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Thermal bridge analysis in practice
KOBRA software and EUROKOBRA database

P. Wouters, J. Schietecat
Belgian Building Research Institute

P. Standaert
Physibel c.v.

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Synopsis

Thermal bridges are the typical locations for moisture and mould problems in buildings. Low surface temperatures in combination with a high humidity level in buildings can lead to severe problems and complaints by the occupants. Thermal bridges lead also to a significant increase of the energy losses in well insulated buildings. At present, thermal bridge problems still frequently occur in new buildings but especially in rehabilitation projects. In several countries so-called thermal bridge atlases already exist. These can help the designer to increase his understanding of the problems but they are not a real help in solving his specific problems. One alternative is to perform detailed thermal bridge simulations. This however is expensive and not at all part of the daily practice.

In the framework of several European and Belgian projects, the KOBRA software and EUROKOBRA database has been developed, offering a computerised thermal bridge atlas for 2-dimensional details. The main characteristics of the proposed atlas is its user friendliness, the large flexibility of modifying the detail (layer thickness, materials, boundary conditions,...) and the way of presenting the results (e.g. colour pictures showing the isothermal lines, the heat flux lines,...). The final product of these projects is an extremely powerful tool for so-called global training actions (for schools, colleges, architects, building contractors,...), which can be used in relation to all building types. Before the end of 2001, software and database will probably be available for many end users at no cost or very low price.

The presentation shows the major features of software and database and its possibilities for optimisation of buildings design and for retrofitting of buildings.

1. Introduction

Since the beginning of the eighties, the improvement of the thermal insulation of the building envelope has become a standard intervention in most Western countries in all well balanced proposals in order to :

- reduce the energy consumption of buildings;
- reduce the risk of condensation and mould growth;
- improve the thermal comfort in winter and/or summer conditions.

However, one has observed in the eighties that in many well insulated buildings (new buildings as well as renovated buildings), the number of condensation and mould growth problems was not decreasing but instead increasing. The main reasons for this situation are :

- the fact that often a large number of important thermal bridges were created by insulating the envelope;
- the fact that no attention was given to appropriate ventilation provisions.

As a result, there are thousands of buildings with severe condensation and mould growth problems. In Belgium for instance, nearly 10 % of all social dwellings suffered in the middle of the eighties from such kind of severe problems [1]. Besides the problem of condensation and mould growth, thermal bridges lead also often to a significant increase of the heat losses. They may represent 20 % or more of the total transmission losses [2],[3].

During the last decade, most of the architects, designers and building contractors have become aware of the detrimental effects of thermal bridges. At present, a large part of them understands the basic principles for avoiding thermal bridges.

However, the number of designs for new buildings, including important thermal bridges, is still frightening. Also and even more in the case of rehabilitation of old buildings, the number of thermal bridges which remains or which is created during the rehabilitation is very high. In this latter case, it is not always possible to fully eliminate thermal bridges but often it is technically possible to strongly reduce its effect.

2. Thermal bridges and European standardisation

At present, the European Standardisation Organisation (CEN) is preparing a whole range of standards dealing with thermal performances of buildings and building components. Specific standards concerning thermal bridges have been prepared by WG1 of CEN/TC 89 “'Thermal performances of buildings” [4],[5],[6]. The application or implementation of these 3 standards is officially still not possible, since they are included in CEN’s famous TC 89-package of 22 interrelated European standards which only can be fully applied when they are all available as EN. The latest announced target date of common availability of these 22 standards is appointed at March 2003. However, in the meantime the already existing EN-standards can always be applied in each country as “rules of good practice” as far as they do not conflict with existing national standards.

3. Concept of KOBRA and EUROKOBRA

3.1. General

Building details (connections between plane elements of the building envelope, having a relatively high geometrical complexity) play a prominent part in the global thermal behaviour of buildings. For the thermal evaluation of the building details, i.e. the analysis of heat losses and surface temperatures, mainly two different possibilities are available:

1) The use of computer programs based on finite differences or finite elements. Such programs offer a good precision and a large flexibility. The knowledge of a syntax and of the principles of heat transfer in building physics are required in order to use such programs. Therefore, their use is limited to people with a good knowledge of building physics. In the design practice, the access to these methods is too difficult.
2) The use of catalogues, offered as books containing a certain amount of sketches of building details and some thermal relevant results (e.g. temperature factor, ψ-value). The French "Règles TH" probably may be considered as the first catalogue; several other recent catalogues exist now (e.g. in Germany, Austria, Switzerland). Catalogues do not require the same level of building physics knowledge and can therefore be used on larger scale, e.g. by architects. On the other hand their flexibility is weak, as normally differences will occur very often between the detail under consideration and the catalogue detail.

