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CLIMATE RESPONSIVE BUILDING CONCEPTS IN HONG KONG

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ABSTRACT

There is a global need for a more sustainable building development. About 50% of energy is used in buildings indicating that buildings provide a considerable potential for operational energy savings. Studies were conducted with the following objectives:

- to perform a state-of-the-art review of responsive building elements, of integrated building concepts and of environmental performance assessment methods
- to improve and optimize responsive building elements
- to develop and optimize new building concepts with integration of responsive building elements, HVAC-systems as well as natural and renewable energy strategies
- to develop guidelines and procedures for estimation of environmental performance of responsive building elements and integrated building concepts

This paper introduces the ideas of this collaborative work within the framework of the Annex44 of the International Energy Agency (IEA) and discusses its usefulness for Hong Kong. Special focus was put on the description of the state of the art of the application of responsive building elements and of integrated building concepts in Hong Kong. A number of interviews of key players in the construction industry in Hong Kong revealed that not many of the established responsive building elements have been applied. This is mainly due to lack of information, lack of incentives, high capital cost, lack of competition between suppliers, lack of guidelines and design tools, lack of practical demonstrations, lack of cooperation between designers. On the other hand energy saving installations are increasingly applied as heat pumps in combination with energy storage, balanced ventilation with heat recovery, cooling towers etc.

In Hong Kong in most cases there is no integrated design process for building projects. This means that projects are developed and designed in accordance with the energy performance calculations based on economic energy saving measures.

1 INTRODUCTION

Energy usage for room heating, cooling and ventilation still accounts for more than one third of the total, primary energy demand in the industrialized countries, and is in this way a major polluter of the environment with CO2 and greenhouse-gases (Annex44

2006a). Moreover, there is world-wide growing concern about the type of energy used for different purposes.

Research into building energy efficiency over the last decade has focused on efficiency improvements of specific building elements like the building envelope, including its walls, roofs and fenestration components (windows, daylighting, ventilation, etc.) and building equipment such as heating, ventilation, air handling, cooling equipment and lighting. In the framework of IEA research in ECBCS Annexes has focused on:

- the optimization of the building envelope - Annex 32 "Integral Building Envelope Performance Assessment" (Annex32 1999)
- the optimization of ventilation by intelligent hybrid ventilation - Annex 35 "Control Strategies for Hybrid Ventilation in New and Retrofitted Office Buildings (HybVent)" (Annex35 2002)
- the optimization of the heating and cooling system by low temperature heating and high temperature cooling - Annex 37 "Low Exergy Systems for Heating and Cooling" (Annex37 2003)

Significant improvements have been made, and whilst most building elements still offer opportunities for efficiency improvements, the greatest future potential lies with technologies that promote the integration of active building elements and communication among building services. In this perspective Whole Building Concepts are defined as solutions where reactive building elements together with service functions are integrated into one system to reach an optimal environmental performance in terms of energy performance, resource consumption, ecological loadings and indoor environmental quality. Reactive Building Elements are defined as building construction elements which are actively used for transfer of heat, light, water and air. This means that construction elements (like floors, walls, roofs, foundation etc.) are logically and rationally combined and integrated with building service functions such as heating, cooling, ventilation and energy storage. The development, application and implementation of reactive building elements are considered to be a necessary step towards further energy efficiency improvements in the built environment (Annex44 2006b).

With the integration of reactive building elements and building services, building design completely changes from design of individual systems to integrated design of "whole building concepts, augmented by "intelligent" systems and equipment. Development of enabling technologies such as sensors, controls and information systems are needed to allow the integration. Design strategies should allow for optimal use of natural energy strategies (daylighting, natural ventilation, passive cooling, etc.) as well as integration of renewable energy devices (Annex44 2006a).

