เอกสารประกอบรายงานฉบับสุดท้าย

ภาคผนวก ก , ข

โครงการ
การวิจัยประยุกต์ ประกอบการออกแบบ
อาคารประหยัดพลังงาน

เสนอต่อ

กรมพัฒนาและส่งเสริมพลังงาน
กระทรวงวิทยาศาสตร์และเทคโนโลยี

โดย

สถาบันวิจัยพลังงาน
จุฬาลงกรณ์มหาวิทยาลัย

26 กรกฎาคม 2539

เล่มที่ 2

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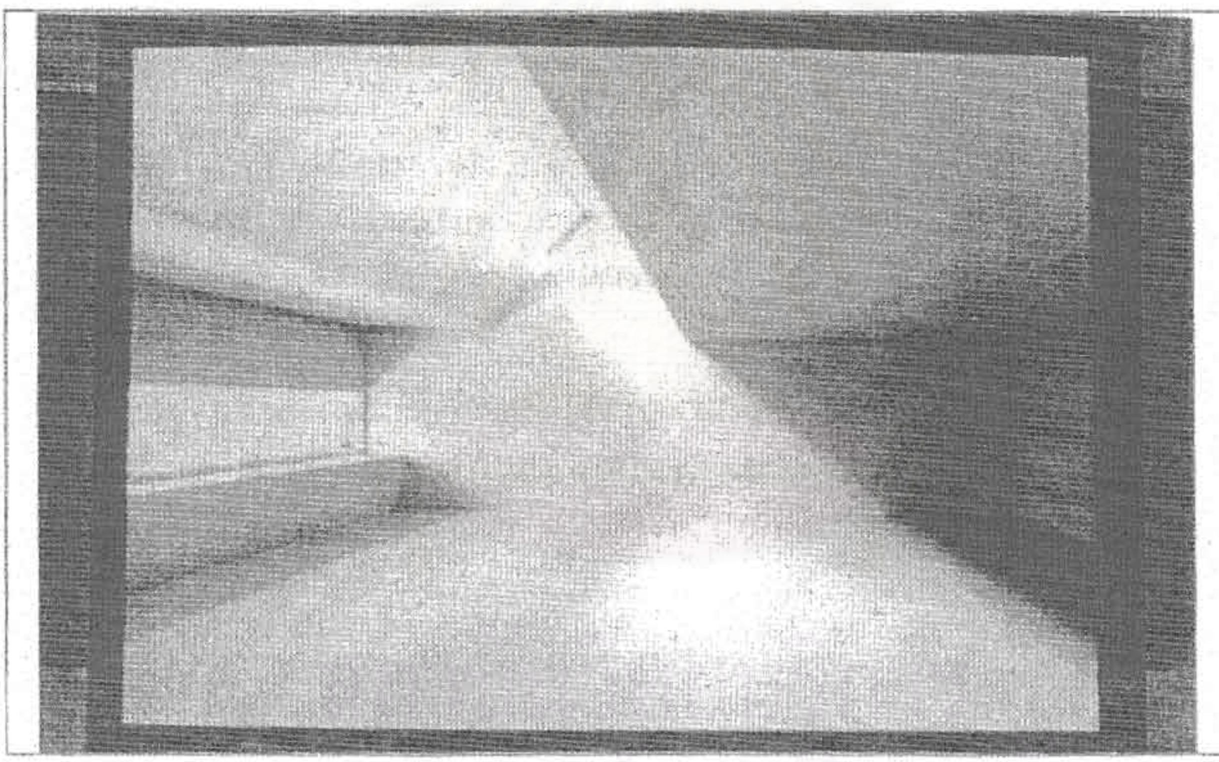
การจำลองสภาวะทางแสงธรรมชาติด้วยโปรแกรมคอมพิวเตอร์
อาคารอนุรักษ์พลังงาน

Danish
Environmental
Protection
Agency

DANCED
Danish Cooperation
for Environment
and Development

Technical Assistance Report
for
Energy Optimization of Energy Saving House
Bangkok - Thailand



By
Esbensen Consulting Engineers FIDIC, Denmark

May 11-19 1995

สารบัญ

ภาคผนวก ก การจำลองสภาวะทางแสงธรรมชาติด้วยโปรแกรมคอมพิวเตอร์ อาคารอนุรักษ์พลังงาน

Contents **Page**

สารบัญ

ภาคผนวก ข การจำลองสภาวะทางแสงธรรมชาติด้วยโปรแกรมคอมพิวเตอร์ อาคารอนุรักษ์พลังงาน

Contents **Page**

0. List of acronyms and abbreviations

ADELINE	Advanced Daylighting and Electric Lighting Integrated New Environment
ASHRAE	American Society of Heating, Refrigerating and Air-conditioning Engineers
BMS	Building Management System
DANCED	Danish Cooperation for Environment and Development
DEDP	Department of Energy Development and Promotion
ECPA	Energy Conservation Promotion Act
EEC	Environmental Engineering Consultants Co. Ltd., Bangkok
ERI	Energy Research Institute, Bangkok Thailand
HF ballast	High Frequency ballast
IEA	International Energy Agency
VAV	Variable Air Volume
VDU	Visual Display Unit

Technical Assistance Report
for DEDP Energy Efficient Demonstration Building
Bangkok - Thailand

By
Christina E. Madsen and Henrik Sørensen
Esbensen Consulting Engineers FIDIC, Denmark

DANCED MISSION May 11-19 1995

1. Executive Summary

The 6000 m^2 Energy Efficient Office Building of DEDP Thailand is planned for construction 1995-1996 and the DANCED team is convinced that the building in its design will be one of the most visionary and energy efficient buildings in the region.

DANCED under the Danish Ministry of Energy and Environment has offered technical assistance to DEDP now under two missions from Danish experts in energy efficient building design. Brief of first mission was call for recommendations and evaluation of the energy concepts of the building. Brief of current mission has been to assist in more technical specific issues, among others to identify critical components of the building and exploit the possibilities of detailed computer energy simulations to assist the design team in making specifications and verification of the innovative design strategies of the building.

The findings and recommendations of the mission are summarized below and described in more detail in the enclosed report:

Design concept verified — The general project evaluation and computer simulations on daylighting and thermal performance of the building verified the overall design philosophy of the building. Especially the improved comfort possibilities by means of very conscious control of indoor climate and the awareness of the importance of insulation and moisture control in the building was identified being critical to the function of the building.

Daylight simulations — Daylight simulations of the office space show very promising results with respect to potential energy savings due to utilization of daylight. The DANCED team is very convinced about the lighting design, and sees no further need for changes in the building envelope in order to improve daylight utilization. Though care must be taken in the design of the interior of the building because potential sources of glare were identified in the daylighting simulations of the office areas in the building. Especially the wall area near the skylights in the office section should be considered.

Systematic specifications — By systematic analysis of the functional differences of the building, 10 different room categories were identified and marked on plans. The DANCED team has to each of these categories specified design parameters to aim for during detailed design and tendering in order to ensure the right properties of the components and systems employed in the building.

The specifications have been formalized into a set of forms, and it is the recommendation of the DANCED team to introduce these forms to all members of the design team in order to define a common basis for detailed specifications of the building.

Tendering — Due to the very tight time schedule for finishing tendering documents the DANCED team strongly recommends to form tendering documents in a flexible manner allowing for optional bids, predefined formats for pricing including break down of total bids and options for the client to choose between bids according to other criteria than lowest price exclusively.

Monitoring — In order to be able to monitor the energy performance of the building and its components the DANCED team suggests to include the acceptance from the companies to do so already in the tendering documents. Detailed recommendations on the procedure are listed in the report together with general guidelines on monitoring programmes and the use of Building Management Systems.

The overall recommendation of the DANCED team to the ongoing phase of detailing the building for tendering is to emphasize the circulation of more standardized documentation formats in order to improve the communication possibilities between the design team members. Also the use of companies as information sources for deciding on the detailing of the building is to the experience of the DANCED team a valuable and time saving strategy in the current phase of the project.

Ms. Christina E. Madsen — Henrik Sørensen

2. Introduction

The current report documents the findings and recommendations of work carried out by the DANCED team during the mission in Bangkok May 11-19 1995. Work was carried out in close collaboration with the architectural design team of the building (Dr. Soontorn and Ms. Surprenant). The primary issues for the mission were the identification of critical parameters to the energy saving measures in the building and detailed energy performance simulations, according to the Terms of Reference included in Appendix 1 of this report.

The report consists basically of two parts:

1) Text part with the documentation on all findings and conclusions on the work carried out.

2) Appendices including Terms of Reference for the current mission and Building Design Data Sheets designed for the current project to be used in the ongoing process of specification of the building parts towards tendering.
In Appendix 3 an agenda for a design meeting 16th of May with the EEC engineering company is listed.

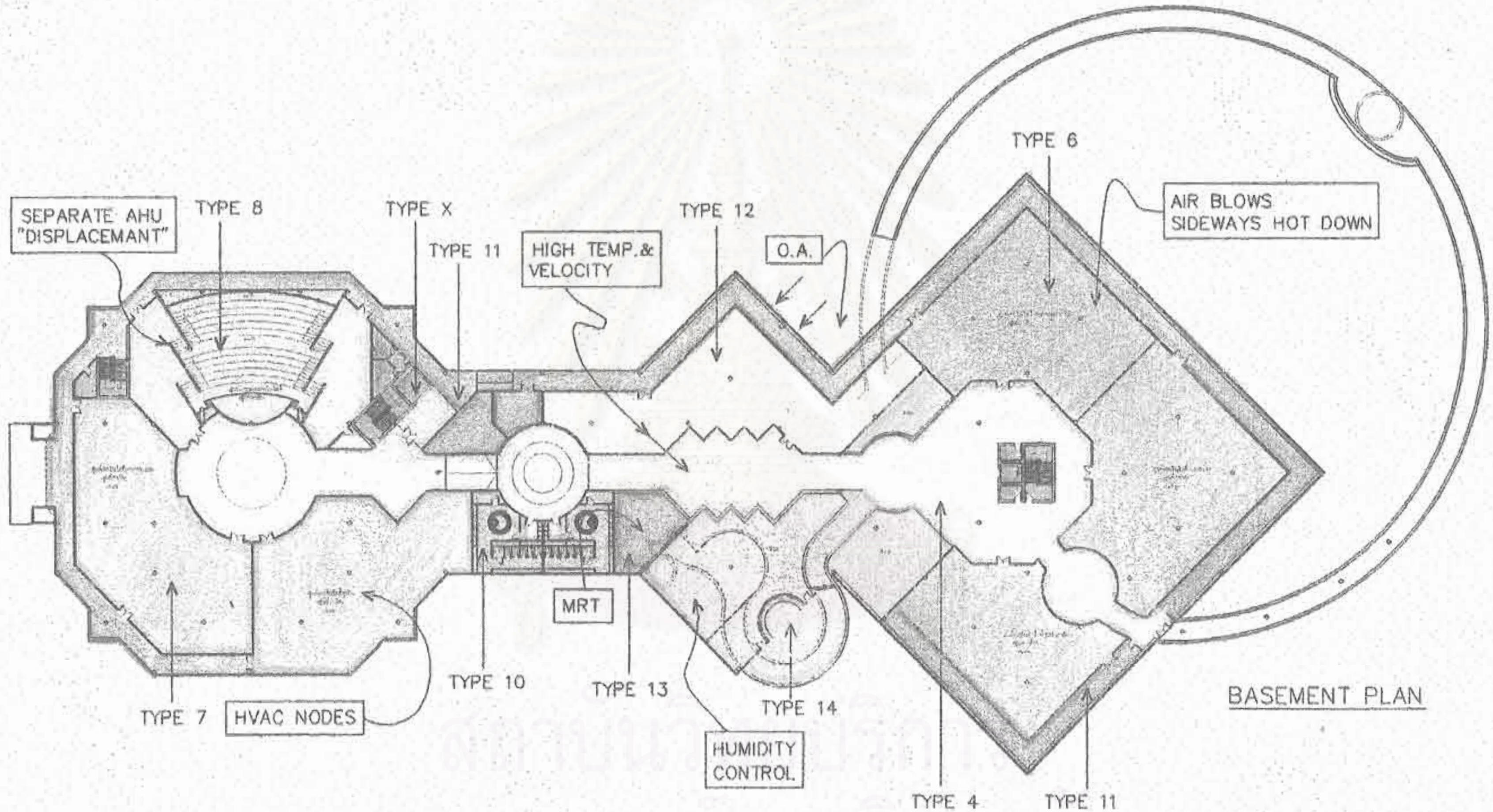
3. Specifications of energy design

In the overall concept of the building a primary issue is the use of the building as an integrated part of the energy system in the building. This approach seems in the current project to be a prerequisite to meet the energy saving goals of the project.