The purpose of the EUROKOBRA-project is to combine at a European level the advantages of both methods mentioned, i.e. a high precision, a large flexibility, an easy use and a fast access to relevant information. For this purpose a computer program KOBRA is used, in combination with a data base of thermal bridges EUROKOBRA.

3.2. The computer program KOBRA

KOBRA is a computer program to query an atlas of building details on their thermal behaviour (two-dimensional & steady state). This program, developed by Physibel, has the following essential characteristics :

- it allows a fast selection of a building detail from a graphical database
- it offers relevant information on its thermal behaviour, i.e. a temperature factor (evaluation of condensation risk) and a ψ-value (evaluation of extra heat loss)
- it has the possibility to change the dimensions and materials in a very comprehensive way, followed by the accurate re-calculation (based on a numerical method) and by reporting the updated relevant information.

The atlas can contain several pages of building details, each page containing up to 16 details (see figures 1 and 2). After the selection of a detail, a thermal bridge analysis is reported, giving relevant information on condensation risk and heat loss effect (surface temperatures, temperature factor, heat losses, U-values, ψ-values) (see figure 3).

The flexibility of KOBRA lies in the facts (1) that the detail can be edited : dimensions, materials and boundary conditions can be altered easily (figures 4 and 5), and (2) that subsequently the temperature field is re-calculated (using the accurate energy balance technique). Isotherms and heat flow lines can be represented in a clear way. (figure 6)

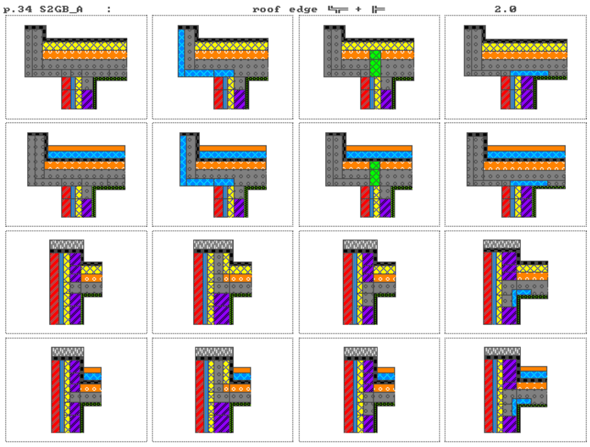

Fig. 1 – Topo view

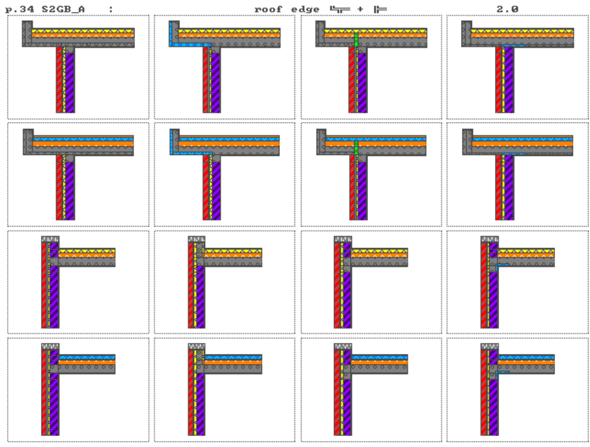

Fig. 2 – Atlas page (real view)