The annex will, based on the knowledge gained in the work so far, address the following objectives:

- Define state-of-the-art of reactive building elements
- Improve and optimize reactive building elements and technologies
- Develop and optimize new building concepts with integration of reactive building elements, building services as well as natural and renewable energy strategies

- Develop tools for the early assessment of the impact of reactive building elements on the environmental performance of buildings
- Develop guidelines for procedures and tools for detailed simulation of environmental performance of reactive building elements and integrated building concepts

2 OBJECTIVES

The aims of this work were to gather information on the building process in HK by interviewing a number of experts in the building sector and asking them for their opinion. The first part of the study looks into the building stock and tries to get a better understanding in respect to the future development.

Then, in order to be able to develop responsive building elements it is necessary to have an overview of techniques that are already known and applied in Hong Kong, what are the prospects are and what kind of information is needed for introduction or further implementation.

Finally, the development of integrated building concepts needs knowledge about how the building process in Hong Kong is organised, which parties are involved, who are the main key players, what kind of integrated building concepts are already applied. Next, information is needed about the future development in Hong Kong. What way will the building sector development, what are the driving forces and accents and which concepts are most favourable to succeed. It is also important to know which information is needed from the work of IEA Annex 44 as an outcome to enhance an integrated design process in Hong Kong.

3 PRESENT BUILDING MARKET AND CUSTOMER CHARACTERISTICS

The urban form of HK is historically dominated by high-rise, high-density buildings either side of Victoria Harbour. Since 1973, new town (Tsuen Wan, Sha Tin, Tuen Mun, Tai Po, Fanling/Sheung Shui, Yuen Long, Tin Shui Wai, Tseung Kwan O, and Tung Chung) were established around historic settlements.

The basic concept for developing a new town was to offer a balanced and self-contained community as far as possible in terms of provision of infrastructure and community facilities. In rural townships, the major focus was to increase and advance the infrastructure and community facilities. In addition, the provision of village flood protection schemes was introduced where necessary. Hong Kong has developed nine new towns since the initiation of its New Town Development Program in 1973 to cope with the increase in population and to improve the living environment by decentralizing the population from the over-crowded urban districts. The target at the commencement of the New Town Development Program was to provide housing for about 1.8 million people in the first three new towns, namely, Tsuen Wan, Sha Tin and Tuen Mun. The population of Hong Kong has risen from about 4.2 million to about 6.9 million.

Planning and development studies have been conducted and the feasibility of different locations in North East New Territories and North West New Territories Development could be shown.

The urban city areas have been increased steadily through reclamation of land from surrounding waters.Reclaimed land was formed to allow growth, to decant existing population and to provide or upgrade facilities to enable the re-development of old run-down areas. There are five major areas of development:

- Central and Wan Chai Reclamation
- Kai Tak Development
- Choi Wan Road and Jordan Valley Development
- West Kowloon Cultural District (WKCD)
- West Kowloon Reclamation

Table 1: Hong Kong Population and Average Annual Growth Rate (CSD 2006)

Population Census/By-census	Hong Kong Population	Net Increase	Average Annual Growth Rate (%)
1991	5 674 114 (1)	178 626	0.6
1996	6 412 937 (2)	543 442 (3)	1.8 (3)
2001	6 708 389 (2)	295 452 (2)	0.9 (2)

Notes : (1) The figure includes 151 833 residents temporarily away from Hong Kong at the time of the 1991 Population Census conducted in March 1991.
(2) The figures are compiled based on Hong Kong Resident Population.
(3) The figures refer to residents present in Hong Kong at the census/by-census moment, including those who were temporarily away from Hong Kong. The population figure compiled on this basis at the 1996 Population By-census was 6 217 556.