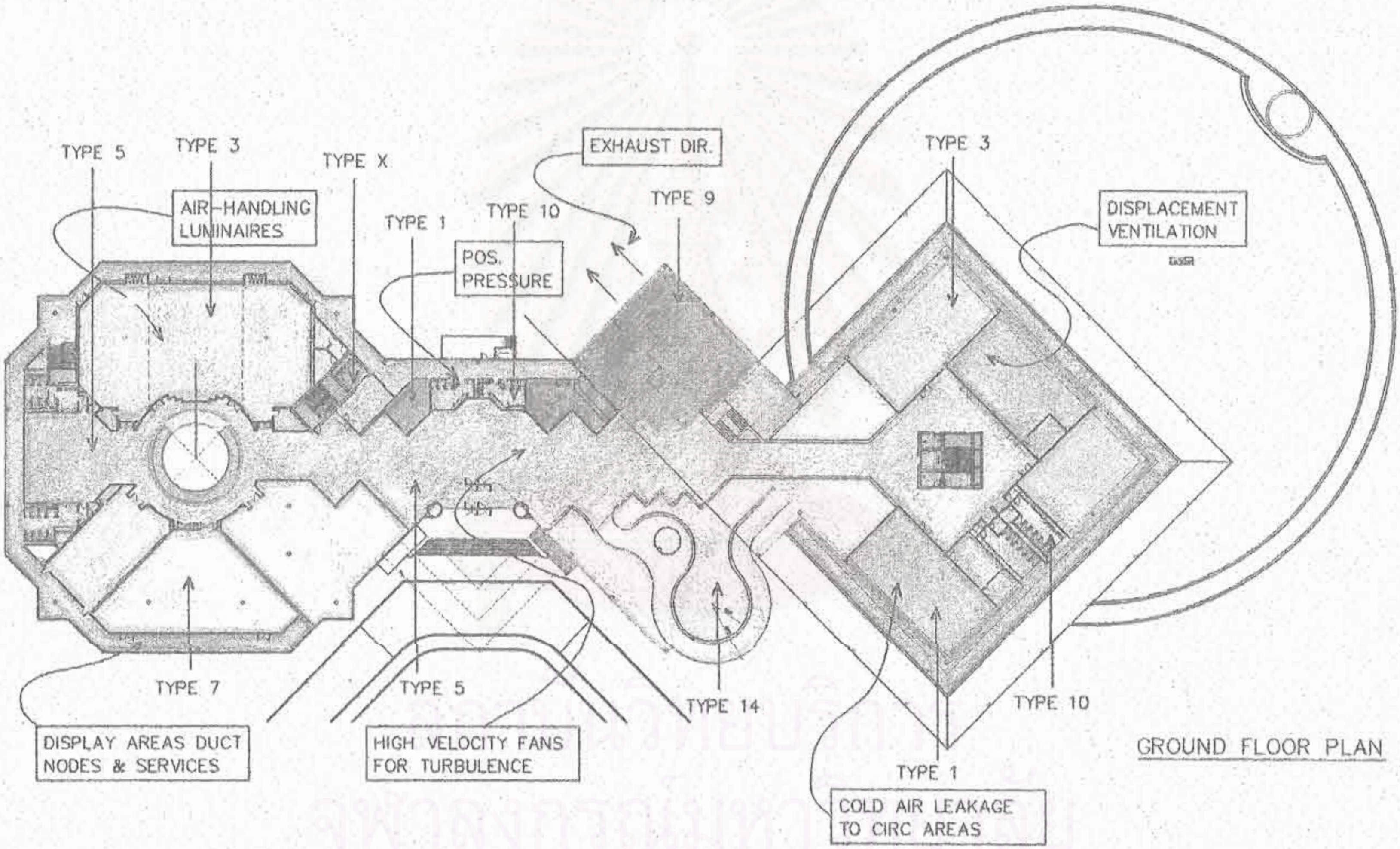
In the overall design of energy efficient buildings, is it the experience of the DANCED team, that an extra investment in not direct usable floor area for optimization of natural energy flows can turn out to be very profitable during the lifetime of the building with respect to saved running costs (energy savings). I.e. instead of the investment in surplus machinery for the building the investment can be in extra space needed for the building itself to contribute to the natural energy flows in the interior.

In the following coloured plans the building has been characterized by a number of principal room categories. The purpose of this systematic approach has been to identify and verify the energy concepts and energy flow paths in the building and to identify areas where less demanding areas with respect to thermal comfort could benefit from controlled leakage from adjacent rooms with higher comfort requirements. In this way the cooling energy added to the building will be utilized to the maximum extend and users and visitors will feel thermal, visual and acoustic comfort in the building. The room categories identified in the building are:

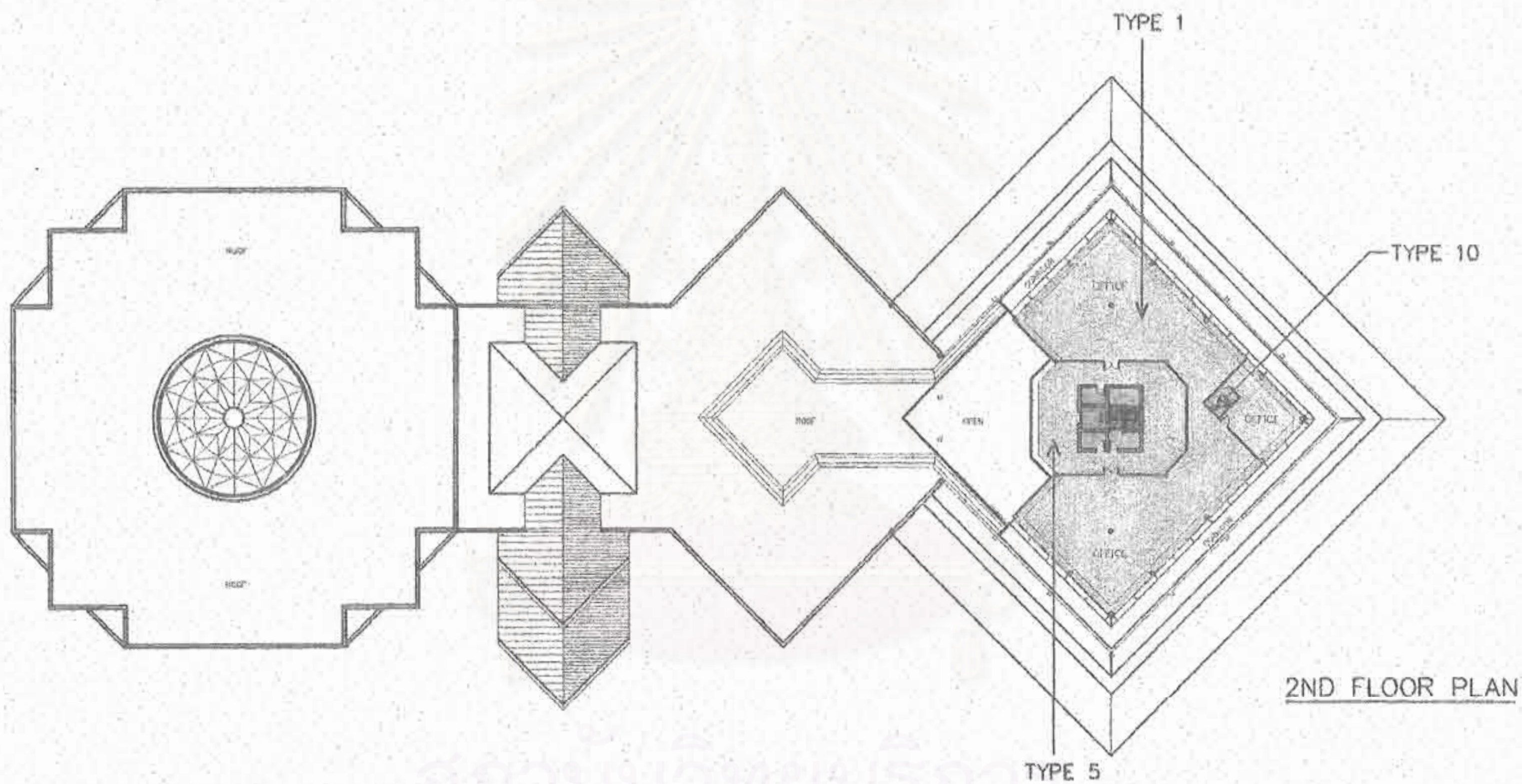
Type 1	Office areas, permanently occupied
Type 2	Offices, occasionally occupied
Type 3	Seminar and meeting rooms, occasionally occupied
Type 4	Corridors and circulation space at basement level
Type 5	Corridors and circulation space above basement level
Type 6	Exhibition areas, low internal heat gains
Type 7	Exhibition areas, high internal heat gains
Type 8	Lecture theatre at basement level
Type 9	Restaurant and catering area
Type 10	Lavatories
Type X	Other rooms specified on sheet



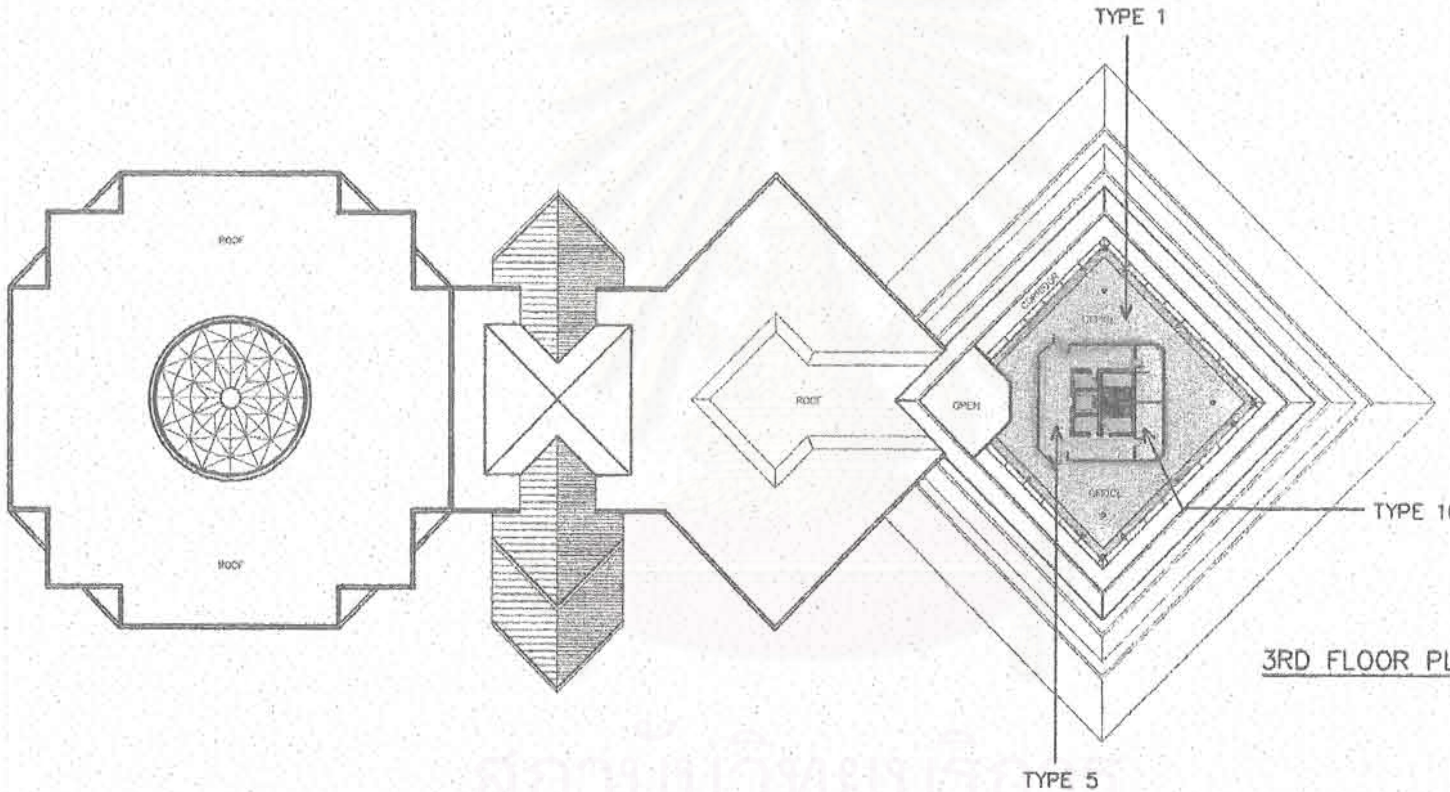
BASEMENT PLAN



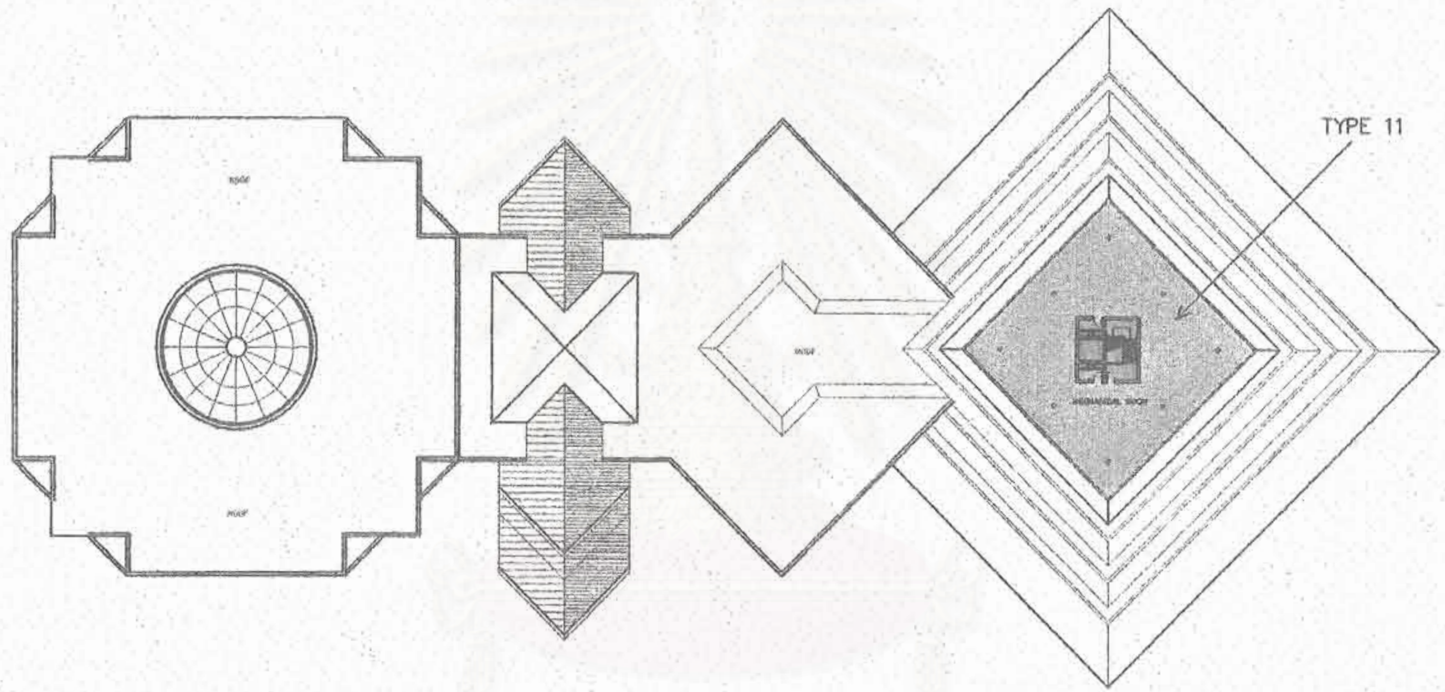
GROUND FLOOR PLAN



2ND FLOOR PLAN



3RD FLOOR PLAN



MECHANICAL FLOOR PLAN

The possible interaction between the areas in each room category, can be summarized as follows:

The requirements for comfort in zones with permanent occupancy and low activity level are the design situation for the air conditionering system of the building with respect to control of air flow, low temperature and good air quality. Contrary to this, obtaining good indoor climate within the circulation space of the building is possible by using several strategies, because occupants in these areas can accept higher air velocities and are less critical to variations to the comfort level obtained.

