A SYNTHESIS OF EXISTING ENERGY CODES IN SELECTED COUNTRIES

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1. Introduction

The purpose of this study was to review the available literature on existing energy codes in other countries in the region for later use in developing an energy efficient building code for the commercial sector in Sri Lanka. The selected countries are The Philippines, Malaysia, Hong Kong and Singapore to represent Asia, Jamaica to represent a similar climatic conditions as of Sri Lanka and Canada to represent the latest approaches to the development of energy codes in the developed world.

The main objective of this work is to concentrate on key aspects covered in these energy codes, their scope and limitations and the specific approach adapted in each of these. It can be seen that each of these building codes cover a subset of the key aspects such as building envelop, lighting, air-conditioning, electrical power distribution, steam and hot water systems, energy management, auxiliary systems and the whole building energy budget. These codes set minimum standards for energy efficiency in the design of new buildings.

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2.1 Republic Of The Philippines: *"Guide Lines For Energy Conserving Design Of Buildings And Utility Systems"*

These guide lines address the design of new buildings as well as upgrading of existing buildings excluding any residential units and premises using large quantities of process heat. Main aspects covered in this document are exterior envelop of the building, selection of equipment for power, lighting, air-conditioning and steam & hot water systems. These guide lines are also applicable for new buildings classified as offices, hotels shopping centres, hospitals, as well as parts of industrial buildings used primarily for human occupancy.

Lighting

The selection of an appropriate lighting system to provide a flexible, effective and a pleasing visual environment is covered in this code. It is required that task oriented lighting is arranged wherever it is possible. All necessary data related to recommended design, iluminance levels of different lamps, efficacy and colour rendering indices and recommended room surface reflectance are provided for this purpose. A maximum allowable power density for building interior and exterior lighting systems are also provided. Also it deals with lighting controls and their locations and energy conservation requirements of electric motors, transformers and distribution systems.

Building envelop

This applies to air-conditioned buildings with a total cooling load of 175kW or greater and the design criterion is required to be based on the "*Overall Thermal Transfer Value*" (OTTV) to

minimise the external heat gain in order to minimise the interior cooling load.

To determine the OTTV the necessary design data such as solar radiation absorbed by selected building materials, a colour guide with percentage absorption of different colours, thermal conductivities of building materials, air space resistances for walls and roofs, surface film resistances, glass thermal transmittance values, solar factors for various building wall orientations and glass shading coefficients are provided. Also the code highlights the importance of incorporating day lighting and related automatic controls into buildings where air-conditioning is not provided. In addition, the need for adequate insulation at the roof and minimum air leakage at openings such as doors and windows are looked at.

Air-conditioning system
The code covers the design criteria for the air-conditioning system in buildings to optimize the energy use. This provides a minimum design criteria which include load calculations/procedures, system design and sizing, fan system design , pumping system design, controls, piping insulation, air handling system insulation and air-conditioning equipment.

Steam and hot water system
This provides necessary criteria for design and equipment selection for energy saving when applied to steam and hot water systems in buildings such as hotels and hospitals.

Summary
The code focuses only on the air-conditioned buildings and excludes even residential buildings which are heavily dependent on natural light and ventilation. The use of natural ventilation not covered even though some thoughts have been given to the use of natural light.

2.2 Malaysia : *"Guide Lines For Energy Efficiency In Buildings"*

The purpose of these guide lines is to encourage design of new and existing buildings having a peak design rate of electricity usage more than $10W/m^2$ of gross floor area so that they can be constructed, operated and maintained in such a way that the energy usage is minimised without constraining the function of the building, comfort and productivity with due consideration given to the cost. This provides minimum standards for energy efficiency and methods of determining compliance with these standards.

The guide lines cover the requirements associated with exterior envelops, selection of equipment for air-conditioning, illumination and other auxiliary requirements. Main aspects covered in this document are electric power distribution, lighting, air-conditioning, building envelop and energy management.

Electric power and distribution
The code applies to all electrical systems except the separately wired emergency systems and minimum requirements for check-metering, transformers, electric motors and operation & maintenance of electrical systems are given.

Lighting
Day lighting and task-ambient lighting designs are encouraged with emphasis on luminaire systems with heat removal and recovery capabilities. Recommendations are given on general principles of efficient lighting practice, lighting load requirements, maximum allowable power for illumination systems, building exterior lighting power calculations, lighting controls and a submission procedure on lighting installations.

Air-conditioning system
This part of the code deals with load calculations, system and equipment sizing, fan system design criteria, pumping systems design criteria, separate air distribution systems, temperature controls, off-hour controls, piping

insulation, preventive maintenance and submission procedure, in detail. It is required that the calculations are based on the latest edition of the ASHRAE handbook or other equivalent publications.

Building envelop

This covers OTTV as a design criteria, shading coefficient (SC), day lighting, roofs with and without skylights, roof thermal transfer value (RTTV), daylight credit, Air leakage and submission procedure, as applied to building envelop.

