inclusive) to measure the following:
- External conditions: temperature,relative humidity, wind velocity, solar radiation on a horizontal surface;
- Internal conditions: temperature, relative humidity;
- Consumption of auxiliary fuels;
- Performance of the active solar system (to determine its contribution to the space and water heating loads).

Radio-transmitted signals were received by a central unit which stored and processed them.

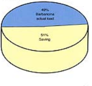
Internal view of the glazed balcony in a corner apartment. The upper part of the glazing consists of sliding windows whilst the lower part forms the balcony parapet.

USER RESPONSE

On the whole, the tenants are quite happy, the main exceptions are those people in the smaller flats, where adequate ventilation is difficult to achieve. The passive controls are extremely simple and very similar to those Italians would normally employ in a traditionally-built house.
The occupants dislike the outward opening north facing windows which are most unusual in Italy. This type of window did not prove to be very suitable for multistorey housing, especially on a windy site such as Barbaricina.
The inhabitants would also have appreciated a larger sunspace area, but unfortunately the sizes were pre-defined by building standards and norms. In Italy, the permissible volume of public housing is constrained, as is the ratio between the non-residential floor area (sunspaces, balconies, halls, porticos, corridors, stairwells, etc) and the heated floor area. To achieve the required low ratio, small, and consequently less useful, sunspaces are specified throughout Italian passive solar designs.

COMPARISON WITH CONVENTIONAL DESIGN

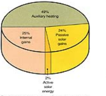
226 110kWh (814GJ) of primary energy would be required to heat the apartment block if it had been built to a conventional design.



The actual primary energy consumed for space heating was 110 840kWh (399GJ), a saving of 51%.

CONTRIBUTION TO TOTAL SPACE HEATING REQUIREMENT

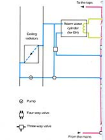
180 830kWh (651GJ)



Passive solar gains contributed 24% to the gross space heating load and active solar heating another 2%.

PERFORMANCE OF SOLAR DESIGN

- The design of the apartment block has produced a 51% saving in the consumption of primary energy for space heating when compared to a conventional building.
- Useful solar energy captured by the glazed balconies contributed 32% to the net annual space heating load. Another 3% was supplied by the active solar system, once the hot water consumption had stabilised.
- Active solar collectors and the heat recovery unit provide 60% of domestic hot water.

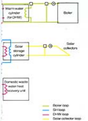


Schematic showing space heating and domestic hot water systems.

COST EFFECTIVENESS

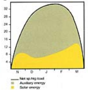
The overall construction cost for the building in 1983 was L 1626M. The passive solar features cost L 200M, and the extra insulation another L 60M. The cost of the space and water heating system was about L 150M, of which just over half was associated with the active solar part. Hence, approximately 21% (L 340M) of the total building costs was spent on energy saving measures and solar technology applications.

The grants obtained met approximately 25% of the costs associated with the additional insulation measures and the passive and active solar designs. Using the 4% discount rate for Italian public sector buildings, the payback period based on energy savings alone is about 20 years. A full assessment of the sunspaces would need to include aspects such as the value of the increased space, to which a cost cannot readily be ascribed.

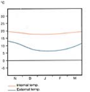


NET MONTHLY SPACE HEATING DEMAND AND SUPPLY

Whole block, 45 dwellings

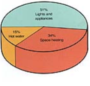


MONTHLY AVERAGE TEMPERATURES



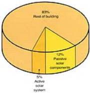
AUXILIARY FUEL USED (PRIMARY ENERGY)

The total primary energy used in the apartment block was 328 060kWh (1181GJ)



COST OF BUILDING AND SOLAR ON -COST

The apartment block cost L 1626 M to build in 1983.



Approximately 21% of the total building cost was spent on energy saving measures and solar features, of which grants met about 25%.

PROJECT DATA

Building

Total volume of housing scheme		11 360	m³
No. of floors		5	+ portico
No. of flats		45	
Total floor area		3983	m² + portico
Total roof area		1039	m²
Windows:	total area	547	m²
	south area	472	m²
	north area	75	m²

Glazed balconies

Volume	1070	m³
Floor area	396	m²
Glass area	640	m²

Thermal Characteristics

U value:	roof	0.55	W/m²K
	floor	0.56	W/m²K
	external walls	0.51	W/m²K
	windows	2.90	W/m²K
	windows with night insulation	2.10	W/m²K
Mean U value		1.48	W/m²K
Global heat loss coefficient		5955	W/K

Infiltration rate	0.5	ac/h
External design temperature	0	°C
Heated floor area	2685	m²
Heated volume	9378	m³
Surface area	4000	m²
Surface to volume ratio	0.43	
Net heat load (heated area)	33	kWh/m²

Site and Climate

Altitude		11	m
Latitude		43° 41'	N
Longitude		10° 24'	E
Average ambient temp:	annual	14.2	°C
	Jan	6.6	°C
	July	22.8	°C
Degree days (base 17°C)		1380	days
Global irradiation on horiz		1416	kWh/m²
Sunshine hours		2350	hr/yr

Costs (1983 prices)

Total cost	L 1626 M	1 205 000	ECU
Passive solar system	L 200 M	148 000	ECU
Active solar system	L 80 M	59 000	ECU

Information

TYPES OF PASSIVE SOLAR SYSTEMS

Project Monitor case studies are published in Directorate General XII of the Commission of the European Communities to show how architects and other building designers can successfully apply passive solar principles to produce attractive energy efficient buildings.