This approach developed by the Thai design team is a general and visionary concept to which the DANCED team can give its full recommendation. The principle of using conscious control of all parameters influencing the indoor climate will certainly give a more flexible control strategy of the building. The concept is also in line with both the ASHRAE standards for indoor climate and the work of leading indoor climate experts like Dr. P.O. Fanger (DK).

3.1 Building design data sheets

The layout of the forms listed in Appendix 2 is based on design documentations from energy efficient buildings in Europe, where a similar integrated approach on building design has been used. In the forms included in Appendix 2 all data have been revised in order to specify the situation of the current building under Thai climate. Aim of the forms are to document and consolidate the goals and requirements of the building and its systems in order to achieve an optimized energy design. The forms have been filled in according to the zone-based description of the building, data known from the concept of the building and data calculated using advanced computer design tools during the mission.

The contents of the forms cover both the special and general requirements for each room category with respect to among other indoor air quality, expected occupancy level, required control strategy for critical components etc. This principle of making general specifications for energy efficient buildings is strongly recommended by the DANCED team in order to get the best coordination of design aims within the architectural and engineering design team.

The format of the sheet shown in Appendix 2 is a layout found by the DANCED team to cover the most critical parameters of the design concept. But it is also the recommendation from the DANCED team, that the forms should be extended to also cover other issues of the building design e.g. interior design, requirements for already known equipment to be exhibited in the building etc.

The detailed description of the contents of the forms is included in Appendix 2.

3.2 Daylighting

The daylight calculations are carried out using the ADELINE-package (Advanced Daylighting and Electric Lighting Integrated New Environment), which is a lighting design and analysis computer tool developed under the International Energy Agency (IEA) - Solar Heating and Cooling - Task 12: Building Energy Analysis and Design Tools for Solar Applications.

ADELINE, which consists of more programmes, produces innovative and reliable lighting design results by processing a variety of data (including geometric, photometric, climatic, optic and human response data) to perform light simulations and to produce comprehensive numeric and graphic information. Both daylighting and artificial lighting problems can be solved.

Radiance is the most sophisticated programme in the ADELINE-package. With Radiance it is possible to perform advanced lighting calculations of daylight factors, glare indices, contrasts and to produce photo realistic pictures.

The DANCED team has evaluated the building to find the needs for detailed daylight modelling. An office at ground floor was selected due to the large energy saving potential for this kind of rooms to find out how big this potential is in the actual case and to evaluate the lighting conditions regarding contrasts. Further more the dome was selected to find out if the lighting level due to daylight at basement level under the dome is sufficient.

Daylight simulation of a typical office space

The selected office is a south-west facing office at ground floor, modelled under overcast sky conditions. Daylight can enter the room through two openings in the building envelope: Through a vertical window in the facade and through a skylight placed a third of the room depth into the room from the facade. In the upper floors the room depth is decreasing. The ground floor offices which are modelled here are with respect to daylight the most difficult part of the building to solve.

The calculations are carried out using the following reflectance for the internal surfaces:

Floor:	60%
Walls:	70%
Ceiling:	80%

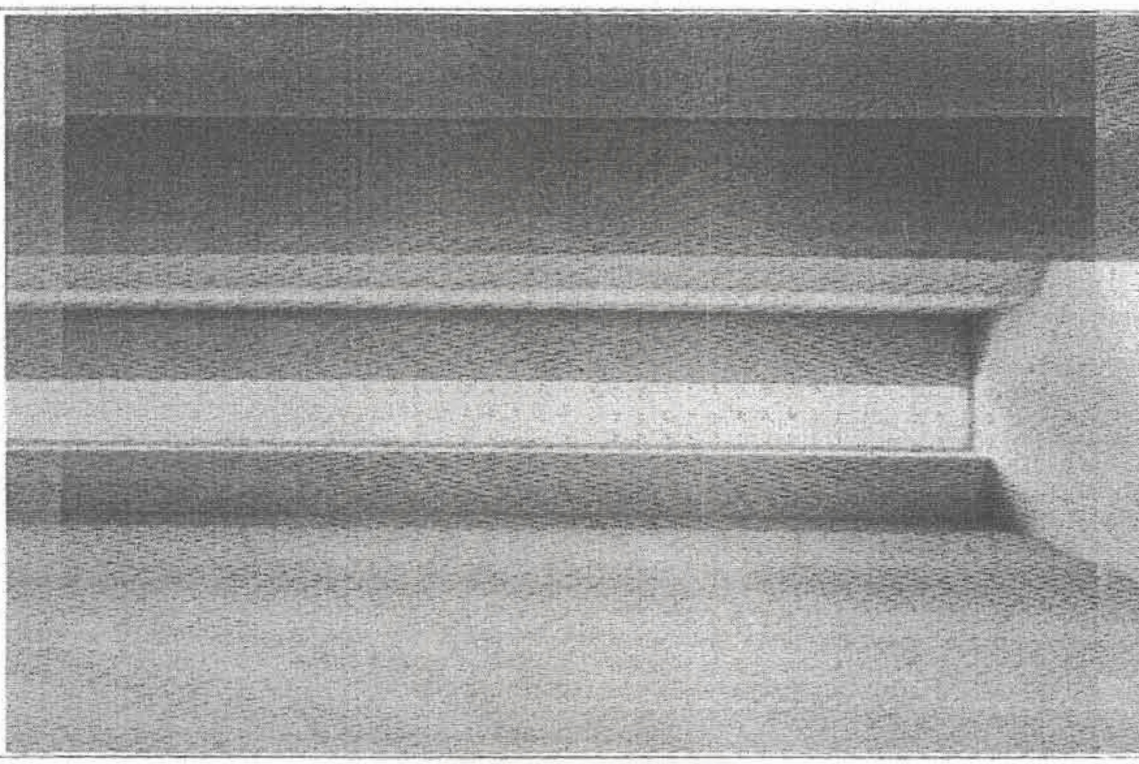
The transmittance of visible light through the windows was as default selected to 80%, which is the transmittance of a normal 2 layer pane. If another glazing with a smaller transmittance is being selected the absolute daylight level will decrease, but the relative distribution of light in the room will be maintained. In other words the images presented in the following showing the light distribution in the rooms are valid also for other choice of glazing.

In general it is possible to decrease the solar transmittance of the glazing by selecting other glazing to decrease the solar gains. This will also cause a decreased light transmittance, and if this is considered, it is important that the selection is done between windows with clear glass to ensure that the colour rendering in the room are not changed due to a coloured glass.

When selecting a window it is important to find one, which has as high a light transmittance as possible to be sure having a high energy saving potential and a low solar transmittance to lower the solar gains and the need for cooling. The need for daylighting throughout the day will have preference for the extra costs in solar shading since these are only in function at specific times during the day because all office areas are very well shaded due to the overhang constructions of the pyramid.

Radiance images

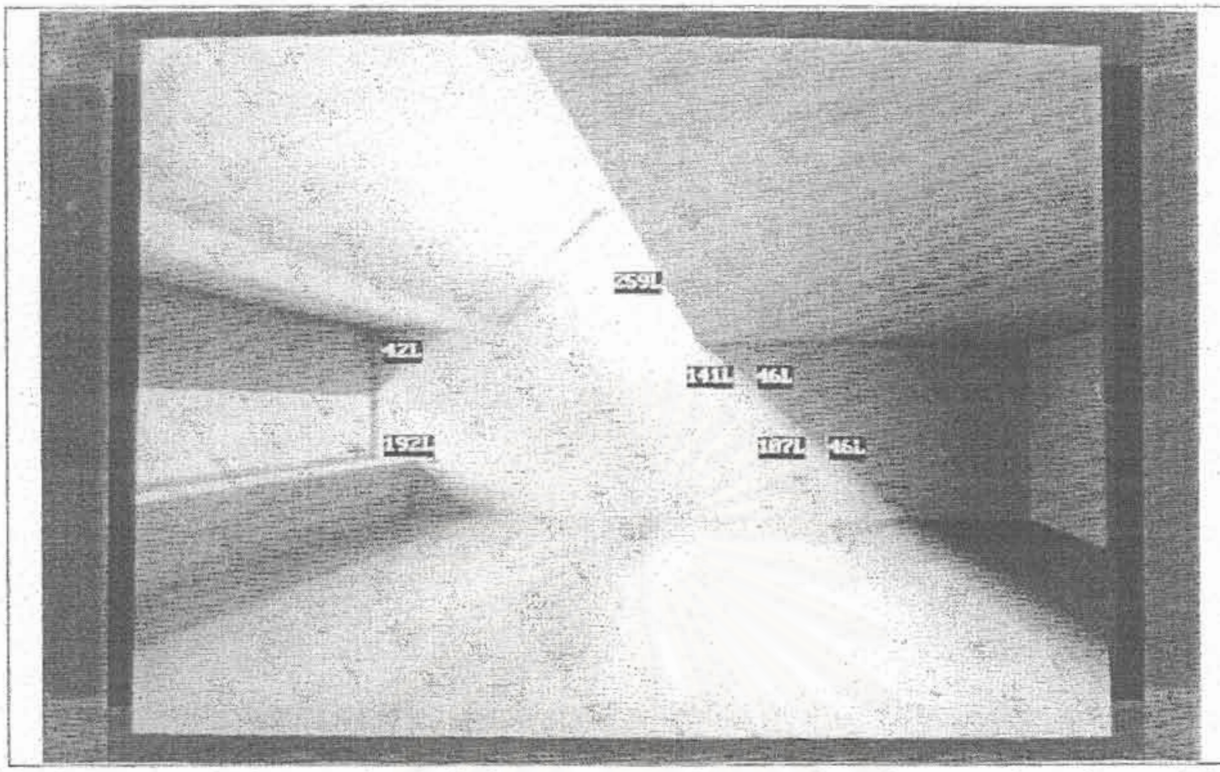
The following 3 pictures are images produced by the DANCED team using Radiance. The first picture shows the visual impression of the office when entered in the back of the room. The person is not able to get a direct view to the skylight, only the sidelight in the vertical facade can be seen. The ceiling at the back of the room is darker than the ceiling close to the facade due to the large room depth.



Radiance image showing the office seen from the back of the room when entering

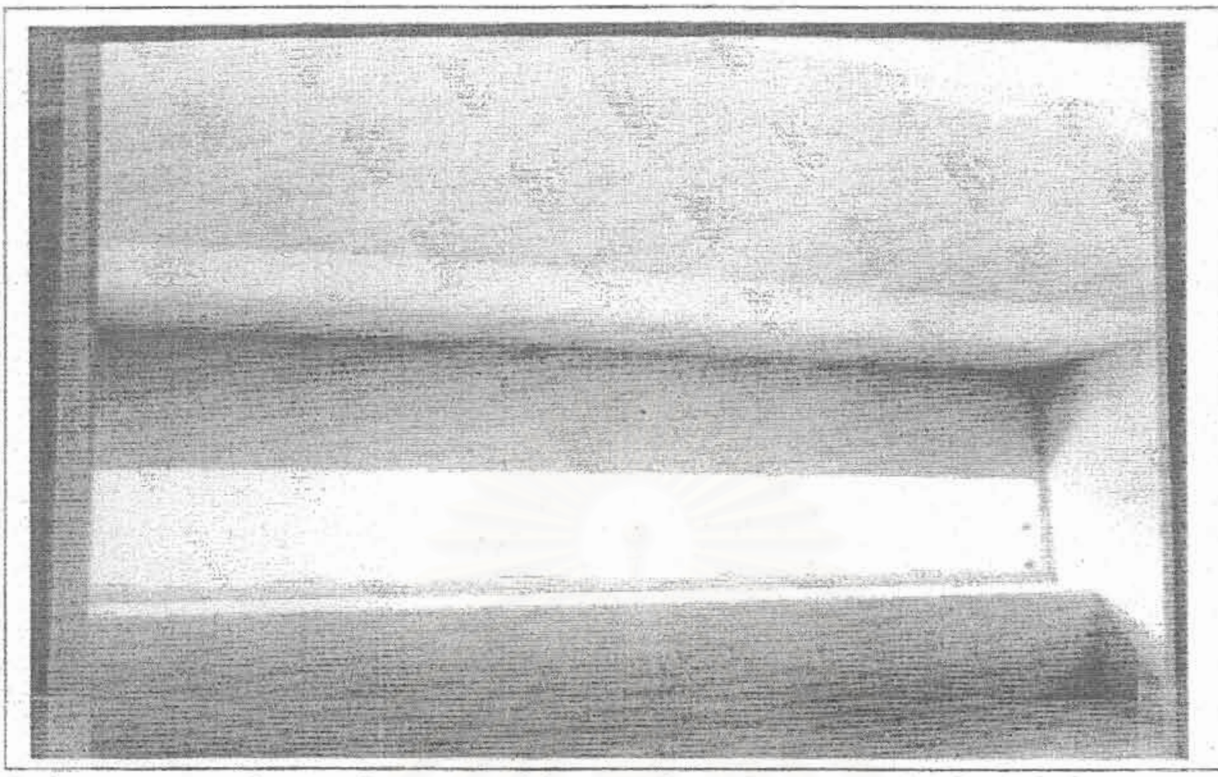
In the view of the room seen parallel to the facade the importance of the skylight to the total lighting level in the room can be seen. In the current configuration of the skylight there is no additional light directing devices installed in connection with the skylight, which could even out the intense contrast on the wall between the area under the skylight and the interior in the room depth.

The numbers shown on the image are luminance in candela/m^2 which is a measure for the brightness of the surface. The contrast in the area under the skylight is illustrated as the differences in luminance values. The maximum allowable ratio between to adjacent points will normally be 1:3, which is exceeded near the ceiling close to the skylight. It is therefore important that the placing of desks and book shelves is considered in detail, since this can help to even out the contrasts.