Energy management

The minimum measurement, control, testing and documentation features that shall be provided for the building are described here.

Summary

The code has focused only on energy conservation in buildings having air-conditioning systems. Therefore it mainly concerns with providing guidelines to minimise external heat transfers into the building and hence the possibility of incorporating natural ventilation is not envisaged. The guide lines stress the need to introduce energy management systems throughout the life of a building.

2.3 Canada : *"National Energy Code For Buildings"*

The most significant feature of the Canadian approach to building codes is that they have developed two separate codes, one for residential premises and another for all other buildings. If the residential building serves more than a single dwelling unit the mechanical system requirements apply. The two codes are very similar to each other in overall structure.

The primary purpose of the building code is to promote a minimum level of energy efficiency in new buildings through out Canada. This provides regulations for minimum energy efficiency considering climate, fuel type & costs and construction costs and it establishes a standard of construction for energy related features in new buildings as well as new additions to existing buildings. The code does not constitute a design procedure but a guide to the designer in order to achieve the required standards. These standards fall into two groups, *mandatory requirements* and *prescriptive requirements* which are mandatory to all but those buildings with alternative measures for energy efficiency covering the corresponding aspect of the code. A process called *performance compliance path* is used to demonstrate and check the energy use of such buildings when satisfying prescriptive requirements. Also there is a provision in the code for regional sensitivities and therefore certain requirements vary by region. The key aspects covered in the code are building envelop, lighting, heating, ventilating & air-conditioning systems, service water heating systems and electric power.

Building Envelop

Building envelop is defined as the components which separate conditioned space from unconditioned space, the exterior air or the ground or which separate conditioned spaces that are intended to be conditioned to temperatures deferring by 10°C at design conditions. This part of the code contains requirements related to thermal resistance and air-tightness of various building assemblies that make up the building envelop.

There are mandatory provisions covering general construction of the building, continuity of insulation, above-ground components of the building envelop, building assemblies in contact with the ground and air-tightness. "Prescriptive compliance" covers certain other aspects of the above-ground components and special interior temperature conditions. "Building energy performance compliance" is applied only when the mandatory provisions and prescriptive requirements are not complied with and requires the building envelop to demonstrate that it uses less energy even under these circumstances.

Lighting
The scope of this section of the code is limited to lighting in interior spaces, building exteriors, exterior building areas and lighting for ground and parking. If the nature of occupancy makes it impractical such spaces may be exempted from applying these requirements.

The mandatory provisions cover the subjects of interior and exterior lighting power, lighting controls, and ballasts. "Prescriptive compliance" covers interior connected lighting power. "Building energy performance compliance" is applied when the lighting system cannot satisfy the "prescriptive compliance" and requires it to demonstrate that it is more energy efficient even under such circumstances.

Heating ventilating and air-conditioning systems
Mandatory provisions cover in detail the system design, air distribution systems, air intake and outlet dampers, piping for heating and cooling systems, pumping system design, equipment installed outdoors, recessed wall heaters, gas heating systems, temperature controls, humidification, shut-off and setback, equipment efficiency and design documentation. "Prescriptive compliance" covers fan system design, cooling with outdoor air, control of heating, ventilating and air-conditioning systems and heat recovery. "Building energy performance compliance" is applied when heating ventilating and air-conditioning systems cannot satisfy the "prescriptive compliance" and requires it to demonstrate that it is more energy efficient even under such circumstances.

Service water heating systems
Mandatory provisions in this part of the code cover system design, storage vessels and heating equipment, piping, controls, systems with more than one end-use design temperature, conservation of hot water and swimming pools. "Prescriptive compliance" imposes conditions on the combination service water and space heating equipment. When prescriptive requirements are not compli with, "Building energy performan compliance" is applied.

Electric power
Except in emergency systems this part of t code is applicable to all electrical systems the building. Mandatory provisions co metering, monitoring, power contro transformers, electrical motors a documentation on system design and operatic

Summary
The code is comprehensive in its coverage a it includes the entire building sector. provides a design guide to energy efficier and is quite flexible due to the adop structure. This code too, deals only w buildings with conditioned interiors due country's distinct climatic conditions.

2.4 Hong Kong: *"Code Of Practice Overall Thermal Transfer Value In Buildin April 1995"*

The code of practice for OTTV in buildi forms the initial step of the Hong K government's aim top formulate comprehensive building energy code. present the code deals with only the build envelop and the area of interest is confine hotels and commercial buildings. Also in OTTV formulation, internal shading dev and solar reflection or shading from o buildings are excluded.

The key aspects covered in the code suitable OTTV, principles of OT calculation, OTTV of external walls, OTTV roofs, calculation component coefficients parameters of OTTV, windows and doors submission of information.

Summary
The energy code to be developed later concerns only the "enclosed" buildings thus use of natural light and ventilation is considered.

