Retrofitting of the Rural and Surveying Engineering Building, N.T.U.A., Athens, Greece

GR3

1 Photos

Figure 1: *Left:* South view of the building before retrofit
Above: View of the north side before retrofit

2 Project summary

The aim of the project is to integrate simple energy conservation and passive solar measures into the retrofitting process of an old building, in order to achieve better thermal and visual comfort for the users as well as lower energy consumption and environmental impact of the building.

Project features

The retrofit measures deal with both the building shell and the infrastructure, such as, improvement of the U value of external walls and windows, reduction of infiltration, use of shading devices and day lighting components, night ventilation, improvement of day lighting levels, control of space heating and artificial lighting and microclimate improvement.

3 Site

Athens, the capital of Greece is located on the Saronic gulf in a valley close to the Hymettus Mountains and the port of Piraeus.
Latitude: 37.58°N, longitude: 23.47°E, altitude: 219 m.
Climate: Mediterranean.
Mean annual temperature: 18°C, mean winter temperature: 10°C.

4 Building description /typology

4.1 Typology / Age

Central corridor university building, multi-storey, (1965).

The Rural and Surveying Engineering building is one of the oldest buildings on the 'new' campus of the National Technical University of Athens. It has a total covered area of 8.550m^2 and it is a long, three storey building with mostly N–S orientation. The building is composed of classrooms, offices, laboratories, two auditoriums and a common room and it badly needed retrofitting both in terms of building envelope and services. Two extensions have recently been added to the old building, sheltering additional classrooms and offices. The building is constructed of reinforced concrete structure and brick infill walls with no insulation. Windows are single-glazed.

4.2 General information

Year of construction:	1965
Year of renovation (as described here):	2003
Total floor area (m^2):	8,550 m^2
Number of students:	900
Number of classrooms:	16
Typical classroom size (m^2):	50 m^2
Number of students per classroom:	50

4.3 Architectural drawings

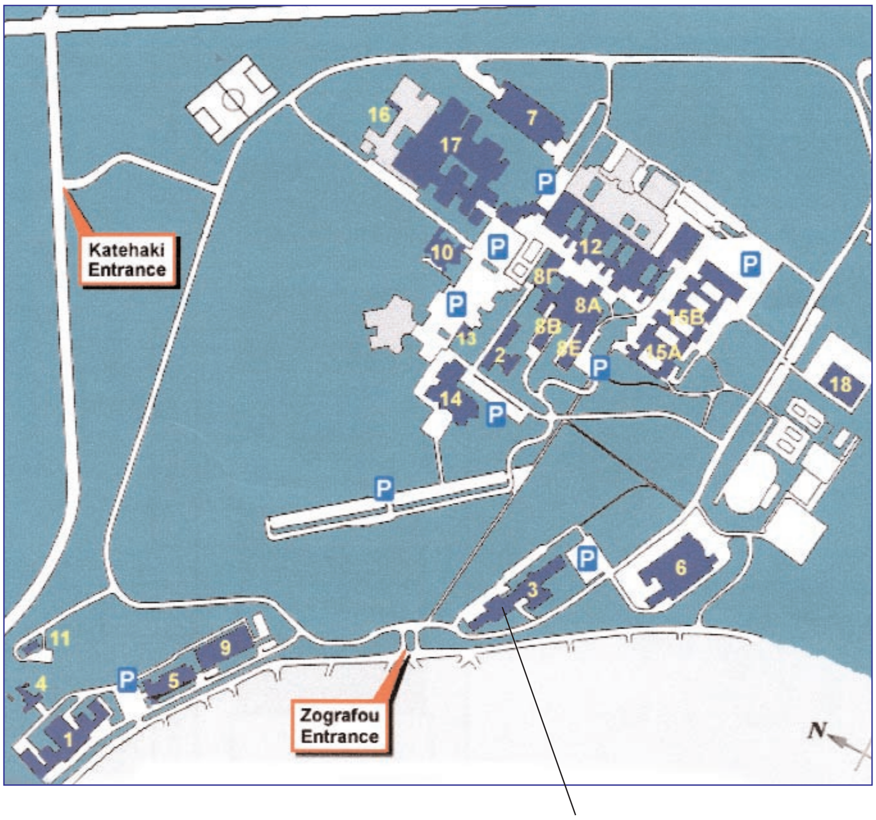


Figure 2: National Technical University of Athens Zografou campus

KEY
1 Civil Eng. Labs (Concrete, Transportation)
2 Physics
3 Rural and Surveying Eng.
4 Acoustic Lab.
5 Civil Eng. (Hydraulics Lab.)
6 Dormitories
7 Naval/Marine Eng.
8 General Sciences
9 Civil Eng. (Lab. of Harbour Works)
10 Computer Center
11 Aseismic Research Lab.
12 Chemical Eng.
13 NMC/NOC
14 Administration
15A Mining and Metallurgical Eng.
15B Electrical & Computer Eng.
16 Thermal/Turbomachines Lab.
17 Mechanical Eng.