Radiance images showing the daylight coming into the room from the vertical window and the skylight. The figures are luminance values measured in cd/m².

The last picture is a view to the corner of the room, looking up to the skylight. The window wall over the window is dark compared to the bright window area and it is important to make calculations of the contrasts if other reflectance are used during the construction phase, due to a change of some of the materials. As calculated the maximum allowable ratio between luminance is not exceeded.



Radiance images showing the corner of the room from a location under the skylight

To see the daylight level in the office the daylight factor is calculated and shown in the figure to the right. The figure does only consist of half of the office, since this is symmetric. The daylight factor is the percentage of illuminance at a horizontal level inside compared to the horizontal illuminance outside at same level. At the figure it can be seen that the illuminance level due to the daylight is very even in the half of the room close to the windows, but in the back of the room it is decreased dramatically. A day-

1,0	1,1	1,2	1,3	1,3	1,4	1,4	1,4	1,4
1,1	1,2	1,3	1,4	1,5	1,5	1,5	1,5	1,5
1,4	1,5	1,6	1,6	1,6	1,7	1,7	1,7	1,7
5,4	6,0	6,5	6,9	7,2	7,2	7,4	7,5	7,5
6,8	7,6	8,0	8,6	8,7	8,9	9,3	9,1	9,2
6,2	6,8	7,3	7,5	7,8	7,9	7,9	8,0	8,1
5,1	5,8	5,9	6,2	6,3	6,4	6,4	6,4	6,5
5,7	6,4	6,8	7,0	7,1	7,1	7,2	7,3	7,1
7,7	8,5	8,9	9,2	9,3	9,3	9,3	9,3	9,4

Daylight factors calculated for the office section in the pyramid. Only half the room is illustrated because of symmetry in lighting level.

light factor of 5% or more ensures that the artificial light can be turned of in more than 95% of normal working time from 9 a.m. to 5 p.m. In the back of the room where the daylight factor is less than 2% it would be a good idea to place the VDU work since direct sun at the screens can cause glare problems if placed close to the window.

Daylight simulations of the dome

For the dome the same internal surface reflectance were selected. The glazing is 1 layer safety glass with a light transmittance of 90%. The daylight factors are calculated for the basement level, which is partly covered by the circulation area at ground level. In the figure to the right the calculated daylight factors are shown for a quarter of the dome. It can be seen that the daylight factors are decreasing without fluctuations. Even though the daylight level is low in the basement it will most of the time be sufficient to lit the circulation space under the dome, since only at low illumination level is necessary.

2,4	[illegible]	[illegible]	2,2	2,0	1,8	0,5	0,4
2,4	2,4	2,3	2,2	2,0	1,8	0,5	0,4
2,5	2,3	2,2	2,1	1,9	1,7	0,5	0,4
2,2	2,2	2,0	1,9	1,8	0,5	0,4	0,4
2,0	2,0	1,9	1,8	0,5	0,5	0,4	
1,8	1,8	1,7	0,5	0,5	0,4		
0,5	0,5	0,5	0,4	0,4			
0,4	0,4	0,4	0,4				

Daylight factors calculated for the basement level directly under the dome. Only one quarter of the circular area is shown due to the symmetry of the light distribution.

4. Monitoring of building performance

In order to gain information and documentation on the energy performance of the building, it is recommended to take considerations on monitoring into account already prior to tendering of the electrical systems of the building. It is the experience of the DANCED team, that the use of the BMS (Building Management System) of the building for monitoring tasks (sampling of data, storage, reporting etc.) can be the most efficient way to document performance of energy efficient and innovative buildings. In order to do so a number of things regarding the design of the electrical controls must be considered:

4.1 Choice of sensors

For controlling the normal operation of the building a large number of sensors will have to be installed. These sensors can also be used for monitoring purposes, because these sensors are not giving combined sensor signals, as e.g. comfort sensors. For the monitoring it is preferable to get separate signals on temperature, moisture etc. and let algorithms in the BMS system perform the necessary calculation of the control signals to run the building and at the same time sample the sensor signals for systematic evaluation of the building performance.

A consequence of this approach is that all sensor signals must be available at the central BMS station (often a powerful PC). Compared to a normal BMS wiring this may lead to extended wiring need for the BMS system, but compared with the need for wiring to separate dataloggers and the tedious collection and evaluation of decentralized monitoring results, the BMS solution is considered to be very advantageous in this building.

This approach will also have a valuable demonstration effect for designers of new buildings, because the aim of the Energy Conservation Promotion Act to make systematic control of the energy consumption of buildings, can be very efficiently carried out by using the BMS, since all data needed to do so are available at a central point in the building.

4.2 Monitoring programme and sampling rates

The set up of a monitoring programme for the building is important for the process of making the detailing of the BMS system. A monitoring programme should basically consist of a listing of the energy saving features of the building and a list of effects which are expected. Using this list a set of physical properties, describing the key values needed to evaluate the effects, should be defined. These properties are the ones, that the BMS system should be capable of monitoring. The sampling rates should be comparable with the time constants of the property monitored, i.e. properties with frequent fluctuations which has large impact on the energy performance should be sampled more frequently than less fluctuating properties.

4.3 Grouping of supply systems

The total energy consumption in terms of energy and water delivered to the building can be monitored where the main supply systems enter the building. These monitoring signals must also be sampled via the BMS so that all monitoring results can be collected at the central BMS station. In the design of the electrical wiring system for the electrical main supply (220 V AC) it is important to separate the electrical groups used for artificial lighting, fans, pumps, cooling equipment etc., so that the electricity consumption for each of these components can be monitored separately via the BMS system.

4.4 Special requirements for tendering of BMS for the building

The above mentioned requirements for using the BMS as the central part of the monitoring must be included in the tender specifications of the BMS for the building. The manufacturer should provide a description on how the system he proposes as a bid for the BMS will fulfill the requirements of the specification. Especially the flexibility of having different types of data for different periods available from the system and the possibilities for getting the data from the BMS in a common data format for further processing of the monitoring results are important. Also the necessary training for the personnel who is going to operate the BMS and use it for producing monitoring results should be included as part of the requirements in the tendering material.

Because of the innovative features of this building there may be some aspects of the building operation which might turn out to need more monitoring or dataprocessing. It should be emphasized in the tendering material that the bidding companies must provide documentation on how the BMS can be extended in operation, number of control nodes, data capacity etc. so the building can remain flexible in operation in spite an increase in the requirements for the BMS system.

Standards for defining monitoring programmes are available in Europe and the United States, and can be used as a basis and checklist for the monitoring programme of this building. The DANCED team will provide references for this as part of the follow up possibilities described in the Terms of Reference.

5. Tendering procedures

Because of the very tight time schedule for the sending out of tendering material it is considered of prime importance by the DANCED Team, that the tendering material will include some flexibility for the contractual procedures follow the call for tender.

5.1 Tendering documents
Due to the innovative elements to be demonstrated in this project the bidding companies have to provide more documentation than usual. This is to the opinion of the DANCED team the best way to verify, that the components and systems suggested are in line with the requirements of the energy concept of the building. Also should the tendering documents provide a certain flexibility to choose components and systems not only based on the lowest price, but also with respect to the performance of the components and with respect to environmental impact.

Specific products defined by the design team can be listed in the tendering documents, but the bidding can be opened up so, that any other producer of similar products can make a bidding using another product. If another products are suggested by the manufacturer, he shall provide sufficient information and documentation to the design team, so they are able to verify, that the alternative product would be an acceptable alternative to the specified component.

The benefit of opening the tendering in this way, is a more competitive tendering and the possibilities of even getting improved components not known to the building design team at the time of call for tenders.

5.2 Evaluation of tendering bids
When all the bids from possible producers and manufacturers are received the process of evaluation can start. It is the experience of the DANCED team, that including a predefined format in the tendering documents for the bidding companies to fill in for pricing of the specific delivery, can be very helpful, because the different bids are easier to compare and evaluate.

In such forms it is also possible to ask for a break down of the total price. This break down can be a very useful way to know what the different components are of the total bid and for negotiation purposes during the contractual phase with the selected companies.

Another benefit of using forms is the possibility of getting bids on specific options to the specified components. This is very useful in situations where several technologies might be a possibility to the project. One example on this in the current project could be the type of ice-producing components in the building where both an ice harvesting machine and maybe also a coil based machinery could be utilized. By specifying these two options in the bid, and emphasize the clients right to choose free in between options, the best possibilities are achieved to obtain a competitive tendering phase of the project.

5.3 Requirements for monitoring availability
Because of the demonstration purposes of the building it is important to specify in the introduction part of the tendering documents, that monitoring will be carried out in order to verify the performance of the building and its components. Companies delivering components to the building have, together with the bids to sign a paper specifying that, if later on a contract is signed

on delivery to the project, no restrictions in monitoring the components and systems can be made as long as it serves to document the function of the building and its components.

For special components where the performance is of prime importance to the function of the building, the tendering material should include a request of documentation that the specifications are being met with the proposed components e.g. with reference to standard testing procedures carried out or a guarantee that the components are fulfilling the requirements. The bidding companies should also agree on giving no limitations on the testing of samples of products to be delivered and if this testing might show that the components are not fulfilling the requirements specified in the tender documents, the client is free to choose another component or manufacturer

Appendix 1 Terms of Reference for the DANCED mission

Terms of Reference
for
Energy Optimization of Energy Saving House
Thailand

May 2, 1995

1. Background

The Department of Energy Development and Promotions (DEDP) is currently designing a new building comprising DEDP offices, an exhibition centre and seminar rooms.

The 6000 m^2 building is being designed to contain all relevant commercially accessible energy saving measures in order to serve as a full-scale demonstration of ways to use these measures under Thai conditions. The design will as a minimum be based on the demands laid down in the new Energy Conservation Promotion Act (ECPA) and serve as a demonstration of its implications for building design as well as introduce new design philosophies in the building sector in Thailand.

During April 17-22 a DANCED mission evaluated the project, and provided recommendations on the overall energy design of the building.

The evaluation turned out to be very positive for the overall building design. The mission recommended additional work of the design group regarding integrated optimization and refinement using computerized design tool for optimizing thermal performance, daylighting performance and indoor working environment. Part of this work has to happen within the month of May 1995, since tendering documents for the building are planned to go out in the end of May 1995.

2. Objectives

The objective of the mission is to provide design support in optimizing the components and the system of the building using computerized design tools. The work should happen in Bangkok, with the DANCED experts working together with the architects and engineers team in an interactive process.

3. Outputs

A Technical Assistance Report containing the consultant's findings and recommendations including the major results of the detailed computer modelling of the building which will be carried out during the mission. The developed input-files for use in these programmes will together with the report submitted to DEDP as well as DANCED-Thailand before departure from Thailand.

4. Activities

The work of the consultant will include, but not necessarily be limited to:

- Participate in the building design work together with the architects and engineers design team.
- Perform detailed modelling of selected parts of the building with computerized design tools in order to assist the design team in optimization of the overall energy function of the building and the function of specific components.
- Assist the architects and engineers design team in the identification of critical components in the building and assist in the specification of the required performance of these.
- Conduct a briefing and de-briefing with the DANCED representation at the Royal Danish Embassy in Bangkok at the beginning and the end of the mission respectively.

5. Timing of mission

The mission will have a duration of 19 calender days. The consultants will commence their activities in Thailand on May 11 1995 and continue until May 19 1995 inclusive. Five working days for preparation in Denmark prior to the mission to prepare the basic computer models of the building. 2,5 working days in Denmark for follow up on technical assistance and review of tender documents forwarded by the Thai design team.

6. Reporting

Before departure from Thailand the consultant shall prepare a Technical Assistance Report, and submit it to DEDP and the DANCED representation in Thailand.

The consultant shall provide for his word processing equipment. The report shall be drafted in WordPerfect 5.1 or 5.2 or compatible software. Spreadsheets shall be drafted in Microsoft Excel 3.0 or compatible software. The report shall be submitted in hard copy and on disk.

7. Consultant

The consultancy will be conducted by Mr. Henrik Sørensen, M.Sc. and Ms. Christina E. Madsen, M.Sc. from Esbensen Consulting Engineers FIDIC, Denmark.

Counterpart: Dr. Itthi Bijayendrayodhin, Deputy Director-General, DEDP.

Appendix 2   Building Design Data Sheets for all room categories

The forms consist of 2 sheets per room category defined below:

Type 1	Office areas, permanently occupied
Type 2	Offices, occasionally occupied
Type 3	Seminar and meeting rooms, occasionally occupied
Type 4	Corridors and circulation space at basement level
Type 5	Corridors and circulation space above basement level
Type 6	Exhibition areas, low internal heat gains
Type 7	Exhibition areas, high internal heat gains
Type 8	Lecture theatre at basement level
Type 9	Restaurant and catering area
Type 10	Lavatories
Type X	Other rooms specified on sheet

The topics covered in the current version of the forms are:

Indoor air quality design parameters	Definition of the comfort range which should be maintained in the current room category.
Constructions	Thermal properties needed of constructions surround the rooms in a specific category. Ceilings are considered to be ceilings to the outside.
Daylight parameters	Minimum reflectance values of interior surfaces. Specified only for rooms which are expected to benefit from daylight utilization.
Dimensional figures for heat balance	Expected internal loads calculated based on the building programme and simulations of the solar radiation through window openings.
Artificial lighting	Recommended maximum allowable installed power and minimum lighting level. Control type suggested according to the best possible energy saving strategy.
Ventilation and cooling	Basic data on sources and needs for fresh air. Detailed data on cooling are to be filled in by the engineering team when specified prior to tendering.
Requirements for other services	Example on other items to be specified during the detailed design process and prior to tendering.

