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FROM SUMMER COOLING TO SUSTAINABLE SUMMER COMFORT IN BUILDING THERMAL REGULATION

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Abstract : *The introduction of the “Energy Performance Building Directive” (EPBD) [1] and consequently the new National Building Regulation [2] in the Member States (MS) lead to a totally new legal situation concerning, requirements and procedures on the building sector. Under the scope of an EU project called Keep Cool, a survey was undertaken in order to review the energy efficiency criteria, in the national building codes, concerning summer comfort or mechanical cooling system in order to elaborate recommendations towards a sustainable summer comfort. This paper presents the results of this survey [3] carried out under the participate countries (7 countries), and the main goals were the following to update the information regarding the new national building regulations to have a first insight regarding the requirements and summer calculations adopted in each country and to identify the positive and the negative aspects of the different regulations and selection of the best practice examples, in order to draw up recommendations for introducing sustainable summer comfort measures into future national building codes. A comparative analysis has started with some very precise answers and had permitted to carry out a comparative analysis between some national building codes. A review was undertaken concerning envelope constructive solutions (opaque and transparent), thermal mass, ventilation rates and the corresponding values limits.*

Keywords: Building Codes, Summer Energy Efficiency, Sustainable Summer Comfort.

INTRODUCTION

The building regulations have a major role in controlling and limiting the energy consumption of the building sector. The Thermal Building Regulations of the European countries although had generally followed the EPBD Directive in what concerns the methodologies, differs on the requirements and recommendations and calculation methodologies on summer comfort and energy consumption for cooling, due to the particular conditions of each country.

As the energy demand for cooling in European buildings has been the energy use in the building sector with high increase rate among the other energy uses, it is very important to analyse how can we move from an approach based on cooling calculation” (summer cooling) to another approach based on the concept of “sustainable summer comfort”.

A review of the national building codes concerning envelope constructive solutions (opaque and transparent), thermal mass, ventilation rates, energy consumption methodology and correspondent values limits has been undertaken for the participating countries of the KeepCool II Project.

GOALS

The goal of this analysis consists on put in evidence the different strategies adopted and try to share and to supply information and experiences clarify some important issues regarding methodologies, procedures and actors.

The questionnaire was grouped in divided in three main parts:

- Part A with general questions about building regulation regarding current status, type of buildings, in which phase is or should be verified (planning stage, after construction or both), main entities involved in the building application and their respective role, the information is or will be collected in a central database, the main aspects of the methodologies used;
- Part B questions on requirements and calculations procedures, climatic conditions, types of actions regarding summer: solar heat prevention requirements, solar heat gain attenuation (U-values and thermal mass), heat dissipation strategies, calculations procedures, and if air conditioning systems are considered and any directives to avoid it;
- Part C refers to recommendations that could be, or should be implemented in order to increase summer comfort and reduce the use of cooling and if summer comfort should be explicitly introduced in the building regulation.

BUILDING REGULATIONS

The new building regulations, in all participating countries of the KeepCool Project, have been published following the Directive and are already in force, in most part of the MS, for all type of buildings (existent and non-existent and residential or non residential). The legal compliance differs very much in terms of verification. Basically there are MS which in verify the compliance before and after construction (Austria, Germany, Portugal) at planning stage, before construction starts, in order to have a permit to build (Italy), after construction (France)

The EPBD also implies the Energy Certification process, which involve the architects or engineers which will have the technical responsibility and will guarantee the compliance with the building directive. The information of the building regulation process will be collected in a central database and the authors of the energy performance certificate are committed to send the results to a statistics centre/state controllers (Austria, France, and Portugal). In Germany and

Italy, at the moment, doesn't exist a central database to collect the building regulation and in Germany the building authorities don't control observance or deviations from the building directive.

