Approachable ZEB (Zero Energy Building) (Part 1)
-CURRENT SITUATION OF OUR LATEST PROJECTS FOR ZEB-

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Abstract. We introduce the outline of the ZEB buildings we designed. Then, we analyse the plots on the ZEB chart, the completion year, the building type, the characteristics of these building, and the possibility of realizable ZEB, etc. And we mention the planning method to achieve ZEB Ready, and Nearly ZEB with less cost. And in this report, the breakdowns of reduction rates with reference to the standard energy consumption are described in figures of energy indicator in all these ZEB ready to Net ZEB projects. Such descriptions are also rare in WSBEC. Also, it seems that there is little description in WSBEC that refers to the relationship between the increase in investment costs and the reduction in energy costs. Taking care of the the clients, we do not mention in this report, but we will make oral comments at the oral presentation.

1. Introduction
In order to accomplish a ZEB, it is absolutely necessary first to reduce to minimum of load and consumption, and next to make the maximum use of natural energy such as earth and solar thermal, hot spring heat and use of snow and renewable energy such as solar and biomass power generation.
In Japan, several Net ZEB projects have appeared, ZEB buildings including ZEB Ready, Nearly ZEB are entering the stage of popularization. The authors plot the ZEB projects designed by us on the ZEB chart. As of March 2018, six projects achieved ZEB Ready, two Nearly ZEB and one Net ZEB.

2. The Environmental Concept of our projects

2.1. Four Viewpoints and 16 Approaches
Since the early 1970s, we have created a variety of advanced green buildings under the slogan “Green Design.” In 2010 the four important viewpoints we have established during the long process of our architectural endeavors are presented in Environment Concept Book: Goals for 2050, published.
They are as follows:
1. Consider the space in terms of human comfort
2. Create zero-energy that corresponds to nature
3. Create new values in architecture by collaborating with stake holders
4. Contribute to the local environment
These viewpoints guide our efforts to materialize our 2010 message on sustainability (“correspondive to human and nature”) and its concept (“raise human sensitivity and creativity, keep nature alive, and realize from zero energy buildings to carbon neutral cities”).

While the four viewpoints expand our focus from the building’s interior space to the vast urban environment, we introduce four approaches for each, which totals 16 approaches for creating more green buildings. The approaches are closely related to the 17 goals and 169 targets of the 2030 Agenda for Sustainable Development Goals, which was adopted by countries at the United Nation’s General Assembly in September 2015.

2.2. Long-term Goals and Achievements

Our long-term goals are: to complete the leading net-zero energy building (nZEB) project by 2020, to make the nZEB standard by 2030, and to materialize a net-plus energy building (nPEB) project after 2030. While nZEB buildings consume zero-net energy not only by thoroughly conserving energy but...
also by generating energy on site, nPEB buildings achieve plus-energy consumption by providing surplus energy to other buildings in local areas.

Regarding our design-built projects, our 2050 goal is to reduce carbon emissions of a standard building by 80% without increasing costs, while creating an nPEB for best-practice projects. Fig.1-3 plots the data for each project designed by us. The vertical axis of each project shows the ratio of energy-consumption in the building immediately after its completion to the reference building. The details are mentioned as [energy] indicators on each project. The interannual data for our Tokyo Main Office (2005, 2009 and 2016) and Higashi-kanto Branch Office are also plotted.

3. ZEB Chart and Energy Indicator

3.1 ZEB Chart
ZEB projects that we designed are plotted in the Fig.2-1. Horizontal axis is an energy consumption axis, and vertical axis is an energy production axis. If the designed project’s calculated or actual value is 50% or more lower than the reference (or standard) value, it is called ZEB ready. If consumption is 75% or more lower than the reference, or in the other case that consumption is 50% and energy production is 25%, it is called Nearly ZEB. And if consumption is 50% or more lower than reference and the energy production is equal to this consumption, it is called Net ZEB. As well, if below As of March 2018, six projects achieved ZEB Ready, two Nearly ZEB and one Net ZEB by us.

