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HEAT-INSULATION SYSTEMS FOR EXTERNAL PARTS OF BUILDINGS

DP/YUC/83/010

YUGOSLAVIA

Terminal report

Prepared for the Government of Yugoslavia by the
United Nations Industrial Development Organization acting
as executing agency for the United Nations Development Programme

Based on the work of Heikki A. Ranki, chief technical adviser,
in co-operation with staff members of the Institute for
Material Testing and Construction, Ljubljana

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United Nations Industrial Development Organization
Vienna

Explanatory notes

The monetary unit in Yugoslavia is the new dinar (ND).

References to dollars ($) are to United States dollars.

Mention of the name of firms and commercial products does not imply endorsement by the United Nations Industrial Development Organization (UNIDO).

ABSTRACT

The project "Heat insulation systems for external parts of buildings" (DP/YUG/83/010) was approved by the United Nations Development Programme (UNDP) in October 1983, and the United Nations Industrial Development Organization (UNIDO) was designated as the executing agency. The UNDP input was $100,000 and the government input ND 7,000,000 in kind. The chief technical adviser was assigned for a total of two man-months, split into four missions. Project work started on 1 November 1983 and ended in November 1987.

The development objective of the project was to propose measures for the reduction of energy consumed for the heating of buildings, because the latter represents an important percentage of the total energy consumption, and thus to contribute to reducing Yugoslavia's heavy dependence on imported energy. The immediate objective was to determine optimal thermal insulation systems for buildings, to evaluate pertaining regulations, and to propose amendments to those regulations in the light of the findings of the project.

Emphasis was therefore on research work, which was carried out by the government implementing agency, the Institute for Material Testing and Construction at Ljubljana, and most of the project budget was used for the acquisition of modern equipment, including thermographical equipment, and for study tours of the research staff of the Institute. These UNDP/UNIDO inputs enabled the Institute to accomplish research on a higher technical level and will ensure a future successful operation of its laboratory for thermal investigations.

The results of the research work are documented in 15 studies, which also contain recommendations for changes of the standards pertaining to the thermal protection of buildings.

The main recommendation is addressed to the Federal Bureau of Standardization, urging it to verify the findings of the project on a wider scale and to change the regulations accordingly, so that they can be enacted as soon as possible.

CONTENTS

INTRODUCTION

A. Project background and official arrangements

Yugoslavia depends heavily on imported energy which adversely affects its balance of payments. A number of measures are being taken to improve that situation. As the energy required for the heating of buildings represents an important percentage of the total energy consumption, substantial savings could be made by optimum thermal protection. It was estimated that by improving the thermal insulation of buildings and by introducing more rational heating methods such savings could be in the order of 30-40 per cent.

Following a request by the Government of Yugoslavia, in March 1983, for assistance in its five-year research programme in the area of optimal heat insulation and rational heating of buildings, the project "Heat insulation systems for external parts of buildings" (DP/YUG/83/010) was approved by the United Nations Development Programme (UNDP) in October 1983, and the United Nations Industrial Development Organization (UNIDO) was designated as the executing agency. The project was planned to last for 3.5 years and was extended by half a year. The UNDP input was $100,000 and the government input ND 7,000,000 in kind. The government implementing agency was the Institute for Material Testing and Construction, Ljubljana. The chief technical adviser (CTA) was assigned for a total of two man-months, split into four missions. Project work started on 1 November 1983.

B. Objectives and logic of the project

Because of the precarious energy situation described above, it was foreseen in the project document to analyse the possibilities of attaining a kind of thermal protection of external building elements that would be optimal with regard to numerous parameters, among which the price of energy was one of the most important. It was further envisaged that by enacting regulations on an optimal thermal protection of buildings, a substantial reduction of energy consumption would be attained, which would contribute to the ultimate objective of reducing Yugoslavia's dependence on imported energy.

I. ACTIVITIES CARRIED OUT AND OUTPUTS PRODUCED

The work performed in the course of the project is described in the following project progress reports:

	Period covered
Report No. 1	1 November 1983-1 May 1984
Report No. 2	1 May 1984-1 January 1985
Report No. 3	1 January 1985-1 July 1985
Report No. 4	1 July 1985-1 January 1986
Report No. 5	1 January 1986-1 July 1986
Report No. 6	1 July 1986-10 March 1987

The most important activities foreseen in the project document to achieve the project objectives were to:

(a) Determine those external elements of buildings which are being mostly used in the Socialist Republic of Slovenia;

(b) Analyse and evaluate existing heat insulation systems in the light of valid regulations;

(c) Research into and recommend optimum thermal protection for external wall elements of buildings and elaborate calculation models;

(d) Apply to and evaluate such optimum thermal protection on external wall elements which are mostly used in Slovenian building construction;

(e) Propose changes to existing regulations based on the findings under (d) above.