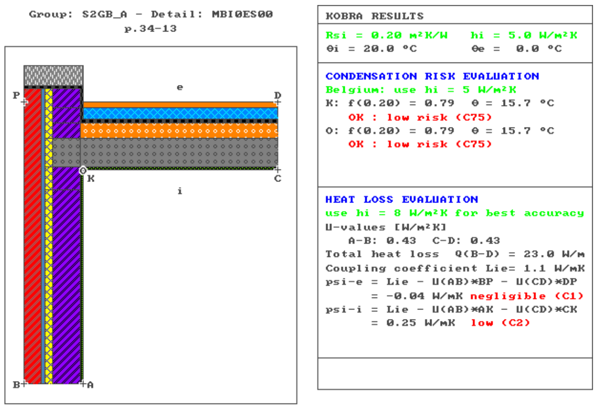

Fig. 3 – Result window

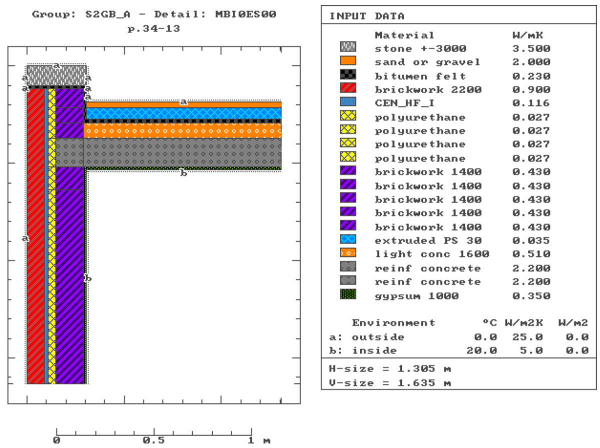

Fig. 4 – Input data

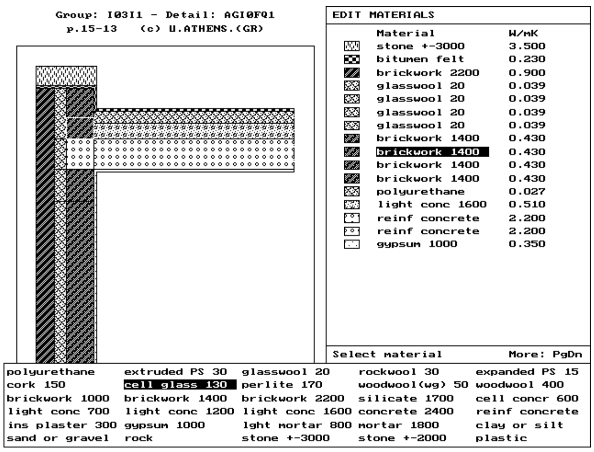

Fig. 5 – Changing materials

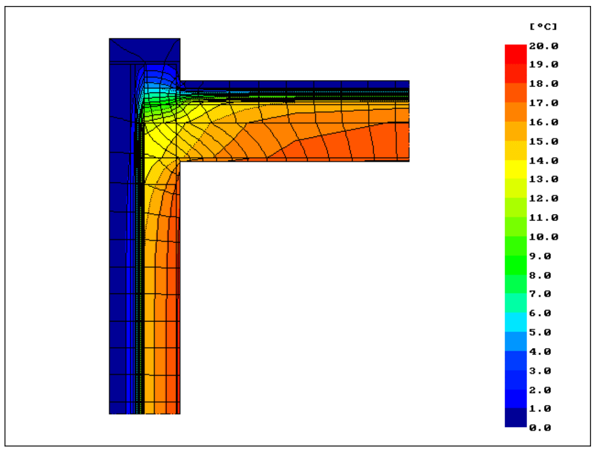

Fig. 6 – Isotherms and heat losses

At present, only geometric configurations which are foreseen by the atlas builders (these are the participants in this project), can be evaluated and modified by the end user (architect, designer,...). Very specific details, which are not part of the atlas, cannot be evaluated.

3.3. The EUROKOBRA database

The KOBRA program is only of interest for end users (architects, building contractors, engineering offices) if it is accompanied by an extensive database containing relevant building details. The present EUROKOBRA database (2001) contains about 3000 different building details.

4. Research activities

4.1. SAVE project on thermal bridges (1993-1995)

At the start of the preparation of this SAVE project (autumn 1992), a first version of the KOBRA program was available. At the end of 1993, a fully operational version of KOBRA was delivered by Physibel which included most of the suggestions discussed by the partners of the project. Further improvements were executed in the course of 1994.

The development of the building detail database EUROKOBRA consisted mainly in the following activities :

1. *Development of a general building detail typology.*

The structure of the first database was based on this typology. The development of the general building detail typology was crucial since it determines the level of flexibility of the atlas. At the end of 1993, this work was to a large extent done.

2. *Development of a building detail database.*

It is clear that the contents of the building detail database is essential for use in practice. A rather large database is e.g. required for use by architects and engineers (design practice) and for educational purposes. The project aimed to provide a first database of about 1000 details. This part of the work included a systematic study of the existing thermal bridge atlases. It is important to stress that the concept of this database is very open in such a way that other software programs can make use of this database when taking into account the structure of the database.