![ZEB Chart (ZEB Projects designed by us)](image)

3.2 Energy Indicator
Five Examples are as follows. Energy indicator showing energy consumption for reference building as actual value and graphically indicating reduction rate is shown on the figure of each project. (Fig.3-2)

* 1,000 MJ/m² (primary) = 88.0 kBtu / ft² (primary) = 32.5 kBtu / ft² (secondary) (EUI: Energy Use Intensity)

![Energy Indicator](image)
4. Five Example of ZEB Project

4.1 Takenaka Corporation Higashi-kanto Branch Office ZEB Renovation

4.1.1 Four concepts of ZEB renovation in actual use

We incorporated the following four concepts in developing the plan:

Change the concept of comfortableness: We incorporated the following four concepts in developing the plan: We changed the conventional concept of keeping the indoor temperature and humidity universal or uniform and instead, increased comfortableness by a combination.

Super energy saving building: In addition to the exterior renovations for higher thermal insulation, use of double skin and reinforcement of solar shading, we have introduced advanced technologies including LED lighting, radiant panel cooling and heating, desiccant air-conditioning and direct use of geothermal energy and solar heat. Moreover, the energy consumption derived from fossil fuels was minimized by performing optimal control.

Consider “smart workstyle”: We reformed an office layout so that the individual workers might prepare the places selectable by works. The environment settings for the individual places were made different, and accordingly enhancement of workplace productivity was aimed at by switching the work modes. The outlet energy consumption was also drastically reduced by sharing the office equipment and PC terminals.

Become disaster-resistant: By taking measures listed above, the building was able to be operated at the minimum energy, and should the lifelines be disrupted in a disaster, the office functions can be maintained for many hours by utilizing the photovoltaic power and storage batteries. The building was transformed into an office building with high BCP performance.

4.1.2 Radiant cooling/ heating using natural energy, desiccant AC and light environment

For the interior environment, a sensible-latent heat separation air-conditioning system is applied, using radiant cooling and heating for temperature control and newly-developed, small desiccant outdoor air handling units for humidity control. Higher thermal insulation of exterior cladding and use of radiant cooling and heating panel have resulted in smaller differences among the temperatures on the interior ceiling, floor and wall surfaces, which led to construction of a comfortable environment with less thermal stress on the human body. In addition, personal fans, one for each person, are installed on the ceilings and provide wellness control adapted to the individual bodily sensations, allowing an air conditioning plan in consideration of the workers’ wellness. The maximum and direct use of natural energy such as solar heat and geothermal heat for the heat sources enabled the minimum reduction of the energy consumption.

Table 4-1 Project outline

| Client          | Takenaka Corporation |
|-----------------|----------------------|
| Building use    | Office               |
| Location        | Chuo Ward, Chiba City, Chiba Pref.JP |
| Total floor area| 1,318 ㎡             |
| Structure       | Reinforced concrete, Steel |
| Story           | 2 floors above ground |
| Construction period | October 2015 ～ March 2016 (Existing building completed in 2003.) |
In terms of light environment, automatic control of new installed blind according with outside light was adopted. We maximized double-sided daylighting, realized the office with a high sense of brightness by daylighting, and greatly reduced lighting consumption.

4.1.3 Evolution of existing façade and smart workplace

The existing façade evolved into a façade with high thermal insulation and high solar shading performance by applying double skin with reuse of the existing exterior aluminum fins, replacing the window glass by highly-insulated argon Low-E glass and installing automatic control blinds in the double skin, in addition to higher heat insulation of roof and exterior walls. Furthermore, we also installed new automatically controlled, natural ventilation openings and let them operate in relation to automatic controlled operation (newly introduced) of the existing skylights, which enabled positive incorporation of natural ventilation during the mid-seasons, and consequently we were able to create office spaces where you can feel gentle breeze and reduce the energy consumption.

The workplace is now changed into a layout that allows the workers to choose the places suited to their own work modes in accordance with the concept of “Activity Based Working”, and thus the environment has been established according to each area. Switching the work modes is aimed at enhancement of workplace productivity and optimization of energy consumption.