Building design data sheet

Project	Room Category No. 1	Sheet No. 1 of 2
Covering: Office areas, permanently occupied		Date 95.05.17
		Revised
		By

Parameter		Value	References & Assumptions
Indoor air quality design parameters			
Activity level		1.0 MET	@ 58 W/MET
Clothing		0.5 clo	
Relative air humidity	max min	60% 35%	
Internal air velocity	max min	0.25 m/s m/s	1 m/s = 196.9 ft/min
Air temperature (dry bulb resultant)	max	27.0 °C 26.0 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping		Reverberation time 0.5 s	at 500 Hz
Constructions			
U-values	ceiling	max 0.3 W/m^2K	1 W/m^2K = 0.1761 $Btu/ft^2h°F$
	external walls	max 0.43 W/m^2K	
	internal walls	W/m^2K	
	windows incl. frame	max 1.5 W/m^2K	
Daylighting parameters Reflectance	ceiling walls floor	min 80% min 70% min 60%	
Glazing	light transm. solar transm.	min 65% max 45%	
Dimensional figures for heat balance			
Occupancy	density load load pattern	0.1 $pers/m^2$ 5.8 W/m^2 Office opening hours	
Solar	load load pattern	W/m^2	
Equipment	load load pattern	10 W/m^2 Office opening hours	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	Fluorescent tubes, HF ballasts max 10 W/m² min 200 lux Daylight controlled	
Task lighting Type Installed power Illumination level Control: type	 W/m² lux	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	VAV displacement Central system Exhaust air along perimeter	Office opening hours
Fresh air supply from rate	Central system m^3/s per m^2 + 4 l/s per person	1 l/s = 2.119 ft^3/min non-smoking area
Temperature control cooling on cooling off		
Cooling load	W/m²	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		
Notes		

Building design data sheet

Project	Room Category No. 2	Sheet No.	1 of 2
Covering: Office areas, occasionally occupied		Date	95.05.17
		Revised	
		By	

Parameter		Value		References & Assumptions
Indoor air quality design parameters				
Activity level			1.0 MET	@ 58 W/MET
Clothing			0.5 clo	
Relative air humidity	max min		60% 35%	
Internal air velocity	max min		0.25 m/s m/s	1 m/s = 196.9 ft/min
Air temperature (dry bulb resultant)	max		27.0 °C 26.0 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping		Reverberation time	0.5 s	at 500 Hz
Constructions				
U-values	ceiling	max	0.3 W/m^2K	1 W/m^2K = 0.1761 $Btu/ft^2h°F$
	external walls	max	0.43 W/m^2K	
	internal walls		W/m^2K	
	windows incl. frame	max	1.5 W/m^2K	
Daylighting parameters				
Reflectance	ceiling walls floor	min min min	80% 70% 60%	
Glazing	light transm. solar transm.	min max	65% 45%	
Dimensional figures for heat balance				
Occupancy	density load load pattern	When occupied	0.1 $pers/m^2$ 5.8 W/m^2	
Solar	load load pattern		W/m^2	
Equipment	load load pattern	When occupied	10 W/m^2	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	Fluorescent tubes, HF ballasts max 10 W/m^2 min 200 lux Daylight and movement sensor	
Task lighting Type Installed power Illumination level Control: type	 W/m^2 lux	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	VAV displacement Central system Central system perimeter and eventually near lighting fixtures	Controlled by movement sensor
Fresh air supply from rate	Central system m^3/s per m^2 + 4 l/s per person	1 l/s = 2.119 ft^3/min non-smoking area
Temperature control cooling on cooling off		
Cooling load	W/m^2	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		
Notes		

Building design data sheet

Project	Room Category No. 3	Sheet No. 1 of 2
Covering: Seminar and meeting rooms, occasionally occupied		Date 95.05.17 Revised By
Parameter	**Value**	**References & Assumptions**
Indoor air quality design parameters		
Activity level	1.0 MET	@ 58 W/MET
Clothing	1.0 clo	
Relative air humidity max min	60% 35%	
Internal air velocity max min	0.25 m/s m/s	1 m/s = 196.9 ft/min
Air temperature max (dry bulb resultant)	24.5 °C 23.5 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping	Reverberation time 0.5 s	at 500 Hz
Constructions		
U-values ceiling	max 0.3 W/m^2K	1 W/m^2K = 0.1761 $Btu/ft^2h°F$
external walls	max 0.43 W/m^2K	
internal walls	W/m^2K	
windows incl. frame	max 1.5 W/m^2K	
Daylighting parameters Reflectance ceiling walls floor Glazing light transm. solar transm.	 min 80% min 70% min 60% min 65% max 45%	
Dimensional figures for heat balance		
Occupancy density load load pattern	0.5 $pers/m^2$ 29 W/m^2 When occupied	
Solar load load pattern	W/m^2	
Equipment load load pattern	W/m^2	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	Mixed max 10 W/m^2 min 200 lux Daylight and movement sensor	
Task lighting Type Installed power Illumination level Control: type	 W/m^2 lux	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	VAV displacement Central system Central system	Timer and movement sensor controlled
Fresh air supply from rate	Central system m^3/s per m^2 + 7.5 l/s per person	1 l/s = 2.119 ft^3/min non-smoking area
Temperature control cooling on cooling off		
Cooling load	W/m^2	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		
Notes		

Building design data sheet

Project	Room Category No. 4	Sheet No. 1 of 2
Covering: Corridors and circulation space at basement level		Date 95.05.17
		Revised
		By
Parameter	**Value**	**References & Assumptions**
Indoor air quality design parameters		
Activity level	1.2 MET	@ 58 W/MET
Clothing	0.5 clo	
Relative air humidity max min	60% 35%	
Internal air velocity max min	1.5 m/s m/s	1 m/s = 196.9 ft/min
Air temperature max (dry bulb resultant)	28.0 °C 27.0 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping	Reverberation time 1.0 s	at 500 Hz
Constructions		
U-values ceiling	max 0.3 W/m^2K	1 W/m^2K = 0.1761 $Btu/ft^2h°F$
external walls	max 0.43 W/m^2K	
internal walls	W/m^2K	
windows incl. frame	max 1.5 W/m^2K	
Daylighting parameters Reflectance ceiling walls floor Glazing light transm. solar transm.	 min 80% min 70% min 60% min 65% max 45%	
Dimensional figures for heat balance		
Occupancy density load load pattern	0.03 $pers/m^2$ 2.1 W/m^2 Building opening hours	
Solar load load pattern	W/m^2	
Equipment load load pattern	W/m^2	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	Mixed max 8 W/m^2 min 50 lux Timer controlled	 eventually movement sensors
Task lighting Type Installed power Illumination level Control: type	 W/m^2 lux	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	VAV mixing Central system and leakage from ice storage adjacent circulation space above basement	
Fresh air supply from rate	Central system m^3/s per m^2 + 4 l/s per person	1 l/s = 2.119 ft^3/min non-smoking area
Temperature control cooling on cooling off		
Cooling load	W/m^2	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		

Notes

High air velocities is achieved by high speed fans giving horizontal air movement

Building design data sheet

Project	Room Category No. 5	Sheet No.	1 of 2
Covering: Corridors and circulation space above basement level		Date	95.05.17
		Revised	
		By	

Parameter		Value		References & Assumptions
Indoor air quality design parameters				
Activity level			1.2 MET	@ 58 W/MET
Clothing			0.5 clo	
Relative air humidity	max min		60% 35%	
Internal air velocity	max min		1.5 m/s m/s	1 m/s = 196.9 ft/min
Air temperature (dry bulb resultant)	max		28.0 °C 27.0 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping		Reverberation time	1.0 s	at 500 Hz
Constructions				
U-values	ceiling	max	0.3 W/m^2K	1 W/m^2K = 0.1761 $Btu/ft^2h°F$
	external walls	max	0.43 W/m^2K	
	internal walls		W/m^2K	
	windows incl. frame	max	1.5 W/m^2K	
Daylighting parameters Reflectance	 ceiling walls floor	 min min min	 80% 70% 60%	
Glazing	light transm. solar transm.	min max	65% 45%	
Dimensional figures for heat balance				
Occupancy	density load load pattern	 Building opening hours	0.03 $pers/m^2$ 2.1 W/m^2	
Solar	load load pattern		W/m^2	
Equipment	load load pattern		W/m^2	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	Mixed max 8 W/m² min 50 lux Daylight controlled	
Task lighting Type Installed power Illumination level Control: type	W/m² lux	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	Horizontal, stratified air movement exhibition area in dome area central system and exhaust in dome, lobby and green area	
Fresh air supply from rate	Central system m^3/s per m^2 + 4 l/s per person	1 l/s = 2.119 ft^3/min non-smoking area
Temperature control cooling on cooling off		
Cooling load	W/m^2	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		

Notes

High air velocities is achieved by high speed fans giving horizontal air movement

Building design data sheet

Project	Room Category No. 6	Sheet No. 1 of 2
Covering: Exhibition areas, low internal heat gains		Date 95.05.17 Revised By

Parameter	Value	References & Assumptions
Indoor air quality design parameters		
Activity level	1.2 MET	@ 58 W/MET
Clothing	0.5 clo	
Relative air humidity max min	60% 35%	
Internal air velocity max min	1.5 m/s m/s	1 m/s = 196.9 ft/min
Air temperature max (dry bulb resultant)	28.0 °C 27.0 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping	Reverberation time 0.8 s	at 500 Hz
Constructions		
U-values ceiling	max 0.3 W/m²K	1 W/m²K = 0.1761 Btu/ft²h°F
external walls	max 0.43 W/m²K	
internal walls	W/m²K	
windows incl. frame	max 1.5 W/m²K	
Daylighting parameters Reflectance ceiling walls floor Glazing light transm. solar transm.	 min 80% min 70% min 60% min 65% max 45%	
Dimensional figures for heat balance		
Occupancy density load load pattern	0.03 pers/m² 2.1 W/m² Building opening hours	
Solar load load pattern	W/m²	
Equipment load load pattern	W/m²	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	 max 10 W/m² min 150 lux Timer controlled	
Task lighting Type Installed power Illumination level Control: type	 W/m² lux User controlled with auto switch off where possible	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	VAV displacement Central system Central system and leakage to adjacent circulation areas	
Fresh air supply from rate	Central system m³/s per m² + 4 l/s per person	1 l/s = 2.119 ft³/min non-smoking area
Temperature control cooling on cooling off		
Cooling load	W/m²	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		

Notes

Building design data sheet

Project	Room Category No. 7	Sheet No.	1 of 2
Covering: Exhibition areas, high internal heat gains		Date	95.05.17
		Revised	
		By	

Parameter	Value	References & Assumptions
Indoor air quality design parameters		
Activity level	1.2 MET	@ 58 W/MET
Clothing	0.5 clo	
Relative air humidity max min	60% 35%	
Internal air velocity max min	1.5 m/s m/s	1 m/s = 196.9 ft/min
Air temperature max (dry bulb resultant)	28.0 °C 27.0 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping	Reverberation time 0.8 s	at 500 Hz
Constructions		
U-values ceiling	max 0.3 W/m^2K	1 W/m^2K = 0.1761 $Btu/ft^2h°F$
external walls	max 0.43 W/m^2K	
internal walls	W/m^2K	
windows incl. frame	max 1.5 W/m^2K	
Daylighting parameters Reflectance ceiling walls floor Glazing light transm. solar transm.	 min 80% min 70% min 60% min 65% max 45%	
Dimensional figures for heat balance		
Occupancy density load load pattern	0.03 $pers/m^2$ 2.1 W/m^2 Building opening hours	
Solar load load pattern	W/m^2	
Equipment load load pattern	W/m^2	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	 max 10 W/m² min 150 lux Timer controlled	
Task lighting Type Installed power Illumination level Control: type	 W/m² lux User controlled with auto switch off where possible	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	VAV displacement, eventually combined with exhaust air from hot spots (machinery) Central system Central system circulation areas	
Fresh air supply from rate	Central system - m^3/s per m^2 + 4 l/s per person	1 l/s = 2.119 ft^3/min non-smoking area
Temperature control cooling on cooling off		
Cooling load	W/m²	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		
Notes		

Building design data sheet

Project	Room Category No. 8	Sheet No. 1 of 2
Covering: Lecture theatre at basement level		Date 95.05.17 Revised By

Parameter	Value	References & Assumptions
Indoor air quality design parameters		
Activity level	1.0 MET	@ 58 W/MET
Clothing	1.0 clo	
Relative air humidity max min	60% 35%	
Internal air velocity max min	0.25 m/s m/s	1 m/s = 196.9 ft/min
Air temperature max (dry bulb resultant)	24.5 °C 23.5 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping	Reverberation time 0.8 s	at 500 Hz
Constructions		
U-values ceiling	max 0.3 W/m^2K	1 W/m^2K = 0.1761 $Btu/ft^2h°F$
external walls	max 0.43 W/m^2K	
internal walls	W/m^2K	
windows incl. frame	max 1.5 W/m^2K	
Daylighting parameters Reflectance ceiling walls floor Glazing light transm. solar transm.	 min 80% min 70% min 60% min 65% max 45%	
Dimensional figures for heat balance		
Occupancy density load load pattern	1.7 $pers/m^2$ 97 W/m^2 When used	
Solar load load pattern	0 W/m^2	
Equipment load load pattern	W/m^2	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	 max 10 W/m^2 min 200 lux User controlled, dimable	
Task lighting Type Installed power Illumination level Control: type	 W/m^2 lux	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	VAV displacement Central system or exhibited systems Central system and adjacent circulation space	Timer controlled
Fresh air supply from rate	Central system m^3/s per m^2 + 10 l/s per person	1 l/s = 2.119 ft^3/min non-smoking area
Temperature control cooling on cooling off		
Cooling load	W/m^2	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		

Notes

Building design data sheet

Project	Room Category No. 9	Sheet No. 1 of 2
Covering: Restaurant and catering area		Date 95.05.17
		Revised
		By

Parameter	Value	References & Assumptions
Indoor air quality design parameters		
Activity level	1.2 MET	@ 58 W/MET
Clothing	0.5 clo	
Relative air humidity max min	60% 35%	
Internal air velocity max min	1.0 m/s m/s	1 m/s = 196.9 ft/min
Air temperature max (dry bulb resultant)	27.5 °C 26.5 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping	Reverberation time 1.0 s	at 500 Hz
Constructions		
U-values ceiling	max 0.3 W/m^2K	1 W/m^2K = 0.1761 $Btu/ft^2h°F$
external walls	max 0.43 W/m^2K	
internal walls	W/m^2K	
windows incl. frame	max 1.5 W/m^2K	
Daylighting parameters Reflectance ceiling walls floor Glazing light transm. solar transm.	 min 80% min 70% min 60% min 65% max 45%	
Dimensional figures for heat balance		
Occupancy density load load pattern	0.7 $pers/m^2$ 46 W/m^2 Building opening hours	
Solar load load pattern	W/m^2	
Equipment load load pattern	W/m^2	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	 max 10 W/m² min 200 lux Timer controlled, daylight controlled near perimeter	
Task lighting Type Installed power Illumination level Control: type	 W/m² lux	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	Fume hoods in display and catering area Central system displacement inlet Outdoors, no heat exchange	
Fresh air supply from rate	Central system m³/s per m² + 10 l/s per person	1 l/s = 2.119 ft³/min
Temperature control cooling on cooling off		
Cooling load	W/m²	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		
Notes		