2.5 Singapore: " *Code Of Practice For Energy Conservation In Building Services*"

The code primarily deals with air-conditioned buildings and consists of three parts; coefficient of performance of air-conditioned equipment, ventilating and air-conditioning systems and procedure for the determination of a lighting power budget. They key aspects covered are lighting and air-conditioning.

Coefficient of performance of air-conditioning equipment.
This establishes a minimum standard on the coefficients of performance of air-conditioning equipment. The equipment and component performances are dealt with in accordance with the criteria for effective utilisation of energy established in the code for new installations or replacement of VAC system equipment and VAC system components used in buildings. The different aspects covered in this part of the code are VAC systems, VAC system equipment, VAC system components, VAC system equipment/components - heat operated, cooling mode and maintenance.

Ventilating and air-conditioning systems
This part of the code provides information on determination of cooling loads, design requirements and control requirements for general comfort applications in new buildings where normally clothed people are engaged in sedentary or near-sedentary activities. Special applications such as hospitals and laboratories are exempted from these requirements in the code.

The main aspects covered in the code are calculation of cooling load, air-leakage, controls, mechanical ventilation, energy for air delivery, energy for water circulation, energy recovery, piping insulation air-handling duct system insulation, duct construction and balancing the air and water system.

Procedure for determination of lighting power budget
This establishes a criteria for luminous efficacy of lamps and light output ration of luminaries for artificial lighting. and provides a procedure for determining a power budget. The aspects dealt with in detail are lighting of building interiors and exteriors and lighting design and control.

Summary
The code provides a comprehensive guide to energy on lighting and air-conditioning but covers only the "enclosed" buildings which excludes the consideration of natural lighting and ventilation.

2.6 Jamaica :"*Energy Efficiency Building Code, Requirements And Guide Lines, 1994*"

The code is developed based on the key technical content and requirements from the latest available versions of ASHRAE and other standards. To ensure the appropriateness of the code, three climatic zones have been identified within the country and the code provides adjustment ratios to buildings located in each zone.

This applies to all buildings or portions of buildings that provide facilities or shelter for human occupancy and use energy primarily to provide human comfort, except single family residential buildings and multi-family residential buildings with three or fewer stories. The buildings intended for manufacturing or commercial or industrial processing , buildings or separately identified parts of buildings with less than $11W/m^2$ of energy use, buildings having a floor area less than $93m^2$, seasonally occupied agricultural buildings, some storage spaces and those buildings identified with historical significance are excluded.

The key aspects covered in the code are, building envelop, lighting, electric power and distribution, ventilating and air-conditioning systems and related equipment, service water heating systems and related equipment, auxiliary systems, energy management and building energy budget and energy cost budget methods.

Building envelop
This part of the code provides basic requirements, prescriptive requirements for walls and roofs, systems performance requirements for external walls and roofs and credits for the use of day lighting. The code is applies to air-conditioned buildings with a total cooling load of 35kW or greater and recommendations are given for non-air-conditioned buildings to improve the comfort level.

Lighting
The scope of this part of the code is limited to interior spaces of the buildings and any exterior space where lighting is required and energised through the building electrical service. This includes basic requirements associated with different aspects such as illuminance levels and lighting controls, prescriptive requirements for building interior lighting and system performance requirements in the absence of prescriptive requirements.

Electric power distribution
Recommendations are given for transformers, electrical motor efficiency and for check-metering of the distribution system.

Ventilating and air-conditioning systems and equipment
Recommendations are given under basic and prescriptive requirements covering many aspects such as load calculations, designs, controls and maintenance.

Service water heating systems and equipment
Recommendations are given on basic requirements in many aspects such as sizing of systems and equipment efficiency and prescriptive requirements on combination of service water heating and space heating equipment.

Auxiliary systems
This area covers building transportation involving automatic elevator systems and conveyor systems and refrigeration systems inside the building.

Energy management
This part of the code describes the minimum measurement, control, testing and documentation features provided for the building. It covers the basic requirements associated with energy measurement capability.

Whole-building energy cost budget method
This provides and opportunity for the building designer to evaluate and take credit for innovative energy conservation designs, materials and equipment and includes annual energy cost budget method and calculation procedures.

Summary
This guide provides a comprehensive approach to energy efficient building design. The structure of the code is found to be quite appropriate with mandatory basic requirements and prescriptive and system performance requirements to give a greater flexibility. The identification of different climatic zones has improved the flexibility and appropriateness of the code. Also the use of day lighting is encouraged.

3. Conclusion

With the exclusion of the Canadian code, all the other codes exclude residential buildings and their primary concern is on air-conditioned buildings. The possibility of incorporating day-lighting is not seriously considered in all but the Jamaican code. Due to the emphasis given for air-conditioned buildings the OTTV is considered to be of primary importance and therefore the recommendations are given basically to keep the OTTV at its minimum.

The codes highlight the importance of cost-effectiveness in designing energy efficient buildings and the need for energy management through out the life span of the building.