4.2 Panasonic Stadium Suita

4.2.1 Community-based compact stadium

This dedicated stadium that has been built to international standards is the new home of the J. League Gamba Osaka team. A fundraising organization took the lead in financing “the first stadium in Japan to be built with contributions from the general public.” For the roof that covers 40,000 spectator seats, a skeleton that is seismically isolated in vertical, horizontal and diagonal directions was developed, and the quantity of steel frame members was reduced by approximately 40%. To minimize the
maintenance burden on operators, the overall building size was made more compact by stacking the
spectator seats, and the building finishing components was reduced as much as possible in order to
make the facility maintenance-free. For environmental considerations, 0.5 MW photovoltaic power
panels were provided and LEDs were used exclusively for the field lighting, and other measures such
as smart power reception in combination with large adjacent complexes were introduced to reduce
regional CO2 emissions. The stadium was the first soccer stadium in Japan to receive the highest (S)
rank of the Comprehensive Assessment System for Building Environmental Efficiency (CASBEE).
The use of design that eliminates all curves made it possible to use precast concrete for 80 % of
skeleton, Enabling maximal labor-saving construction.

4.3 Dai-ichi-Life Shin-Ohi Office

4.3.1 Low-rise office like landscape surrounded by terrace and courtyard

This project involved a construction of a new office / delivery center building of The Dai-ichi Life
Insurance Company, Limited as a part of the headquarters restructuring of the former 45-year old Ohi
Head Office.

In the workplace where the employees perform concentrated work with terminal equipment for a given
length of time, every minute/hour except during the period when they concentrate on business at their
own desks is linked to relaxation. Furthermore, we aimed to design an environmentally-conscious,
“Super Eco” building and developed a plan with the following essential features.

4.3.2 Creation of new prototype of suburban-type back office
Making the best use of the surrounding rich natural environment, realize a verdant workplace with “concentration and relaxation” integrated with the landscape. In addition, continue the inside to the outside while easing the weather conditions, in the environment buffer zone such as a courtyard or terrace. Thus create a space with high amenity that makes the workers feel as if they were working in a park.

Employ a simple and orthodox method of “opening a building” in the surroundings and face nature modestly. Thus promote active use of natural energy and aim at a zero energy building (ZEB) in the future.

Reduce a distance between human beings and nature and have continuous relationship between them. Thus recover the coexistence of nature and human beings which is being lost in the modern society and relationship between humans through nature.

4.3.3 Realization of Super Eco office

Follow the “concept of thoroughly passive use of nature” which continues to the regional environment, such as the building layout to take indoors the local prevailing wind blowing from the ocean towards the mountain, control of the sunshine with deep balconies which allow ventilation by opening windows even on a rainy day, and natural ventilation using solar chimneys, and reduce the primary energy to a half, compared with general office buildings (the actual performance was a 61% reduction in 2012).

Incorporate a 2 meter fence, which was required for the purpose of security, into the sufficient green buffer zone. By eliminating the existence of the fence, the building can continue to the surrounding greenery and create the green landscape open to the surroundings.

4.4 Takenaka Corporation Tokyo Main Office

4.4.1 Breathing from envelope openings to light courts and Activity Based Working (workplace)

We proposed an office space aimed at appealing to the sensitivities of workers and improving communication by using a low-rise section plan with large areas and an open layout of core functions laid out along the central axis of the building.
We have developed an exterior bracing structure produced by refining the structural style of a low-cost shopping center and the “highly-functional exterior walls” and “new ceiling system” by equalizing the beam depth. Furthermore, the building employs positive use of natural energy such as sunlight and wind, and a high-efficiency air conditioning system. It aims to enhance the life cycle performance of the building through flexibility and a longer service life.