Table 2: Mainly used construction methods and materials (results from interviews)

Construction type	Construction methods	Construction materials structure	envelope
Residential	Insitu RC for structure and external walls. Internal walls mainly insitu RC with some use of concrete blocks. The trend, led by Govt., is towards pre-fab pre-cast concrete wall units, fixed to insitu RC structure.	concrete and blockwork	Tiling, Render and paint, granite to high-end units
Non-residential (commercial)	Insitu RC structural frame and core, with curtain-wall outer skin. Minimal use of composite structural systems (i.e. RC core and steel for structural floors or columns) with limited prefabrication, except for facades.	concrete and steel	Tiling, Render and paint, metal panels, granite to high-end commercial
Non-residential (industrial)	Traditionally flatted developments of Insitu RC structure and skin. Some newer facilities using steel as structure with either metal cladding or curtain walls for outer skin (particularly catering for newer “clean” electronic industries or similar). Here, also prefabricated facades are used.	concrete and steel	Tiling, Render and paint, metal panels

The main driving force for the building market in Hong Kong is a lack of residential / offices due to a projected increase in population (CSD 2006). The building market is commercially driven primarily by developer for speculation and profit. Residential development can be distinguished between a Governmental Housing programme, mainly for lower income groups, and private developments targeting mid-high income groups. In this context, there is a trend towards quality improvement and a constant upgrade of living standards and conditions.

Looking at the organisation of a construction project revealed that private sector projects (residential and non-residential) are driven entirely by the development company with decisions being taken by the lead members of the development board. Most developers can finance the bulk of the construction of the project from existing assets and this is topped up with pre-sale revenue. Design teams are the project deliverers following instructions of the developer.

Table 3: Organization of building projects in HK (results from interviews)

building project participants	**Role**
Government	Initiator (responding to a need), sometimes decision maker, financier, property developers, checking, controlling the plan, inspection of work when complete and issue Occupation Permits (OP).
Developers	Initiators (speculation), mainly decision makers, financiers, property developers
International financial institutions / banks	Financiers
Quasi Govt. (MTRC,KCRC, HKHA etc)	Property developers
Design team in the design and construction phase	Deliver a product to meet the developer’s vision or requirements. Occasionally, designers can drive the development, but this is rare. Concept and detailed design are the main role; contract administration during construction phase is required.

The construction market in HK has a number of major local and international players. Most major developers have their own “in-house” contractors. Multi-tier sub-contracting is common with the main contractor acting in a management role only. Private sector projects (residential and non-residential) are driven entirely by the development company with decisions being taken by the lead members of the development board. Most developers can finance the bulk of the construction of the project from existing assets and this is topped up with pre-sale revenue. Design teams are the project deliverers following instructions of the developer.

Usually, the design process is organized as follows:

- Developer gives the idea and then the designer produces the scheme and details. But the planned building use must follow requirements set by Planning Department and lease conditions.
- The next step is submission of drawings to Building Dept (BD) who then does a cursory check on compliance. Other Government Departments (i.e. Fire Services Dept, Water Services Dept etc) issue their own permits / certificates on compliance with specific requirements.
- BD issues Occupation Permits once all certificates are in place.

- Throughout all processes, an “Authorised Person” (AP) must sign that the building works are in compliance. Mistakes by AP’s are considered as criminal negligence.

The following parties are involved in the design process: Developer/project manager, architect, structural engineer, quantity surveyors, Building services consultants/engineers (structural, civil, mechanical, electrical, plumbing and drainage, fire services etc). Sometimes also involve transportation, environmental, lighting, landscape and security consultants.

4 RESPONSIVE BUILDING ELEMENTS AND INTGRATED BUILDING CONCEPTS

While significant improvements in energy efficiency of buildings have been made in the last decade, a great future potential lie within technologies that promote the integration of responsive building elements and communication among building services. In this context building construction elements which are actively used for transfer and storage of heat, light, water and air become highly important. Construction elements (like floors, walls, roofs, foundation etc.) can be logically and rationally combined and integrated with building service functions such as heating, cooling, ventilation and lighting. This requires concepts or solutions where responsive building elements together with energy systems are integrated into one system to reach an optimal environmental performance in terms of energy performance, resource consumption, ecological loadings and indoor environmental quality.