The cited activities were all performed within the foreseen terms, and the project activities were completed by the end of 1987. Intensive use was made of the equipment which had been supplied to carry out the required research work, of the opportunities for local experts to visit well-known foreign institutes and of the co-operation with the international experts.

The project team was constituted mainly from the following members of the Institute for Material Testing and Construction:

Jože Boštjančič, national project director
Matjaž Zupan
Fedor Škerlep
Jelka Lebar
Peter Žargi
Peter Lebar
Franjo Vugrinec

The team collaborated with the CTA, who visited the project four times, twice in 1984, and once in 1985 and 1987. In 1985, Andreas Güttermann, expert in the use of computers for building-energy calculations, was fielded by UNIDO to assist in the project work.

As a great deal of experimental research work was foreseen in the project, and since the equipment of the laboratory for thermal investigations was rather poor, the equipment received through the project enabled the Institute co

accomplish research work on a high technical level. The equipment was chosen, in co-operation with the CTA, in such a way that it can also be successfully used in the future work of the laboratory.

Of special importance for the project, as well as for the future work of the laboratory, is the thermographical equipment provided by UNIDO, because with its help excellent results for the development of thermal insulations of building constructions can be achieved. A list of all equipment supplied to the project is given in annex I.

The study tours foreseen in the terms of reference of the project were most beneficial for local experts as it enabled them to visit a number of leading European institutes in the field of thermal insulation of buildings. In that way the team got a good overview of recent trends in this field and a number of important connections were established which should be profitable for the future work of the Institute. The study tours are listed in annex II.

The extent of the experimental work undertaken and the results achieved are documented in 15 separate studies. The most important among them is the last one, which contains proposals for changes of the existing regulations and covers all the elements anticipated as project activities. Summaries of those 15 studies are present below.

1. Analysis of external parts of buildings on the basis of regulation JUS U.J5.600 (1984)

Regulation JUS U.J5.600 defines the minimal standards that external parts must comply with. These are thermal transmittance, steam diffusion, insulation and time-lag. As a basis for the evaluation of the quality of that regulation, the most commonly used external parts of constructions that comply with the regulation were chosen.

2. Thermal insulation of light external walls (1984)

Seven wall structures meeting the criteria of summer thermal stability according to the JUS U.J5.600 standard were tested under summer thermal load. It was found that the insulation was such that no additional criterium of temperature lag was necessary and it could, therefore, be omitted in a new edition of the mentioned standard.

3. Suggestions for changes in regulations on the thermal insulation of buildings (1984)

On the basis of long-term experience, suggestions for changes of regulation JUS U.J5.600 were prepared. The essential changes concern the reduction of transmission heat losses (of approximately 30 per cent) and the use of bigger transparent parts on the facades, where the passive use of solar energy is of great interest.

4. Building elements as an element of thermal insulation - regulations and quality of products (1984)

As part of the research work, regulations dealing with thermal properties of building elements were reviewed and appraised, as well as the quality of the actual fittings being produced at the time. This study should serve as a guideline for a further development of building elements.

5. Optimization of thermal insulation of external parts of buildings (1985)

This report deals with the optimal thermal insulation for the outer parts of buildings, taking into account economical, technical and meteorological data. Samples of calculations are made for two residential units, a family house and a flat in a big residential building.

6. Thermographical investigations of thermal insulation of external parts of buildings (1985)

A large number of building elements of different types were investigated by thermography. It could be proved that a lot of irregularities occur in the insulation, some of which have serious consequences. The study contains thermographic images of different building systems showing typical insulation differences and indicates the main causes for the irregularities.

7. Proposals for the development of window elements to reduce heat losses - part I (1985)

The heat-insulating properties of window elements presently being manufactured in the Socialist Republic of Slovenia are surveyed. On the basis of preliminary studies, supported by the findings of recent investigations described in pertaining technical literature, it is proposed to develop standard window elements for the passive exploitation of solar radiation, which should, at the same time, be fitted with devices providing additional temporary thermal insulation, as well as with shading devices.

8. Preparation of meteorological patterns for research in thermal protection and rational heating of buildings - part I (1985)

Until now, the available sources of meteorological data in the Socialist Republic of Slovenia have not been systematically exploited in such a form that it could serve as a basis for the preparation of meteorological patterns, which in turn can be used for research in the field of thermal protection and heating of buildings.