Additionally, the layout is designed to reduce the heat-island effect, and the going-on greenery program is shared with the residents in the neighborhood. We have also carried out the energy-saving programs by such means as thermal storage, transportation and low-temperature large-temperature-difference air outlets. The workers can communicate easily with one another in the offices where natural light is taken into every workspace by providing an open layout of the elevators and stairs, which are service spaces in the offices, and locating them in the central row of the building as well as four light wells. The building is in agreement with the spatial sensitivity that inheres in the building, not only depending on the quantitative indices, such as the rate of effectiveness and environmental efficiency, to achieve the main concept, which is the sustainability of the building.

### 4.4.2 Breathing skins

A hybrid air-conditioning unit using natural wind is placed under the buckling-restrained braces dispersed in the outer periphery, and the outside air is taken into the rooms through the louvers behind it. While the outer skins are made of hard envelopes, the exterior cladding of the building is a doughnut structure having outer and inner skins, provided inside with four voids serving as paths of light and wind. Thus light and wind are efficiently taken in through the openings.

### 4.4.3 Workplace transformation: Introduction of Activity-Based Working (free address)

ABW (Activity-Based Working) has been adopted partially on the 5th floor and in a department on the 7th floor. With ABW people can choose their own working environment according to work contents and their mood on any given day. A free address seating system has been made for office duties. In
order to realize the "We can choose the best environment" floor plan, we opened the communication zone and the work zone, and installed a loosely connected "workplace". This was done to create new value and improve productivity.

4.4.4 Energy consumption over years

The energy consumption dropped by 36% from the former office building in one year after completion of the new building, and reached a reduction of 48% in 10 years due to our annual efforts such as further expansion of use of natural energy, improvement of heat source operation, review (and change as necessary) of operation hours, and the 2011 renovation of lighting and photovoltaic power.

generation (PV)=5% per year (Fig.3-16)

4.5 Nissan Global Headquarters

4.5.1 Workplace creativity and central void & double-height space on every other floor

The concept of the headquarters office functions is “Creation of Intelligence,” and the key words for the spatial constitution to realize it are: Agility, Serendipity and Flexibility. By providing a double-height space on every other floor, shifting every story in the north-south direction, the whole building is formed so that it can be traced with one stroke in terms of spatial planning and circulation planning, which symbolizes a unity of the headquarters.

The double-height, semi-public spaces are called “engawa spaces,” where spiral staircases are installed, which induce agile and quick behaviors upstairs and downstairs and intimate communication. Moreover, they are positioned as the zones which give you stimuli of intelligence, unlike general workplaces in terms of quality, in the relationship between viewers and those who are viewed.

In addition, a void space and stairs throughout the high-rise section are located at the center of the workplace, which allows various forms of communication among the stories in terms of circulation patterns and visibility as well as the brightness creation and natural ventilation of the central void. Thus the building is designed to positively provide the whole office areas, especially the communication zone,
with daylighting and natural ventilation in order to change the awareness and behaviors of the workers by letting them concentrate or relax themselves.

5. Conclusion

All five Projects have achieved nZEB, Nearly ZEB, and ZEB ready, but the design approach is different. The examples of Takenaka corporation Tokyo head office and Nissan Global Headquarters are urban offices, but energy savings have been achieved through the use of natural lighting and ventilation using light-well or atrium, lighting and air conditioning control and workplace productivity improvement in workplaces. (ZEB ready)

Takenaka Corporation Higashi-kanto Branch Office ZEB Renovation was designed from the ZEB’s point of view, starting with a thorough reduction the heat load of the envelope, using direct geothermal and solar heat and ultra-compact desiccant air conditioner, etc., and also changed workstyle. (nZEB)

Dai-ichi-Life Shin-Ohi Office is a low-rise office in the suburbs, which has a biofilia aspect integrated with local nature, and is equipped with both-sides daylighting, ventilation, greening and so on. (ZEB ready)

Suta stadium is a soccer stadium, and ensured daylight hours for natural grass, 24 hours of natural ventilation, and ventilation for seats, and PV were also installed on the roof. In addition, the construction impact has been drastically reduced by the compact construction method and pre-fabrication. (Nearly ZEB)

It is important to emphasize the unique design of buildings while reducing costs by combining versatile technologies. We will continue to create various distinctive green buildings and ZEB projects.

References

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