4.1 Responsive Building Elements

Responsive Building Elements (RBE) are defined as building construction elements which are actively used for transfer and storage of heat, light, water and air. This means that construction elements, like floors, walls, roofs, foundation etc., are logically and rationally combined and integrated with building services systems such as heating, cooling, ventilation and lighting. The following RBEs have been considered:

- Earth coupling (EC); the basic principle is to ventilate air to the indoor environment through buried ducts in order to exploit the seasonal thermal storage ability of the soil. This enables a cooling effect of hot summer air and a heating effect of cool winter air.
- Phase Change Material (PCM); PCM are suitable materials that undergo a phase change at ambient temperature. The basic principle is to exploit their capability of storing large amounts of heat and therefore to smooth and shift cooling/heating loads.
- Thermal mass (TM); it is defined as the mass of the building that can be used to store thermal energy for heating/cooling purposes. TM can be effectively used to reduce outdoor temperature fluctuations and thus offers the opportunity to manage energy flows in the building efficiently.
- Ventilated facades (VF); the working principle is to use the air gap between the two glazed panes to reduce the thermal impact on the indoor environment.

- Dynamic insulation wall (DIW); the concept combines conventional insulation with heat exchange characteristics of an outer wall allowing an effective preconditioning of ventilation air while achieving better indoor air quality.

The survey found that with EC and VF only two RBEs are known in Hong Kong and have been applied. Previous studies focused on a survey of existing office buildings in HK with VF concepts and found six projects. Several ventilation concepts of VF have been identified and extensive simulation exercises have been undertaken (ref. Haase) in order to find the optimum working conditions for warm and humid climate.

When asked for the main driving forces for application of responsive building elements 5 different reasons were given as shown in Table 4.

Table 4: Driving forces for application of RBEs (results from interviews)

	EC	**VF**
Whole life costs		*X*
Reduced plant space		*X*
Image	*X*	*X*
Others:		
Energy	*X*	*X*
Regulations (OTTV)		*X*

When asked for the main barriers the following reasons were given:

- Lack of information
- Lack of incentives
- High capital cost
- Lack of competition between suppliers
- Lack of guidelines and design tools
- Lack of practical demonstrations
- Lack of cooperation between designers

In general, all of these reasons are valid for not encouraging innovative and energy-efficient designs. Many buildings when constructed are then sold on, so developer does not have long-term considerations.

4.2 Integrated Building Concepts

Integrated Building Concepts are defined as design solutions where responsive building elements together with energy systems are integrated into one system to reach an optimal environmental performance in terms of energy performance, resource consumption, ecological loadings and indoor environmental quality.

The design process in HK tends to be very traditional with each consultant doing his own work. Very few driving forces at present encourage integrated design. Since the main factors cost and time dominate there is a tendency towards improvement of quality, failure reduction, cost reduction. Foreign companies bring in an image factor that might lead to integrated design and environmental concerns.

- Time consuming /Too much hassles
- Clients / developers / consultants do not see benefits
- Lack of Project Management skills
- Lack of market demand
- Lack of regulations

5 FUTURE BUILDING

The survey found that in order to apply RBEs in the future the following issues have to be solved:

- Cost reduction
- Better information
- Change of building regulations
- Increase of energy prices
- Better availability
- Increase of awareness
- Further technical development

For the application of RBEs in future building projects adequate integrated building concepts have to be developed. Table 5 shows the most important aspects for those future concepts.

Table 5: Important aspects for future concepts (results from interviews)

Aspect	Not important	Minor important	Important	Highly important
Energy			X	
Indoor climate			X	
Comfort			X	
Health				X
Cost reduction		X		
Quality improvement			X	
Improved productivity			X	
Failure reduction during construction			X	
Prefabrication		X		
Industrial building		X		
Reduction of construction time				X

6 CONCLUSIONS

This paper introduced the ideas of this collaborative work within the framework of the Annex44 of the International Energy Agency (IEA) and discusses its usefulness for Hong Kong and China. Special focus was put on the description of the state of the art of the application of responsive building elements and of integrated building concepts in Hong

Kong. A number of interviews of key players in the construction industry in Hong Kong revealed that not many of the established responsive building elements have been applied. Only ventilated facades and Earth coupling have been used in HK. This is mainly due to lack of information, lack of incentives, high capital cost, lack of competition between suppliers, lack of guidelines and design tools, lack of practical demonstrations, lack of cooperation between designers. On the other hand energy efficient installations are increasingly applied (heat pumps in combination with energy storage, balanced ventilation with heat recovery, cooling towers etc.).