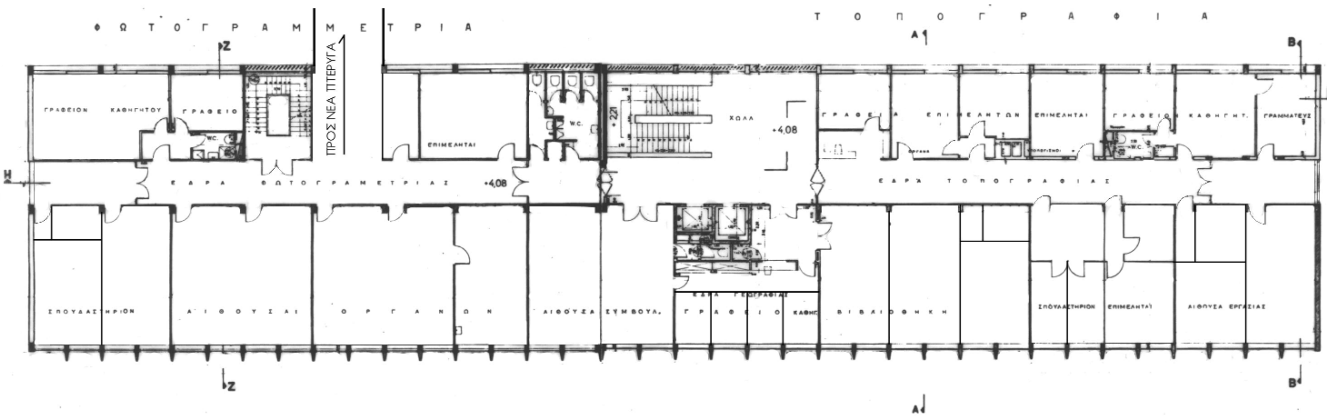


Figure 3: Typical floor plan of the building

5 Previous heating, ventilation, cooling and lighting systems

- *Heating system:* Central boiler *Fuel:* oil
- *Ventilation:* Natural ventilation
- *Cooling:* Local split type heat pumps (for offices and laboratories)
- *Lighting:* Fluorescent centrally or locally controlled (~17W/m^2)

6 Retrofit energy saving features

6.1 Energy saving concept

Following an auditing and survey procedure, during which temperature and daylighting measures were recorded in representative spaces of the building, and questionnaires were distributed to the users, that the following measures of needed to be carried out immediatly:

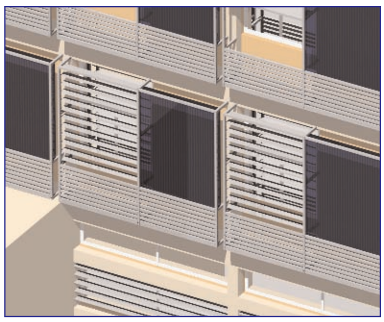
6.2 Building

- Improvements to external wall insulation
- Improvements to U-Value of openings
- Reduction of infiltration through window frames
- Use of shading devices
- Use of simple passive solar systems
- Use of daylighting components

Section of the South façade before retrofitting

6.2 Heating/Cooling

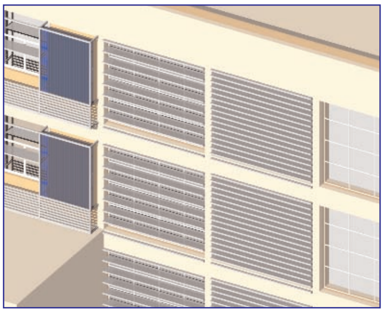
- Control of space heating
- Control of air-conditioning
- Improved efficiency of fans or pumps
- Insulation of ducts and pipes
- Improved heating and cooling supply system
- Replacement of filters and air humidifier unit (ahu).
- Reduced hot water temperature



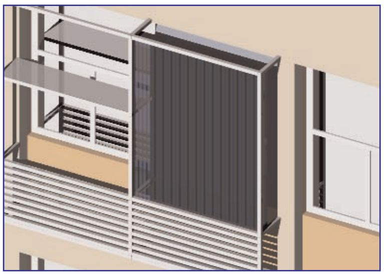
Combination of retrofitting interventions - shading devices and thermosiphonic panels