The project, in which BBRI (B), Physibel (B), CSTB (F), Univ. of Strathclyde and BRE (UK), LBP (NL), EMPA (CH), TU-Wien (A) and NKUA (GR) were involved, resulted finally at the beginning of 1995 in the first version of a complete KOBRA+EUROKOBRA package.

4.2. Creation of the EUROKOBRA EEIG

In order to guarantee the close collaboration between the partners of the SAVE-project the EUROKOBRA EEIG (European Economic Interest Grouping) has been created in March 1995, gathering most partners of the project (BBRI, Physibel, LBP, CSTB, TU-Wien and NKUA). It was the intention of the EEIG to develop further on the actual software and database and also to do further research efforts at a European scale on thermal bridge calculations. The Grouping takes also care of the co-ordination of scientific and organisational activities.

4.3.The EC-SAVE KOPRACTICE project (2001-2003)

This project is co-ordinated by the EUROKOBRA EEIG and gathers, besides the already named EEIG members, also EMPA (CH), BRE (UK) and AICIA (E).

The objectives of the KOPRACTICE project (bringing KOBRA and EUROKOBRA to the building PRACTICE), can be resumed as follows :

- Make software and database available for all European countries, involving the following tasks :
  - Translation of program and database, which is presently available in English, Dutch, French and German, into other European languages.
  - Adaptation to local (national or regional) regulations. Indeed, existing local regulations consider often different specific boundary conditions to evaluate surface condensation risk (temperature factor) and heat losses (linear heat transmission coefficient). The reporting of the calculation results must thus be adapted to the country dependent criteria. Therefore, not only the language, but also the country must be selected when installing the software. The program KOBRA was developed to allow such different criteria. In the project both the availability of specific criteria and the integration of these criteria into the database will be realised for all participating countries.
  - Proposal for a common European regulation. The need for adaptation to local regulation as mentioned above is due to the absence of a standardised evaluation method. No European standard deals at this moment with general criteria for the selection of internal surface heat transfer coefficients and minimum values for the temperature factor. However, from the scientific point of view (cf. report IEA annex XIV, Volume 1, Sourcebook) a unified approach to prevent condensation risk is possible. A proposal for such an approach will be developed and integrated into the software and could form a good basis for the preparation of a European standard.
- Adaptation of the existing manuals or user guides for software and database; the thermal bridge user guide explains in a detailed but clear way the theoretical and practical backgrounds of thermal bridge analysis and will also include national information provided by all partners.
- Preparation of local seminars and support teams.
  - It is the aim to have in each country involved in the project a team who is able to take care of the distribution of the software and database and who will be in charge for organising a seminar. The selected teams consist of a professional organisation in the sector of thermal insulation (selected through the European Insulation Manufacturers Association - EURIMA) and an organisation with appropriate scientific background (university, research centre,…)
  - The external scientific partners, who accepted to collaborate in the project, are Politecnico di Torino (I), KTH (S), UCD (IRL), NBI (N), University of Porto (P) and VTT (FI). Two other interested institutes, coming from Eastern Europe, joined also as external partner in the project : the Polish Building Research Institute and the University of Technology of Budapest.

- Creation of a website for end-users and project partners (under development), offering the possibility for downloading programme and database and future updates
- Organisation of local workshops and distribution of software and database
- Setting up of a network structure for follow-up after end of project

5. Conclusions

1. The development of the interactive software package for the evaluation of thermal bridges (KOBRA) in combination with the thermal bridge database (EUROKOBRA) will offer for the first time the opportunity to building professionals to analyse easily most of their construction details with respect to condensation risks and/or energy losses.
2. All calculation results are in line with the existing European standardisation, taking into account the criteria for the evaluation of condensation risk and heat losses which are given in the existing national or local regulations
3. Software and database are extremely user friendly which means that almost no time has to be spent for understanding the use of the programme.
4. The package (software + database) will be available before end of 2001 in all European countries which have a representing partner in the KOPRACTICE project. These partners have the exclusive distribution right in their own country. It is expected that software and database will be available free of charge or at least at a very low price.

More information can be obtained at the following address :

EUROKOBRA EEIG - Poincarélaan, 79 - B 1060 Brussels (Belgium)
tel +32 2 655 77 11 - fax +32 2 653 07 29 - e-mail : jacques.schietecat@bbri.be

6. References

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