Building design data sheet

Project	Room Category No. 10	Sheet No.	1 of 2
Covering:		Date	95.05.17
Lavatories		Revised	
		By	

Parameter		Value		References & Assumptions
Indoor air quality design parameters				
Activity level			1.2 MET	@ 58 W/MET
Clothing			0.5 clo	
Relative air humidity	max min		60% 35%	
Internal air velocity	max min		1.5 m/s m/s	1 m/s = 196.9 ft/min
Air temperature (dry bulb resultant)	max		28.0 °C 27.0 °C	at 35% relative air humidity at 60% relative air humidity
Acoustic damping		*Reverberation time*	*- s*	*at 500 Hz*
Constructions				
U-values	ceiling	max	0.3 W/m²K	1 W/m²K = 0.1761 Btu/ft²h°F
	external walls	max	0.43 W/m²K	
	internal walls		W/m²K	
	windows incl. frame	max	1.5 W/m²K	
Daylighting parameters Reflectance Glazing	 ceiling walls floor light transm. solar transm.	 min min min min max	 - % - % - % 65% 45%	
Dimensional figures for heat balance				
Occupancy	density load load pattern		0.03 pers/m² 2.1 W/m²	
Solar	load load pattern		0 W/m²	
Equipment	load load pattern		0 W/m²	

Artificial lighting		
General lighting Type Installed power Illumination level Control: type	 max 8 W/m² min 100 lux Movement sensor	
Task lighting Type Installed power Illumination level Control: type	 W/m² lux	
Ventilation and cooling		
Ventilation principle supply air from exhaust air to	Exhaust air ventilation Outdoors, no heat exchange	
Fresh air supply from rate	Circulation space m³/s per m² + 24 l/s per person	1 l/s = 2.119 ft³/min
Temperature control cooling on cooling off		
Cooling load	W/m²	
Requirements for other services installations		
Electrical high voltage low voltage data, telecom etc.		
Water Domestic Cold Domestic Hot Drainage Sprinkling (Fire)		
Fire Warning system		
Notes		

Appendix 3 Agenda for meeting with EEC

Items for Discussion With EEC Engineering Team, ERI Team, and DANCED Mission Team

May 17, 1995

Overall Cooling Strategy

- Vary air temperature and air speed to obtain comfort in all areas which have different uses.
- Rely on stratification to conserve energy in cooling.
- Identify comfort needs by area use and occupancy. Achieve airflow and temperatures required by areas or zones.

Ground Floor

Cooling Principles

1. Circulation areas and corridors have higher temperature, and higher turbulence (by means of high velocity fans).
2. High-bay areas (dome and skylights) are used for exhaust air from the highest points to maintain stratification. (Note: Need to run enthalpy calculations for these points to avoid condensation.)
3. Use floor plenum as central duct run as air to ground floor delivered at low height above finished floor and air to basement delivered at high height above finished floor.
4. Utilize leakage from low temperature areas to cool circulation spaces.
5. Cooking area and cafeteria to utilize fume hoods to exhaust air. Restrooms to use exhaust fans. These airstreams not to re-circulate, nor heat exchange.

Basement Floor

Cooling Principles

1. Circulation areas have higher temperature, higher turbulence than closed areas.
2. Openings is ceiling (dome and ramp area) are used to allow heat to escape to unoccupied areas.
3. Ideally, none of basement areas would have cold air introduced to them, as this would cause increased heat transmission from the ground.
4. Ceiling plenum to be used as air delivery area. Air delivered at higher level than on Ground Floor and air delivery direction to be from the sideways direction.
5. Separate air handler to service higher occupancy areas, like auditorium. Auditorium is primary place to showcase displacement ventilation.
6. Display areas should have lower temperatures than circulation spaces but will leak air to circulation areas for added cooling effect.
7. Garden area at ramp to have special considerations for humidity control through, for example, controlled air movement around moisture-emitting areas.

Office Areas All Levels

General Principles

1. Daylighting to be used as a means of primary lighting.
2. Control strategies for artificial lighting giving preference for daylight whenever possible.
3. Air handling luminaries to be used for return air.
4. Minimal heat gain from all luminaires.
5. Perimeter duct to be used for exhaust.

Sanitary Services

General Discussion

- Scubber location and internal downspouts to be accounted for.
- Water main location discussed.
- Specifications of fixtures and fittings described with cutsheets.
- Water service main location.
- Water service and waste provision at display areas to be discussed.
- Drainage for planted areas.
- Pond recirculation to avoid stagnation.

Other Discussions

- Outside Air intake and exhaust locations.
- Dehumidification Means
- Main power supply placement and capacity. (Lead time.)
- Occupancy levels in different room types.
- Lighting design and control in general.

Appendix 4 List of persons met

The Royal Danish Embassy:

Mr. John Carstensen, Environment Attaché, DANCED Thailand
Ms. Viali Vasoontraluk, Environmental Programme Officer, DANCED Thailand
Mr. Lars Friis-Jensen, Commercial counsellor, Royal Danish Embassy

DEDP:

Mr. Kriengkorn Bejraputra, Executive Director DEDP
Mr. Pramoul Chanpong, Acting Director DEDP
Mr. Pramote Iamsiri, Director DEDP

ERI, Chulalongkorn University:

Dr. Soontorn Boonyatikarn, Assoc. Prof. and Deputy Director for Research Affairs
Ms. Lisa Surprenant, International Project Director

EEC:

Mr. Tammanoon Chantavorn, Associate EEC
Mr. Chiraphon Chayasathit, Project Manager EEC
Mr. Chakrapan Pawangkarat, Mechanical Engineer EEC
Mr. Wanchai Bunditkitsada, Senior Environmental Engineer EEC
Mr. Kwanchai Gunsantithamrong, Senior Electrical Engineer EEC

ACTEC Consulting Engineers:

Mr. Vanchai Meteveravong, Deputy Managing Director

ภาคผนวก ข.
การจำลองสภาวะทางแสงธรรมชาติด้วยโปรแกรมคอมพิวเตอร์
อาคารอนุรักษ์พลังงาน

Danish Environmental Protection Agency

DANCED
Danish Cooperation for Environment and Development

Technical Assistance Report

for

DEDP Energy Efficient Demonstration Building

Bangkok - Thailand

By
Esbensen Consulting Engineers FIDIC, Denmark

April 17-21 1995

Contents

0. List of acronyms and abbreviations

ADELINE	Advanced Daylighting and Electric Lighting Integrated New Environment
CFC-gases	Chlorofluorocarbon gases
DANCED	Danish Cooperation for Environment and Development
DEDP	Department of Energy Development and Promotion
ECPA	Energy Conservation Promotion Act
EEC	Environmental Engineering Consultants Co. Ltd., Bangkok Thailand
ERI	Energy Research Institute, Bangkok Thailand
IAQ	Indoor Air Quality
LowE	Low Emission
OTTV	Overall Thermal Transfer Value
PV-panels	Photovoltaic panels
U-value	Heat Transfer Coefficient
VAV	Variable Air Volume

Technical Assistance Report
for DEDP Energy Efficient Demonstration Building
Bangkok - Thailand

By
Poul E. Kristensen and Henrik Sørensen
Esbensen Consulting Engineers FIDIC, Denmark

DANCED MISSION April 17-21 1995

1. Executive Summary

Background

The new 6000 m^2 DEDP building near Bangkok will have offices as well as exhibition areas and training facilities for energy efficiency in buildings. The building itself is being designed as an exemplar low energy building, so that the building itself can serve as a full scale exhibit.

DANCED under the Danish Ministry of Energy and Environment has offered assistance to the Department of Energy Development and Promotion DEDP in evaluating the project at its present stage. The brief for the DANCED experts calls for recommendations on optimal integration of the energy concepts, advise and suggestions regarding choice of components and systems, and utilization of experiences from European building energy research, whenever appropriate to the conditions in Thailand. This report describes the findings and recommendations of the DANCED team, the work and the documentation being carried out by two Danish experts through a 5 day visit in Bangkok.

At present, mid April 1995, the overall building design is detailed. The components such as windows, exterior walls and interior finishes are not detailed, but suggestions on choices have been made. Equally, a layout and design of the ventilation and cooling system has been proposed, however still with room for detailing and modifications.

Findings and recommendations

Designing energy efficient non-domestic buildings is a difficult and complex task. The building planning and layout, design of the building envelope and design of the lighting and air-conditioning system has to be done in an integrated process, where the interaction between the various components is considered.

The overall layout of the DEDP building and the landscaping around the building looks very promising. To the South-West, the direction of the prevailing wind direction, an artificial pond and trees with water evaporation in the canopies is proposed. Evaporation will create passive cooling of the wind that will pass the building, thereby reducing the cooling load. A temperature reduction of 2-3°C is expected, which is regarded as realistic by the DANCED team. Around the rest of the building sprinkling of the surroundings near the building is planned in order to reduce heat radiation from the ground onto the building shell. This too is regarded as very worthwhile and feasible by the DANCED team.

The building layout consist of two compact buildings, the dome building and the pyramid building, being connected by a lower building with entrance and support facilities. The compact buildings reduce cooling load due to a relatively small building envelope. The pyramid building with primarily offices has relatively large window areas, in order to allow good utilization of natural daylight as the prime light source. The dome building has primarily exhibition area and conference rooms, areas where daylight is difficult to utilize. Therefore the dome building has relatively small window areas in order to reduce cooling load.

The windows are generally well protected from direct sun via overhangs. The window design in the pyramid building allows a good distribution of daylight in the rooms. The latest development in innovative glazing technologies is proposed: a double glazed unit with a good daylight transmissivity, a good solar shading coefficient, and a very low U-value.

The combination of window sizing, shading and choice of glazing system is regarded as being near to optimal by the DANCED team, being confirmed by initial computer modelling done by the team during the mission. Also the proposed insulation values, 3 inches in the walls and 6 inches in the roof seems to be a feasible choice. However it is strongly recommended by the team to finally optimize these values using a dynamic building simulation tool.

The overall evaluation of the building layout and the building envelope is very positive. The DANCED team only suggests to consider minor modifications in the room planning to improve thermal performance and user comfort.

Artificial lighting is proposed to be fluorescent tubes with high frequency electronic ballasts. A sufficient light level of 4-500 lux is expected to be achieved with an installed capacity of 8-10 W/m^2, or considerable lower than the building regulation maximum value of 16 W/m . The DANCED team considers this to be possible and feasible, provided that the tubes are installed in high efficiency luminaries.

The air-conditioning system is proposed as a flexible system with modular cooling units, variable speed control on pumps and fans, and Variable Air Volume control of the air to the different zones of the buildings. The fresh air intake to the system is proposed to be controlled by an indoor air quality (IAQ) sensor, probably with CO_2 as air quality indicator.

The engineers of EEC and the DANCED team discussed the possibility to dump heat from the cooling machines in the pond instead of utilizing a cooling tower. This possibility is very interesting, and should be investigated further.

The DANCED team generally approve with this system design. The system will provide a good efficiency at partial load, which will happen most of the time in this building. It is recommended to consider the possibility of applying IAQ control on the individual zones of the building. The temperature set point of the zones should be adapted to varying temperature requirements, ie 23-24°C in the seminar rooms and 27-28°C in the lobby area where higher air speed and therefore higher design temperatures can be accepted.

It is proposed to consider the use of Displacement Ventilation in some parts of the building, meeting room and maybe offices. This provides a good ventilation efficiency of the rooms, and return air from these rooms could possible be utilized in the circulation spaces, where a higher air temperature is acceptable.

Furthermore it is highly recommended, that the final sizing of the air-conditioning system is done based on the actual numbers for solar gains, and gains from lighting and people, using a dynamic computer design tool.

Findings regarding Energy Conservation and Promotion Act ECPA

The DANCED team has evaluated the DEDP building against the requirements in the Energy Conservation and Promotion Act ECPA. A final assessment has not been possible, since the project is still at a preliminary stage. However it is the evaluation by the DANCED team, that all requirements can easily be met, if the design proceeds as presented now.

Additionally to the ECPA requirements, the following measures can be regarded as extra innovative energy saving measures:

- Daylight utilization with a control system on artificial lighting
- Evaporative cooling of the exterior surroundings
- Photovoltaic cells for water pumping in the exterior evaporation system
- Advanced high performance glazing
- Temperature zoning of the building
- Indoor Air Quality control of ventilation system

Recommendations regarding planning

The DANCED has the following recommendations regarding planning of the coming development and detailing of the project.

The basic project with landscaping, foundation work and erection of the building shell go into tendering as planned within 1-2 months.

Refinement of the design of windows, installations and interior finishes is continued now, with tendering in 4-5 months. These activities are crucial in order to obtain the full benefits of the integrated design process.

The following activities are proposed to be offered to the design team:

- Computerized modelling of the daylight design
- Computerized modelling of the thermal comfort and energy consumption of the integrated building and system design
- Environmental assessment of the building using the British BREEAM method and/or the Green Building method from US

Poul E. Kristensen Henrik Sørensen

2. Introduction

The current report documents the findings and recommendations of work carried out by the DANCED team during the mission in Bangkok April 17-21 1995. Work was carried out in close collaboration with the architectural design team of the building (Dr. Soontorn and Ms. Surprenant). The primary issue for the mission was to set up recommendations on the optimal integration of energy conservation concepts in the design of the Energy Saving House, according to the Terms of Reference included in Appendix 1 of this report.

3. Microclimate

This project seeks to take maximum advantage of utilizing the landscape and microclimate around the building, and indeed active measures are taken to improve the microclimate in the near surroundings.