REQUIREMENTS ON SOLAR HEAT PREVENTION, ATTENUATION AND DISSIPATION STRATEGIES

In what concerns the quality of the envelope and requirements concerning U-Values depending on the envelope element and vary according to:

- Wall - 0.28 to 0.70 W/m²°C;
- Roof - 0.20 to 0.50 (other type) W/m²°C;
- Floor - 0.35 to 0.50 W/m²°C;
- Windows - 1.3 to 1.9 W/m²°C.
- Doors 1,8 W/m²°C (Slovenia)

The upper limits corresponds to the southern countries (Italy and Portugal) while the lowest ones to Slovenia followed by Austria and France. In Germany in what concerns the quality of the envelope there are any indication about requirements concerning maximum U-Values only on thermal mass for new residential buildings. For Sweden, is the opposite, there is any indication about thermal mass but there are requirements concerning maximum U-value average = 0.5 W/m²°C.

In what concerns thermal mass Austria and Italy have very precise requirements. For Austria according to the next table:

Immission area referred hourly air flow $V_{L,s}$ in m ³ /(hm ²)	Immission area referred storage mass $m_{w,l}^{(2)}$ in kg/m ²
≥ 100	≥ 2000
75	≥ 4000
50 ⁽¹⁾	≥ 8000
⁽¹⁾ Immission area referred air flows on less than 50 m ³ /(hm ²) lead to a high overheating risk and are therefore to be avoided.	
⁽²⁾ Have to be interpolated if required	

and for Italy, the thermal mass should be higher than 230 kg/m² whenever monthly horizontal mean irradiance is higher than 290 W/m² during the most insolate month. In Portugal is included in the calculation procedure itself and are defined 3 thermal inertia estimated by the relationship where M_{si} is superficial thermal mass of the i element, S_i the i element area, r_i the reducing factor of the thermal mass and A_p the floor area:

$$I_t = \frac{\sum M_{si} \cdot r_i \cdot S_i}{A_p}$$

Low thermal inertia: $I_t < 150 \text{ kg/m}^2$

Medium thermal inertia: $150 \text{ kg/m}^2 \leq I_t \leq 400 \text{ kg/m}^2$

High thermal inertia: $I_t > 400 \text{ kg/m}^2$

The approach used for glazed areas (U-values) differs significantly. Some countries imposed maximum U-values for windows: Austria (1.7 to 1.9 W/m²°C), France– 2.6 W/m²°C, Italy (1.70 - 4.50 W/m²°C) and Sweden (1.3 W/m²°C areas < 100 m²).

For other countries (France, Portugal) the solar heat prevention requirements are based on the limitation of solar factor (g_{\perp}). In France is related to maximum solar factor in bedrooms and in Portugal, orientations between NE and NW (south quadrant), for all new buildings and for existing ones under great renovation/rehabilitation (residential and non residential):

$0.15 \leq (g_{\perp}) \leq 0.56$, depending on summer climatic zone and thermal inertia

Directly or indirectly the Portuguese thermal building regulation takes in consideration the glazing areas per façade and orientation

In Germany there existed recommendations to glazing areas, and have been extended to specific requirements related to the maximum solar gains, for window to floor area ratios > 30% the standard defines a factor as maximum limit for solar input that depends on: climate conditions but, for small windows <10% (ratio between window area and floor area), it is not necessary any verification. In Italy effective shadings are not better specified.

In Slovenia glazing areas are limited in ruled for design of residential buildings due to daylight (<20%) and should have obligatory shading (internal shading is not acceptable, only for north oriented windows), solar thermal and reflective glazing are allowed if incoming radiation.

Concerning heat dissipation strategies natural ventilation are already implemented in Austria, France, to ensure the necessary day and night ventilation. In Sweden the reduction of the demand for cooling is also recommended based on the use of free-cooling and cooling storage (night cooling and accumulation of cold in the building structure). Portugal imposed a minimum value for air renovation in order to guarantee the inside air quality (0.6 ACH) and in the thermal building regulation the ventilation in summer is always treated as a dissipation strategy due to the mean external air temperature for the summer period to be always lower than 25 °C, for all summer climatic zones.

France is the only country that expressly refers, concerning heat dissipation strategies, the use of the earth as a cooling source.

CALCULATIONS PROCEDURES

Some countries refers that cooling loads are calculated according to the standard EN ISO 13790 ($E_p < E_{pmax}$), even if adapted to their National thermal building regulations: Austria (ÖNORM B 8110-6), Germany (new DIN V 18599, 2007), and Portugal (RCCTE). The balance covers energy expenditures for heating, ventilation, cooling, hot water supply and lighting.