Further studies of ventilated facades will be conducted in order to identify their potential especially in combination with other RBEs in HK.

In most cases there is no integrated design process for building projects. This means that projects are developed and designed in accordance with the energy performance calculations based on economic energy saving measures. Future building concepts will have to take as highly important aspects Health and Reduction of construction time into consideration. Further important aspects are Energy, Indoor climate, Comfort, Quality improvement, Improved productivity, and Failure reduction during construction.

A few good examples have also been identified (Wetland Park, New emsd HQ). Together with the promotion of future outcomes of the work within the Annex44 it is hoped that this will have a positive impact on the future building design process.

7 FUTURE WORK TO BE DONE

Improvement of concepts for responsive building elements

- Qualitative and quantitative investigation of environmental performance of existing technologies by means of case studies and site measurements, laboratory tests and simulation exercises
- Development and optimization of improved concepts and technologies, especially with regard to implementation in integrated building concepts
- Analyses of robustness and performance sensitivity to differences in boundary conditions (outdoor climate, building use, occupant behavior)
- Control strategies and implementation strategies in integrated building concepts

The results will be:

- State-of-the-art of responsive building elements, experimental procedures and application of simulation tools
- Responsive building elements with improved environmental performance and guidelines for their optimal use
- Improved implementation strategies for responsive building elements in integrated building concepts
- Guidelines for application of methods and tools for estimation of environmental performance of responsive building elements
- Information on experimental procedures for evaluation of environmental performance of responsive building elements
- Documentation of results

- Manufacturers’ Guide: Guidelines for development, optimization and performance assessment of responsive building elements including examples of application in integrated building concepts

Development and environmental performance assessment of integrated building concepts

- Define performance criteria for integration of responsive building elements in different types of buildings
- Develop and optimise control strategies at system (building) level and communication with BEMS or other building services systems
- Develop new integrated building concepts according to differences in building type, building use, occupant behavior, climate, location, energy sources, services, etc., based on environmental performance assessment,
- analysis of performance sensitivity and cost analysis.

8 REFERENCES

Annex32. (1999). "Integral Building Envelope Performance Assessment." International Energy, Agency. Energy Conservation in Buildings and Community Systems Programme. http://www.ecbcs.org/annexes/annex32.htm. Accessed on October 2006

Annex35. (2002). "Control Strategies for Hybrid Ventilation in New and Retrofitted Office Buildings (HYBVENT)." International Energy, Agency Energy Conservation in Buildings and Community Systems Programme. http://www.ecbcs.org/annexes/annex35.htm. Accessed on 23 October 2006

Annex37. (2003). "Low Exergy Systems for Heating and Cooling." International Energy, Agency Energy Conservation in Buildings and Community Systems Programme. http://www.ecbcs.org/annexes/annex37.htm. Accessed on 23 October 2006

Annex44. (2006a). "Introduction to the Annex44 work - Scope and objectives." International Energy, Agency Energy Conservation in Buildings and Community Systems Programme. http://www.civil.aau.dk/Annex44/. Accessed on 23 October 2006

Annex44. (2006b). "State of the Art report." International Energy Agency Energy Conservation in Buildings and Community Systems Programme. http://www.civil.aau.dk/Annex44/. Accessed on 23 October 2006

CSD. (2006). "Hong Kong statistics." Census and Statistics Department, HK. http://www.censtatd.gov.hk/home/index.jsp. Accessed on 23 Oct 2006