The prevailing wind direction is from Southwest. On this side of the building complex an artificial pond is excavated. By passing the pond the air will be humidified and thereby reduce temperature. This evaporative cooling effect will be further stimulated by trees being planted around the pond. The intention is to have high canopies where evaporative cooling is being stimulated by spraying water in the canopies. The high canopies will protect the ground from direct solar radiation and will allow wind to pass under, the wind being cooled by evaporative cooling on its way towards the building.

The overall effect of this strategy is to reduce the air temperature around the building and thereby decrease the cooling load. A reduction of the air temperature of 2-3°C has been estimated. This figure seems realistic compared to a situation with no pond and no vegetation. Reduction of cooling load will only occur when the wind passes the evaporative area.

This solution seems all in all to be very feasible. Although it has not been possible to calculate the payback period of the system, it seems likely that the investment in the pond and the trees will be payed back quickly. Furthermore there is the added value of a green landscape in general, giving a better view both outside the building and from inside the building.

On the other facades of the building, the intention is to evaporate water on the ground in order to reduce the ground surface temperature, and thereby to reduce heat radiation from the ground onto the building envelope. This measure also seems very feasible. The areas around the building that will be kept humid by spraying would probably be kept as grass areas, another added value of the environmental system.

The water needed and the storage capacity needed has not been assessed, however it would be very interesting if the water pond could be part of the storage system. Preference should be given to water that could be collected and stored during the rain season for use during the dry season. Furthermore, it could be interesting to utilize electricity generated by Photovoltaic (PV) panels for pumping and spraying the water. There is a good coincidence between availability of solar electricity and the need for evaporative cooling, and this feature would be an extra energy conscious feature to the exterior natural evaporative cooling system.

The DANCED team know of similar approaches to the control of the microclimate around buildings from the projects carried out in connection with the World Exhibition in Seville 1992, and will see to that information and experiences about these projects will be made available to the design team.

4. Building shape and orientation

The building has the shape of two main buildings being connected by a lower building containing entrance, lobby and various support rooms.

Both of the two main buildings are relatively compact, reducing the exterior surface area, and thereby reducing cooling loss through the envelope.

The Eastern building contains meeting rooms, exhibition areas and a theatre. This building is internally-oriented with a limited window area. The main entrance of daylight to the building is the globe covering the central lobby of this building. Large parts of the envelope walls consist of a double envelope system creating a service corridor wrapped around the exhibition rooms.

Generally there seems to be good reason behind reducing the window area in this part of the building. It will not be permanently in occupation, and daylight will only have little use in the exhibition area, which will be dominated by (low energy) function light. However if the training rooms were to the north instead of to the south, they might receive daylight via larger window areas without the penalty of increased cooling load due to solar load.

The Western pyramid building contains primarily offices. They have larger window areas in a split window system, in order to allow daylight to be utilized as the prime light source during the occupancy hours, i.e. during daytime. Many of the offices have the value of the view towards the pond and the evaporation forest.

The offices are fairly deep from the facade, 6-7 metres from the facade. However there is a good potential for well distributed daylight in those rooms with a split window system consisting of a vertical outer window and a skylight pulled back in the room.

It is believed that the top floor offices could also benefit from a skylight, and the recommendation is therefore to consider the possibility of adding this as a light well that would cut through the perimeter zone of the mechanical area on the floor above.

The light distribution from the skylight might be further improved by introducing a reflector below the window, reflecting diffuse light deeper into the room via the ceiling.

The general evaluation of the pyramid is very favourable. From an energy and comfort point of view the building looks very positive. In order to fully utilize the potential of the building it is recommended to refine the design of the windows, the skylight, shading system and light redistribution systems using scale modelling, or even better using a computer-based simulation tool such as *ADELINE /Radiance*. In the latter case the daylighting model could be connected to computerized thermal modelling. This will allow an integrated analysis and optimization of cooling energy consumption, electricity for lighting and indoor visual and thermal comfort.

5. Building envelope

The building envelope has been designed carefully in order to serve several functions, especially: protection against rain, solar shading, access to daylight in working areas, access for maintenance, insulation in order to reduce cooling loss etc. All these requirements seems to be incorporated in the current design of the building envelope and the general recommendation of the DANCED team is in the continuing design process to focus on the fine tuning of the critical parameters of the building.

In order to catalyse this process, the building envelope was scrutinized together with the design team in order to discuss which parameters should be focused on and what the necessary tasks prior to finalizing the design would be.

With respect to the building envelope, a number of important issues were identified:

- Identification of the net solar gains in office sections of the building for different glazing types.
- Analysis of the sun path and building geometry in order to identify time during the day, where the sun will enter the room through the sloped skylight window in the office section.
- Use of additional sun-shading device.
- Choice of insulation material.

In the following these issues are discussed and recommendations given.

Weather data used in order to estimate solar loads: For use in computer models dealing with the dynamics of the outdoor climate, the DANCED team brought a set of weather files based measured data hour by hour at Bangkok Metropolis Weather Station in the year 1993. Since these data, based on only one year of measurements, generally can not be considered as being sufficient for fully representing the dynamics of a typical site climate, the computer simulations presented in the following are focusing on relative energy saving potentials and expected design conditions for the energy function of the building.

The measured data on solar radiation on horizontal was prior to the simulations split into a data set of hour by hour values for both the direct and the diffuse irradiation. This allows for a more detailed analysis of the building performance with respect to utilization of daylight and avoiding to much sunlight entering the building.

Energy benefits from skylights in office areas: The DANCED team consider the use of the sloped skylight as a very innovative and important energy saving measure in the building. In order to verify the positive effects of using the skylight in the office section of the building, a tsbi3 computer model of a typical part of the building was made by the DANCED team. Tsbi3 is a thermal simulation program developed at the Danish Building Research Institute. In this computer model all parameters with impact on the energy behaviour of the building can be taken into account.

Illustration of the Impact of Shading and Glazing type on Passive Solar Gains in the DEPD Demonstration building

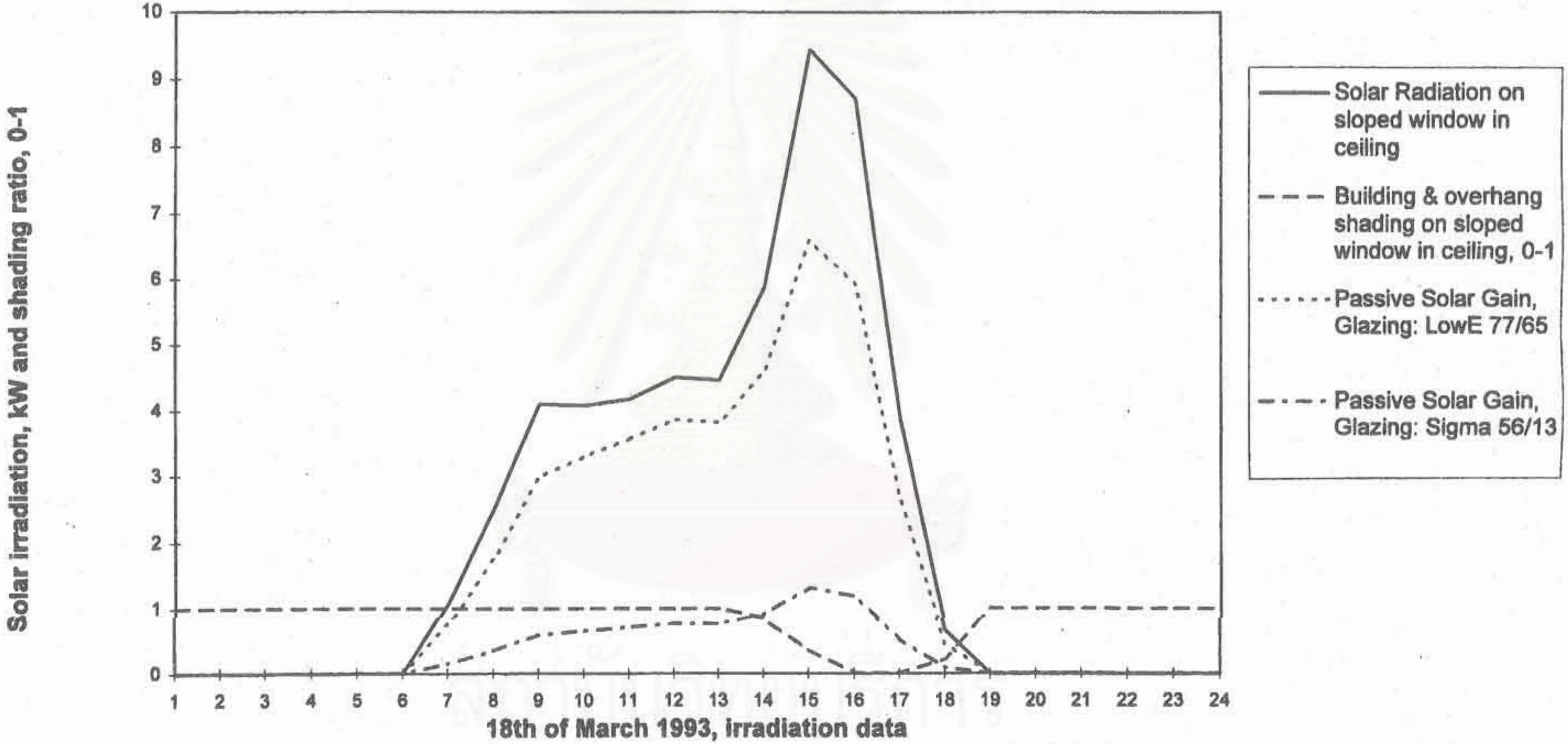


Figure 1

DANCED team fully agrees with the importance of these measures in order to reduce the heat conduction into the building from the warmer climate outside. In order to find the best insulation solution considerations on the environmental issues should have a high priority. The suggested use of foam insulation is technically a good approach, but only if it will be possible to find foam materials which do not include CFC-gases. To the knowledge of the DANCED team, there are now being produced foam types in Europe, which do not include CFC-gases, and availability of these on the Asian market should be investigated. As an alternative mineral wool solutions could be considered, where also solutions for exterior insulation combined with plastering, is a known technique.

The DANCED team strongly recommends that these investigations are started soon because this might have an impact of the detailing of the structures of the building.

Summary of comments and recommendations regarding building envelope:

The building envelope is in general very well designed and relevant precautions regarding the need for solar shading and daylight is being dealt with.

It is the recommendation know to focus on the detailing of the design of the envelope regarding glazing and solar shading in order to have the maximum use of daylight with the minimum total internal gains from sun light and artificial lighting. The use of the Sigma 56/13 windows seems to be a good approach, but other glazing could be relevant if too less daylight is available.

Avoiding use of CFC-gases in the insulation material by using foam insulation material expanded with other gases or using alternative materials such as mineral wool or similar.

6. Ventilation/Cooling strategy

The building is proposed to be ventilated and cooled with a central cooling machine connected to two air handling units, one for the dome building, and one for the pyramid building. The cooling machine will be connected to an ice storage system.

The objective is to improve the efficiency of the overall cooling and ventilation system as much as possible using several means.

Cool air is distributed to the rooms at a very low temperature, down to 6°C. In the room air is distributed through a diffuser, so that the cool air is mixed before it enters the occupancy zone. The low distribution temperature allows a reduction in the air volume that has to be circulated, for the benefit of reduced fan electricity consumption and reduced size of the ducts. In combination with the generally low cooling load of the building it is the evaluation that the proposed system will generally be very energy efficient, but care must be taken to evaluate the increase in cooling capacity the lower temperature in the inlet air is designed. An optimum combination between cooling capacity and air flow would be possible to identify during the detailed design process.

The design capacity of the cooling system is based on full occupancy (800 people), an installed lighting capacity of 16 W/m^2, and assumptions regarding solar load that are not yet known in detail. However, normally the cooling load will be considerably lower. Therefore it is most important that the ventilation and cooling system can operate efficiently at part load.

The air entering the different parts of the building is controlled via a VAV (Variable Air Volume) system. The capacities of the cooling liquid pumps and the fans are regulated according to demand using frequency control systems. This should all secure the energy efficiency when the ventilation/cooling system is running at part load.

The amount of fresh air which is added to the ventilation system is controlled according to an IAQ (Indoor Air Quality) sensor on the return air to the air handling unit. This will generally secure that as little fresh air, and cooling, is used. However the possibility of having IAQ sensors separately for each of the larger spaces should be evaluated. This could secure a more close matching of the actual air volume to each room to the volume required by the occupancy (if not superseded by the cooling requirement).

The DANCED team experience from other energy efficient office and exhibitions buildings has shown that the air movement from the ventilation system can add substantially to the energy saving potential of the buildings. The principle behind this is to avoid the full mixing between fresh air and used air during the operation of the ventilation system. One way of doing this is the use of *displacement ventilation*, where air at a low speed, with a temperature lower than the room temperature is being blown into the rooms. This air will then constantly move the air in the room as a bulk flow towards an exhaust air duct near the ceiling, thus giving a better air quality with a decrease flow rate and a better use of the cooling capacity. The DANCED team will ensure that information about these techniques will be made available to the design team.

Furthermore it is anticipated that the cooling requirement of rooms that are only occasionally used will be managed via the Building Management System.

Rejection of heating from the cooling machines can be achieved in the conventional way via cooling towers. However it will be considered to utilize the lake as the heat sink. Electricity consumption for driving the fan in the cooling tower can be saved, and the pond will have one more additional function in saving energy. However this concept is not yet evaluated in detail, but the DANCED team strongly supports to explore this possibility further.

7. Lighting strategy

In the DEDP building, the attempt is to maximize the use of daylight as a light source and to install energy efficient artificial lighting which is controlled according to daylight availability.

Often when utilizing daylight as a light source it is difficult to control the access of sunlight through the windows, and to have an even distribution of daylight in the room.

However for this building the windows are generally well protected using overhangs and movable shading, as described in the section on the building envelope. Furthermore, the choice of glazing with a high transmissivity to visible light and a low transmissivity to infrared and ultraviolet light helps to reduce unwanted solar gains through the windows. Only those usable portions of the light spectrum will be introduced into the building. The daylight distribution in the pyramid building will be greatly enhanced by the split window design which will shade against direct solar gain.