After exploring different approaches, it was decided that the most suitable method for a systematic and realistic representation of the above-mentioned data was to choose a so-called "normal meteorological year". The first part of the study concentrated on Ljubljana.

It is hoped that the data represented in that way will be of great practical value, not only for civil engineering and heating techniques, but also in other areas where such meteorological patterns will facilitate decision-making.

9. Study on thermal losses due to ventilation (1985)

This research study deals with the status of existing regulations in the field of ventilation. Different types and elements of ventilation were investigated on a theoretical basis for the calculation of air-flow through the external elements of buildings.

The air-leakage through windows and balcony doors had been measured and recorded over many years, in the laboratory as well as in-situ, and based on those results the air-tightness of building elements was established. The average intensity of ventilation of rooms was measured. Energy losses due to ventilation were calculated for different types of buildings, and their share in the total energy loss was established.

10. Proposals for the development of window elements to reduce heat losses - part II (1986)

A prototype window with a simplified window seal, assuring a perfect air and water tightness was developed and tested within the context of this research project. The same results were obtained after accelerated exposure to weathering of the prototype. In spite of some air-leakage, the temperature distribution, according to the thermographical readings, was favourable, and there is no danger of freezing in the area of the seal. A more universal design for a steel frame that would ensure an efficient sealing, should be developed.

11. Preparation of meteorological patterns for research in thermal protection and rational heating of buildings - part II (1986)

In the second part of that research work meteorological data were gathered for the area Maribor - Tezno and Koper - Portorož. The data are stored on a computer tape and include hourly values for temperature, relative humidity, duration of insolation, wind direction and velocity, and for Koper also global solar irradiation.

12. Investigation of dynamic processes in waterproofing roof systems - part I (1986)

The purpose of this research was to study the causes for the cracking and folding of bitumen waterproofing membranes on build-up roofs. In the first part the problems were determined which will have to be observed in the second part, with the aim of explaining the processes occurring in the waterproofing membranes and of investigating them. The relative temperature deformation of most bitumen tapes produced in the Socialist Republic of Slovenia was measured.

13. Thermal protection of existing buildings and possibilities for its improvement (1986)

The accuracy of thermographical surface temperature measurements depends on several factors. The most important among them are different emission rates, the radiation of surrounding objects and the radiation and absorption of the atmosphere. The methods for emissivity measurement and for the elimination of disturbing influences during thermographical temperature measurement are described. The study constitutes a first step towards progressing from qualitative to quantitative thermographical measurement.

14. Analysis of thermal losses of buildings by means of thermography (1986)

In this study the basic facts about surface temperature measurement by means of infra-red light are explained. The effects of emissivity, the distance between the object and the detector and the angle of detection in the measurement were determined. A series of measurements was made on different buildings and typical irregularities are described. The future development of quantitative measurements is discussed.

15. Recommendations for changes in regulations on thermal insulation of buildings based on optimal thermal protection (1987)

In this report the results of research work and analyses carried out under the project "Heat insulation systems for external parts of buildings" are summarized and recommendations are made for changes in regulation JUS U.J5.600, based on optimal thermal insulation. It includes specifications for the construction of the most commonly used elements (walls, roofs, ceilings) that correspond to the proposed regulations.

II. ACHIEVEMENT OF IMMEDIATE OBJECTIVES

Parallel to the project work, preparations were made to change the standards on thermal protection of buildings in the Socialist Republic of Yugoslavia. The Institute has taken an active part in these proceedings, supported by the results of the research work performed until then. In the new standards some of the findings of the project will be incorporated which should contribute to energy savings in the years to come. However, the new standards, unfortunately, do not yet contain the final recommendations for an optimal thermal protection of external wall elements which emerged from this project. These results, together with the final proposals for the change of the regulations, were submitted to the Federal Bureau for Standardization with the recommendation to legalize them as soon as possible.

III. UTILIZATION OF PROJECT RESULTS

The new standards to be issued will tighten up the requirements for thermal protection of buildings and thus have a direct influence on energy saving. The recommendations for optimum thermal protection of buildings resulting from the present project may be legalized in one or two years. Nevertheless, the existence of recommendations will contribute to a better management of energy, because investors, designers and contractors who are energy-conscious will aim at achieving an optimal thermal protection and make use of the proposals elaborated by this project.

IV. FINDINGS

The research undertaken has revealed that the maximum allowed coefficients of thermal transmittance of external wall elements of buildings, as required by the existing regulations, considerably exceed the optimal ones. In numerous thermographical tests it was found that, because of intensive and wide heat conducting bridges, the thermal insulation of the buildings was substantially (in some cases two times) lower than the foreseen or the declared one.