Further information or copies of case studies can be obtained from J Owen Lewis, School of Architecture, University College Dublin, Richview, Clonskeagh, Dublin 14.

CREDITS

Client
IACP Pisa (Istituto Autonomo Case Popolari)
Via Fermi 4
Pisa

Architect
Solar Energy Developments
(Now Michaelis, Francis Le Roith Architects Ltd)
Bay 8
16 South Wharf Road
London W2 1PF

Project Management
IACP Pisa

AGIP Petroli
Via Laurentina 437
00144 Roma

APRE SpA
(Azienda Per il Risparmio Energetico)
Via V Brancati 64
00144 Roma

Energy Consultants
AGIP Petroli
APRE SpA

Services Consultants
AGIP Petroli
APRE SpA

Building Contractor
SELT (Pisa)
Via Di Nudo 36
Pisa

Services Contractor
APRE SpA

Monitoring Organisation
AGIP Petroli
APRE SpA

Financial Support
CER (Comitato Edilizia Residenziale)
presso Ministero Lavori Pubblici
(Ministry of Public Works)
Piazzale Porto Pia
00100 Roma

PROJECT MONITOR PARTICIPANTS

Project Director
Theo C Steemers
Directorate General XII for Science Research & Development
Commission of the European Communities
Wetstraat 200
1049 Brussels Belgium

Project Coordinators
John Doggart and Simon Burton
The ECD Partnership
11-15 Emerald Street
London WC1N 3QL

Belgium
André de Herde & Anne Minne
Centre de Recherches en Architecture
Université Catholique de Louvain
Place de Levant 1
1348 Louvain-La -Neuve

Denmark
Poul Kristensen
Esbensen
Havnegade 41
1058 Copenhagen K

France
Eric Durand
Service Habitat et Tertiaire
Agence Française pour la Maîtrise de l'Energie
Avenue Emile Hugues
06565 Valbonne Cedex

Germany
Ulrich Luboschik
IST Energietechnik GmbH
Ritterweg 1
7842 Kandern-Wollbach

Ireland
J Owen Lewis
School of Architecture
University College Dublin
Richview
Clonskeagh
Dublin 14

Italy
Gianni de Giorgio e Paola Fragnito
Progettazione e Ricerca
C so Como 9
20154 Milan

Netherlands
Ton Trijssenaar
Provinciaal Bureau Energiebesparing Noord Holland
Postbus 633
2003 RP Haarlem

Portugal
Eduardo Maldonado
INEGI
Faculdade de Engenharia
Rua dos Bragas
4099 Porto Codex

Spain
Albert Mitjà i Sarvisé
Direcció General d'Energia
Departament d'Indústria i Energia
Generalitat de Catalunya
Av Diagonal 449-7e
08036 Barcelona

PROJECT MONITOR SERIES

1	**Giffard Park** Milton Keynes	Housing
2	**Maison Quinet** Nandrin Belgium	House
3	**Polysportive** Esterri d'Aneu Spain	Sports Hall
4	**Boegehusene** Greve Denmark	Housing
5	**Liceo** Casalpalocco Italy	School
6	**Am Lindenwäldle** Freiburg Germany	Housing
7	**Maison Monchoux** Toulouse France	House
8	**JEL** Stockport UK	Factory/Offices
9	**Casa Termicamente Optimizada** Porto Portugal	Housing
10	**La Salut** Barcelona Spain	Housing
11	**Les Basses Fouassieres** Angers France	Housing
12	**Briarcliff House** Farnborough UK	Housing
13	**Lawrie Park Road** London UK	Housing
14	**Marostica** Marostica Italy	Housing
15	**Hoofddorp** Hoofddorp Netherlands	Housing
16	**Lievre D'Or** Dreux France	Housing
17	**Baggesensgade** Copenhagen Denmark	Housing
18	**Ecole Primaire deTournai** Tournai Belgium	School
19	**Barbaricina** Pisa Italy	Housing
20	**Lou Souleu** Avignon France	Housing
21	**Arona** Lake Maggiore Italy	Housing

Future Issues
Further projects, including schools, offices, factories and housing, will be published in the next year.