Regarding choice of artificial lighting sources, it can be greatly recommended to choose fluorescent lighting with high frequency electronic ballasts as the main light source. Artificial lighting should release the least possible energy for a given light quantity. This means a low electricity consumption, and in addition a reduction in sensible loads introduced into the building interiors. The lumen/watt number for fluorescent lighting can be around 60 lumen/watt, being raised to around 80 lumen/watt if high frequency electronic ballasts are utilized. The daylighting contribution can be as much as 120 lumen/watt for diffuse light.

For function lighting and spot lighting in the exhibition areas other more light fixtures will be preferred. In some cases compact fluorescent light sources can be utilized. Additionally the DANCED group will explore the possibilities for high efficiency spotlights that are currently under development in Europe.

The ECPA guidelines this building will adhere to specify an overall maximum of 16 W/m^2 for lighting. However with fluorescent lighting in a high performance lighting fixture and electronic ballasts, a required light level of 500 W can be achieved with a considerably lower installed power, possibly down to 8 - 10 W/m^2. Furthermore it is highly recommended to introduce daylight control of the artificial lighting system. This will conserve electricity, and assist in controlling the cooling load during peak demand hours of mid- to late- afternoon.

The optimal control strategy both from an economy and from a user comfort point of view should be studied in more detail. This can be done as a part of the integrated design process, where both lighting and cooling energy is considered together with consideration of visual and thermal comfort. Because of the innovative approach shown in the lighting design of this building, the DANCED team recommends this carried out prior to the detailed design phase.

A system with on/off control in combination with occupancy sensors might prove to be feasible. Whenever the room is unoccupied, only daylight is available. When occupied, supplementary artificial lighting is allowed if the occupants so wish. When the Building Management System calculates that daylight in a given room is adequate, artificial lighting is automatically shut off, however with a possibility of manual override by the user, if the light level is felt to be inadequate.

8. Overall energy performance - ECPA

The Energy Conservation and Promotion Act (ECPA) of April 1992 outlines various measures, such as incentives, regulatory measures and penalties, in order to promote energy conservation in Thailand.

The ECPA outlines various measures that should be considered in the building sector, new and existing buildings. The ECPA has been followed up by specific requirements in the building code regarding heat loss of the building fabric, energy efficient lighting and energy efficient air conditioning systems.

The requirements in the ECPA and in the building code has been evaluated against the DEDP Energy Efficient Demonstration Building project. Some measures can be directly compared against the actual project at the level of detail at present. However for most measures, the fulfilment of the requirements is assessed on what is planned but not detailed, or what can be recommended by the DANCED team.

Below, the various ECPA requirements regarding buildings, and known energy regulations in the building code are commented one by one.

A. *Reduction of heat from the sunlight that enters the building.*

Efficient measures has been taken in the design of shading and overhangs, as discussed in section IV and V. Furthermore if high performance glazing with thermal transmission coefficient of 20-30% can be applied, the DANCED team concludes that the ECPA requirements are more than met.

B. *Efficient air-conditioning, including maintaining room temperatures at an appropriate level.*

The proposed air-conditioning system is very flexible, and can run with a good efficiency at part loads, see section VI. Using the pond as a heat sink from the cooling machines instead of using conventional cooling towers can probably improve energy efficiency even further, beyond what can be expected by the ECPA.

The temperature level of the various areas of the building is proposed to be adapted carefully to the functions, thereby creating a thermal zoning of the building, where parts of the building will only require an air temperature of 28-29°C. This will reduce the cooling load beyond what can be expected following the "appropriate temperature level" clause of the ECPA.

C. *Use of energy efficient construction materials and demonstration of qualities of such materials.*

The overall energy efficiency of a building must be evaluated as the life cycle energy consumption. This includes energy consumption for manufacturing of building materials, transport of materials and people, construction of the building, energy consumption for running the building through the lifetime, and energy consumption for demolition of the building.

The energy consumption for running the building is the dominant figure, typically comprising 80-95% of the life cycle energy consumption. However, when extensive measures for reducing that consumption are utilized, the energy consumption for manufacturing the building components can be significant. This is now the case in Northern Europe, where thermal insulation thicknesses of the building envelope of 8-16 inches are becoming common.

Without having evaluated the actual case in detail, the conclusion of the DANCED team is, that in the actual case running energy consumption is still totally dominant, even if insulation thicknesses of 3-4 inches of the envelope is applied. Therefore the conclusion is, that the ECPA recommendation is met.

D. Efficient use of light in the building (ECPA), and a maximum lighting power density installed of 16 W/m² (building code)

A general office lighting system with an installed density of 8-10 W/m² is regarded as possible both by ERI and by the DANCED team. Therefore the requirements are more than met. Furthermore daylight will be utilized in large parts of the building, accounting for another reduction of the electricity consumption for lighting by at least 50% in the parts of the building with daylight admission.

The conclusion is, that in the area of lighting efficiency, this building will be much better than the minimum requirements, however with measures that still are regarded as being technically and economically feasible.

E. Use and installation of machinery, equipment, and materials that contribute to energy conservation in the building.

It is difficult to identify specific machinery and equipment that has not been mentioned under the other headings. Generally this item seems to be fulfilled, but additional energy saving features might be added as the detailed design development and design refinement moves ahead.

F. Use of operation control systems for machinery and equipment.

Advanced control systems have been proposed for controlling the ventilation system, the cooling systems and the lighting system. These controls seek to adapt the system performance to the actual needs. Furthermore an overall Building Management System has been proposed by the DANCED team. With these measures, the DANCED team regards the ECPA requirement as being fulfilled.

G. Other measures for energy conservation as prescribed by the Ministerial Regulations.

The DANCED team has not been able to explore this topic in depth. However building regulation requirements regarding OTTV (Overall Thermal Transfer Value) of the exterior envelope is regarded as having been more than met, given that the following values are used: 3 inches of insulation in the wall, 6 inches of insulation on the roof, and double glazed windows with an U-value of 1.1-1.5 W/m²K.

The OTTV value of the DEDP building should obviously be documented, however given that the procedure is quite detailed and takes some time to carry through, the DANCED team has not been able to specifically verify the figure.

The building regulations give specific requirements on the efficiency of the air-conditioning system. The DANCED team has not been presented with specific suggestions for system and component choice. However it is definitely the judgment that the government requirements can be met, and that it might be feasible to go beyond the minimum requirements.

Appendix 1: Terms of Reference for the DANCED mission

Terms of Reference
for
Review of Design of Energy Saving House
Thailand

April 5, 1995

1. Background

The department of Energy Development and Promotion (DEDP) is currently designing a new building comprising DEDP offices, a display centre and seminar rooms.

The 6,000 m^2 building is being designed to contain all relevant commercially accessible energy saving measures in order to serve a full-scale demonstration of ways to use these measures under Thai conditions. The design will as a minimum be based on the demands laid down in the new Energy Conservation Promotion Act (ECPA) and serve as a demonstration of its implications for building design as well as introduce new design philosophies in the building sector in Thailand.

Since most of these technologies are novel in Thailand, DEDP has requested technical assistance from DANCED in the form of expertise in energy saving in the design phase of DEDP's new building.

2. Objectives

The objective of the consultant is to provide recommendations on the optimal integration of energy conservation concepts in the design of DEDP's new building.

3. Outputs

The outputs of the mission will be:

A technical Assistance Report containing the consultant's findings and recommendations. The report will be submitted to DEDP as well as DANCED-Thailand before departure from Thailand.

4. Activities

The work of the consultant will include, but not necessarily be limited to:

- Participate in the review group which will follow the architect's design process with the purpose of scrutinizing and ensuring the technical feasibility of the measures proposed by the architect

- Use the new ECPA as a minimum reference for energy recommendations to be considered in the design of the building

- Suggest other energy saving measures or technologies to be considered based on relevant experience from Danish and other EU development and demonstration projects

- Include aspects of cleaner technology to ensure that other environmental parameters than energy are not compromised

- Extend advice to the Commercial Counsellor, Mr. Lars Friis-Jensen, Royal Danish Embassy, Bangkok, on possible Danish participation during the construction phase

- Conduct a briefing and debriefing with the DANCED representation at the Royal Danish Embassy in Bangkok at the beginning and the end of the mission respectively

5. Timing of mission

The mission will have a duration of 6 calender days. The consultant and the trainee will commence their activities in Thailand on April 17, 1995. Two work days for preparation in Denmark and five work days for report refinement are foreseen, also (four for the trainee).

Due to the short duration of the mission, a brief follow-up mission may be relevant on a later stage. This will be assessed upon completion of the mission in consultation with the parties involved.

6. Reporting

Before departure from Thailand the consultant shall prepare a Technical Assistance Report, as specified under para 3, and submit it to DEDP and the DANCED representation in Thailand.

The consultant shall provide for his word processing equipment. The report shall be drafted in WordPerfect 5.1 or 5.2 or compatible software. Spreadsheets shall be drafted in Microsoft Excel 4.0 or compatible software. The report shall be submitted in hard copy and on disk.

7. Consultant

The consultancy will be conducted by Mr. Poul E. Kristensen, SBC, from Esbensen consulting company. Mr. Henrik Sørensen, also from Esbensen, will assist him as a trainee.

Counterpart: Dr. Itthi Bijayendrayodhin, Deputy Director-General, DEDP.

8. Attachments

8.1 The Energy Conservation Promotion Act
8.2 Assorted handouts from the DEDP on the new building, energy conservation measures etc.

Appendix 2: Activities and Meeting Record

Monday April 17

Meeting at Department of Energy Development and Promotion DEDP 09.00 - 11.30

Participants:
Dr. Itthi Bijayendrayodhin, Deputy Director General DEDP
Mr. Kriengkorn Bejraputra, Executive Director DEDP
Mr. Pramote Iamsiri, Director DEDP
Mr. Pramoul Champong, Acting Director DEDP
Dr. Soontorn Boonyatikarn, Energy Research Institute ERI, Chulalongkorn University
Ms Lisa Surprenant, International Project Director ERI
Mr. Henrik Sørensen, DANCED/Esbensen Consulting Engineers
Mr. Poul Kristensen, DANCED/Esbensen Consulting Engineers

Meeting Objective:
Briefing about the project background, objectives and present status by Dr. Itthi and by the project architect Dr. Soontorn.

Results:
A detailed project briefing occurred. Building drawings were presented. Time schedule for the work of the DANCED mission for the coming weeks work was agreed.

Working meeting at Energy Research Institute ERI, Chulalongkorn University 13.30 - 18.00

Participants:

Dr. Soontorn Boonyatikarn, Energy Research Institute ERI, Chulalongkorn University
Ms Lisa Surprenant, International Project Director ERI
Mr. Henrik Sørensen, DANCED/Esbensen Consulting Engineers
Mr. Poul Kristensen, DANCED/Esbensen Consulting Engineers

Meeting Objectives:
Detailed briefing and discussion of the project design, discussion of project concept and details of the building layout.

Tuesday, April 18

Morning:
Work in the hotel

Afternoon:
Working at Energy Research Institute ERI, Chulalongkorn University 13.00 - 18.30, ad hoc discussions with Ms Lisa Surprenant and Dr. Soontorn.

Wednesday April 19

Meeting at ERI with the project engineer Environmental Engineering Consultants Co. Ltd., Bangkok (EEC)

Participants:
Mr. Tammanoon Chantavorn, Associate EEC
Mr. Chiraphon Chayasathit, Project Manager EEC
Mr. Chakrapan Pawangkarat, Mechanical Engineer EEC
Mr. Wanchai Bunditkitsada, Senior Environmental Engineer EEC
Mr. Kwanchai Gunsantithamrong, Sr. Electrical Engineer EEC
Ms Lisa Surprenant, International Project Director ERI
Mr. Henrik Sørensen, DANCED/Esbensen Consulting Engineers
Mr. Poul Kristensen, DANCED/Esbensen Consulting Engineers

Meeting Objectives:
To brief EEC on the objectives for the DANCED mission, and to receive a detailed briefing from EEC regarding the present status of the engineering design. To mutually stimulate an exchange of views and to stimulate a discussion on energy and environmental design of the DEDP low energy building project.

Afternoon:
Work on mission report at ERI.

Thursday April 20

Meeting at Royal Danish Embassy 08.15 - 09.15

Participants:
Mr. John Carstensen, Environment Attaché, DANCED Thailand
Ms Viali Vasoontraluk, Environmental Programme Officer, DANCED Thailand
Mr. Henrik Sørensen, DANCED/Esbensen Consulting Engineers
Mr. Poul Kristensen, DANCED/Esbensen Consulting Engineers

Meeting Objective:
To conduct briefing with the DANCED representation in Bangkok.

Meeting at the Royal Danish Embassy 14.00 - 15.00

Participants:
Mr. Lars Friis-Jensen, Commercial Counsellor, Royal Danish Embassy
Mr. Henrik Sørensen, DANCED/Esbensen Consulting Engineers
Mr. Poul Kristensen, DANCED/Esbensen Consulting Engineers

Meeting Objectives:
Discuss possibilities of Danish participation during the construction phase of the DEDP low energy building project.

Afternoon/evening:
Work on mission report in the hotel.

Friday April 21

Morning/afternoon:
Finalization of mission report at ERI

Meeting at Department of Energy Development and Promotion DEDP 11.00 - 13.00

Participants:
Dr. Itthi Bijayendrayodhin, Deputy Director General DEDP
Mr. Kriengkorn Bejraputra, Executive Director DEDP
Mr. Pramote Iamsiri, Director DEDP
Mr. Pramoul Champong, Acting Director DEDP
Mr. Pongphat Munkkunk, Electrical Engineer DEDP
Dr. Soontorn Boonyatikarn, Energy Research Institute ERI, Chulalongkorn University
Ms Lisa Surprenant, International Project Director ERI
Mr. Henrik Sørensen, DANCED/Esbensen Consulting Engineers
Mr. Poul Kristensen, DANCED/Esbensen Consulting Engineers

Meeting Objective:
For the DANCED team to brief DEDP, Dr. Soontorn and Ms Lisa Surprenant on the initial findings and conclusions, and to receive comments on the same.

Evening 19.00 - 22.00:
Presentation and discussion of report with DEDP

Saturday April 22

Meeting between Ms.Lisa Suprenant and Poul E. Kristensen 12.00 - 14.00

Meeting objectives:
To assess the results of the mission.