The French thermal regulation, besides the energy calculation in an hourly base times simulation procedure using official software and is expressed in primary energy /m², is the only that explicitly refers summer comfort for new buildings ($T_{ic} \leq T_{ic\ ref}$, $T_{ic\ ref}$ depend on climatic zone and use an official software, for residential buildings or non-cooled buildings, to estimate the internal maximum temperature T_{ic} for a reference warm day (calculated as the average operative temperature for the 3 consecutives warmest days) must be verify the previous relationship being $T_{ic\ ref}$ calculated by applying reference solar protections.

The Italian thermal regulation is applied only to the delivered energy for space heating by energy law in force (Dlgs 311/2006) where the internal and solar gains are considered in the building calculation methodology according also to EN ISO 13790/2008.

In Slovenia there is no differentiation in minimum requirements or calculation approach per building type. The central part of minimum requirements are expressed in maximum allowed power of systems for heating and cooling based on (a) SIST EN12831:2004 calculation for specific heating power demand (W/m³) and (b) based on VDI 2078:1996 or ASHRAE calculation for specific cooling power demand (W/m³). For checking the compliance with minimum requirements on the (final) energy use for cooling the calculation shall be done by a simplified method (system power and seasonal calculation with cooling degree days). Optionally EN ISO 13790 can be used for energy calculations.

In Sweden the calculation procedures are not mandatory however there are methodologies adopted for new buildings, for the existents are not yet regulated. The building regulation does not refer specific temperatures for the cooling season as the most relevant season is the winter with 8 months duration and minimum and maximum mean temperatures in winter and summer equal to, respectively, -5.0 °C and 13.2 °C.

SUMMER COMFORT

All answers to the questionnaire are unanimous regarding to summer comfort be explicitly introduced in the building regulation for all type of buildings and, according to the French position could be expressed for new and existing buildings, residential and non-residential, by checking the indoor temperatures and the standards should be explicitly introduced in the building regulation

The Portuguese answer manifests also that summer comfort should be explicitly introduced in the building regulation and the cornering with the cooling energy demands limit values and points out that, in a future revision, should be modified because at the moment those limits are quite permissive, in opposition, with heating energy demands.

Germany as a suggestion towards a sustainable summer comfort, for the residential buildings news and existing, consists on “eliminate enforcement deficits”.

Slovenia considers that the promotion of passive cooling measures should be promoted event if it is not acceptable in all cases and that summer comfort conditions should be achieved for residential buildings without cooling devices based on good architectural solutions in most of Slovenia.

CONCLUSIONS

Summer comfort should be explicitly introduced in the national building regulations, for all type of buildings (news and existing, residential and non-residential).

In what concerns the inclusion of the standards in the National Building explicitly, the answers are not unanimous, some ones consider that should be applied only for new buildings, and even in this case, in a different way: compulsory for residential and recommendations for non residential.

For the attenuation of the solar heat gains, the countries that don't have any requirements in their Building Regulations conclude that they should implement measures like: shading devices, glazing area and total area of the façade, glazing area per orientation.

Regarding ventilation strategies natural ventilation is always referred as a measure to be adopted and, if natural ventilation is not sufficient is pointed out mechanical ventilation systems.

Although these countries consider that those aspects should be introduced, opinion diverges on how it should be implemented. Some considers the voluntary application and others prefer the

mandatory application. These two approaches are also related if the building is new (mandatory requirement) or existent (voluntary approach), like Italy.

The use of mechanical cooling systems should only be allowed after the application of passive measures (solar heat attenuation and heat dissipation) and if the internal gains are too high or, if due to others circumstances, the spaces require particular low temperatures.

Particularly, according to the Austrian position, the use of mechanical cooling systems for should be avoided in all situations residential buildings. The adaptation and use of passive systems must be always checked and their contribution should be incorporated in the building regulation like France did concerning the earth as a cooling source. The same opinion is defended by Slovenia pointing out that more emphasize should be put on passive measures in order to reduce cooling devices and that shading and night ventilation should be promoted instead of AC devices.

For a sustainable summer comfort, especially in southern countries, it is necessary to establish more exigent limit values of the cooling energy demands.

REFERENCES

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