6.3 Ventilation

- Natural ventilation
- Night ventilation
- Ceiling fans
- Other ventilation devices
- Evaporative coolers
- Solar chimneys
- Ground cooling
- Thermal mass
- Microclimate improvement



Combination of retrofitting interventions - light shelves, shading devices and PV panels



Combination of retrofitting interventions - light shelves and PV panels

6.5 Lighting
- Reduction of indoor illumination levels
- Task lighting
- Control of indoor lighting equipment
- Improved effectiveness of luminaries
- Use of efficient lamps or ballasts
- Control of outdoor lighting

6.6 Other environmental design elements
- P.V. systems
- Other energy sources
- Microclimate improvement

7 Resulting Energy Savings
Several scenarios were trialled for energy performance situations using the TRNSYS 14.2 software. The results below present the energy savings obtained for heating and cooling.

Heating:
Present energy consumption for heating: 49.1 kWh/m^2.
Following a combination of simple energy conservation measures the energy consumption for heating will be reduced to 26.5 kWh/m^2 a reduction of ~ 46%, as calculated using the TRNSYS program.

Cooling:
Present energy consumption for cooling: 41.5 kWh/m^2.
If a combination of retrofitting scenarios based on 6.1, 6.2 and 6.3 are used the energy consumption for cooling is reduced to 11,1kWh/m^2. A reduction of 73.3% of energy required for cooling will be achieved, as calculated using the TRNSYS program.

Electrical Energy:
Electrical energy for lighting is estimated at 17W/m^2 for classrooms, 18.2 W/m^2 for offices and laboratories and 14 W/m^2 for corridors and service spaces.
The implementation of energy conservation measures for artificial lighting proposed in this project, combined with a reduction of indoor illumination levels and the use of improved lighting controls will contribute to a reduction of electrical energy consumption of approximately 45%.

8 User evaluation
Indoor air quality:

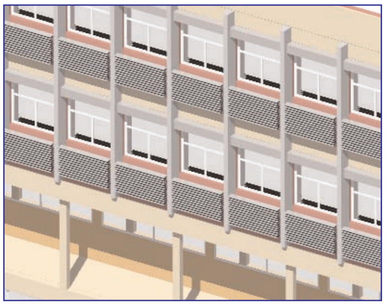
In general terms:	Moderate to low.
Dry, humid, smelly, etc.:	Stuffy in some spaces
Irritations (eyes, nose, throat, skin, ..)	None.
Quality of daylight / artificial light:	Low daylighting in some spaces. Artificial light turned on permanently in common areas.
Sound quality:	Moderate
General feeling:	Old building needs improvements.
General well being: Headache:	None.
Difficult to concentrate:	No.
Technical functionality:	Low.
Architectural quality:	Moderate.

9 Renovation costs

The total cost is estimated at about €45,000 for retrofitting measures on the building shell and €90,000 for heating/cooling systems improvements.

10 Experiences/Lessons learned

A combination of some or all of the measures stated would be the most efficient strategy to follow if the initial cost is not a problem – for instance if a refurbishment of the building is decided. Some low cost measures, however, especially those dealing with electric lighting improvements and passive cooling techniques, can have a considerable impact on energy efficiency and comfort even if applied one at a time. Such measures usually involve control and maintenance schemes of lighting and hvac systems.



Retrofitting interventions on the North façade of the building.

10.1 Impact on indoor climate

It is expected to be considerable since the users will be able to control natural ventilation, lighting and heating/cooling of their own spaces.

10.2 Practical experiences of interest for a broader audience

The use of exterior shading devices can prove cumbersome and hard to operate by the users if their size, weight or mechanisms make them difficult to handle. In this case users actually preferred to keep shutters closed during the day as well as turning artificial lighting on. Therefore this should be taken into account whenever moveable shading/insulating devices are used.

10.3 Resulting design guidance

The analysis presented above shows that retrofitting measures such as those described above would usually cover a considerable percentage of heating, cooling and lighting needs for an educational building, while improving thermal and visual comfort for its users

11 General data

11.1 Address of project

9 Heroon Polytechniou NTUA Campus, Athens, Greece

11.2 Date of report / revision no.

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12 Acknowledgements

Architects: Euphrosyne Triantis, Flora Bougiatioti, Aenias Economou.

Energy systems: A. Argyriou, S. Kontoyiannides
National Observatory of Athens
Institute of Environmental Research & Sustainable Development

Author: Euphrosyne S. Triantis

13 References

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