V. RECOMMENDATIONS

The proposed changes of the regulations should be verified, as soon as possible, on a wider Slovenian or Yugoslav level, corrected if necessary, and legalized. The Federal Bureau for Standardization should proceed with the standardization without delay in order to increase energy savings immediately. Until the new regulations will be enacted, investors, designers and contractors should apply the criteria elaborated for an optimal thermal protection when designing thermal insulations of buildings. The material generated by this project will be useful in their work. After legalization of the new regulations, their practical implementation will have to be ensured.

Annex I

EQUIPMENT SUPPLIED TO THE PROJECT

Quantity	Unit	Description
1	each	CM 11 pyrometer, complete with screen and levelling screws No. 1305-952
1	each	Hygrophil, type 4455-D, including battery and recharger
1	each	Thermophil intra, type T 203
1	each	T 1 063 radiation probe
1	each	Programme calculator, type HP 11 C
1	each	Instrument for measuring of thermal transmittance, "K" type therm 7320 - 1
		Heat-flow plates and accessories, Datenblatt 97..300
1	set	Digital thermometer and multi-channel switch, type 2572-10 and 2815-01
1	set	Digital AC meter, type 2504-31
1	each	Anemometer 4000, SN 402 3317 0539
1	each	AGA thermovision for measuring surface temperatures in the range of 30 °C up to 120 °C for field use, consisting of a THV 782 SW, complete with IR lens, recording equipment VTR, RGB monitor, digital scan converter and accessories
1	each	LP 12 twelve-channel point printing recorder Linocod, complete
2	each	CM 11 pyrometer, complete with screen
1		Equipment for air-flow measuring

Annex II

LIST OF STUDY TOURS

Participant	Date	Country	Institute
Ramšak, M. Lebar, J.	21-24 Nov. 1983	Federal Republic of Germany	Fraunhofer Institut für Bauphysik, Stuttgart
			Forschungsinstitut für Wärmeschutz, Munich
Ramšak, M.	6-9 May 1984	Switzerland	International Congress of Thermography, Lucerne
Boštjančič, J. Škerlep, F. Lebar, J.	10-16 June 1984	Finland	EKONO, Helsinki
			University of Technology, Helsinki
			Technical Research Centre of Finland, Helsinki
			Ministry of the Environment, Helsinki
Zupan, M.	28 Jan.-1 Feb. 1985	Italy	AGA Italia, Milan
			Istituto Centrale per l'Industrializzazione e la Tecnologia Edilitia, Milan
Boštjančič, J. Zupan, M.	24-30 March 1985	Federal Republic of Germany	Bundesanstalt für Materialprüfung, Berlin
Zupan, M.	6-31 May 1985	Federal Republic of Germany	Fraunhofer Institut für Bauphysik, Stuttgart
			Fraunhofer Institut für Bauphysik, Holzkirchen
Škerlep, F.	15-22 June 1985	Sweden	Swedish Housing Exhibition, Upplands Wasby
			Swedish Byggtjansk, Stockholm
			Royal Institute of Technology, Department of Heating and Ventilation, Stockholm
			Laboratory of the Royal Institute of Technology, Stockholm

continued

Annex II (continued)

Participant	Date	Country	Institute
			National Testing Institute, Department of Building Physics, Boras
			Royal Institute of Technology, Department of Building Technology, Lund
Zupan, M.	10-31 Jan. 1986	Switzerland	Eidgenössische Materialprüfings- und Versuchsanstalt (EMPA), Dübendorf
			Second Expert User's Conference for the "DEROB"
			Laboratorio di Fisica Terrestre, Lugano
			Technical Highschool (EPFL), Lausanne
Boštjančič, J. Lebar, P.	24-31 Jan. 1986	Switzerland	Eidgenössische Materialsprüfungs- und Versuchsanstalt (EMPA), Dübendorf
			Laboratorio di Fisica Terrestre, Lugano
			Technical Highschool (EPFL), Lausanne
Boštjančič, J. Škerlep, F. Zupan, M. Lebar, P. Vugrinec, F. Vitorovič, Z.	23-27 June 1986	Federal Rpublic of Germany	Fraunhofer Institut für Bauphysik, Holzkirchen
			Forschungsinstitut für Wärmeschutz, Munich
			Institut für Fenstertechnik, Rosenheim
Boštjančič, J. Lebar, J.	5-9 August 1986	Hungary	Hungarian Institute for Building Science (ETI), Budapest
			Institute for Quality Control of Building, Budapest