Field Survey of the Emergency Power Supply Related to Business Continuity

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Abstract
With the development of economic globalization, as well as the current industrial structure in which the interruption of business activities would have a worldwide impact, preparations to maintain the operation level of important business tasks in the event of a disaster have become increasingly important in both the public and private sectors. This study focused on the electrical power system in buildings and a field survey was performed on emergency power supply facilities to secure an emergency power supply in the major business districts of Japan. The objective of the study was to extract beneficial information regarding the emergency power supply capacity related to business continuity in buildings located in the central business district, to contribute to the future establishment of BCPs.

The results of the analysis indicated that the percentage of the capacity of the emergency power supply in contract demand tends to be larger when running time equivalent to full-load operation is longer on the whole. The survey indicated that in the majority of the buildings, the maximum operating time on the emergency power supply is 24 h or less. Therefore, business continuity will be impossible if the power supply is interrupted for more than 24 h.

Keywords: emergency power supply capacity; business continuity; running time equivalent to full-load operation; the central business districts; interruption of business activities

1. Introduction
There is a great deal of concern about the impact of an earthquake with its epicenter immediately beneath Tokyo, Japan. The Central Disaster Prevention Council of Japan concluded that such an earthquake would interrupt key functions of the capital city and cause enormous human and material damage. The impact of such an interruption of key functions of the capital city would extend beyond Tokyo, and may interfere with different aspects of life of many Japanese citizens as well as affecting both domestic and global economic activities. This would not only reduce the international competitiveness, but would also have an unavoidable impact on foreign Asian and global countries. There is also concern regarding the prolonged period of recovery and restoration after such a domestic natural disaster.

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regarding the emergency power supply capacity related to business continuity in buildings located in the central business district, to contribute to the future establishment and development of BCPs.

2. Focus of this Study
2.1 Importance of maintaining appropriate functions of buildings in the event of an emergency

An earthquake with its epicenter beneath a country's capital city, which is the political and economic center of the country, is expected to result in both large-scale direct and indirect damage, which may lead to functional building loss. However, as BCPs are concerned mainly with business contents from the management side, measures regarding the physical basis of the business may often be overlooked. For example, measures to be taken in the event of the death of the CEO or when the supply chain is cut are considered first, with considerations regarding the buildings—which are the business and production base—often limited to determination of earthquake resistance and antiseismic reinforcement. With regard to risks related to building facilities and equipment, such as ensuring the safety and reliability of power supply and air conditioning systems, the diagnosis and evaluation of a business facility from the viewpoint of maintenance and operation of building functionality are extremely important.

The most important system that must be secured to ensure business continuity in an emergency situation is the electric power source. Almost all building utility equipment uses electricity, and therefore if the power supply is interrupted by an infrastructure failure and insufficient emergency power supply, it would be impossible to achieve business continuity.

A field survey was performed with regard to securing an emergency power supply for buildings in the case of an emergency. This study was performed to aid in the establishment and development of BCPs and to improve the reliability of building functionality maintenance by analyzing and determining the emergency power supply performance requirements for business use, especially for business continuity in the case of an emergency.

2.2 Security load and disaster prevention load

It is necessary to secure two types of power load in an emergency, such as an earthquake or a power supply failure for commercial use: disaster prevention load and security load.
1. Disaster prevention load:
   In the case of power failure due to a fire, the load to supply power to disaster prevention equipment/systems installed in the facility (automatic fire alarm systems, escape guiding systems, fire alarm apparatus, extinguishers, smoke control equipment, emergency use power outlet, etc.).
2. Security load:
   The load to supply power to maintain the functionality of a facility during a general power failure.

In Japan, the legal minimum time for power supply in an emergency situation is set based on the disaster prevention load by appropriate regulations, such as the Building Standards Law and the Fire Protection Law. These regulations stipulate the requirements for in-house power generators, storage battery systems, and incoming electricity power receiving system exclusively for emergency power, and buildings subject to these laws must comply with the legal minimum time for power supply in an emergency situation. However, as the disaster prevention load is calculated and designed based on the load necessary for fire extinguisher equipment, escape facilities, etc., the electrical power load required for business continuation is not considered. Therefore, it is necessary to take the security load into consideration in designing disaster prevention facilities to preserve building functionality in an emergency.

A sampling survey on office buildings conducted during the initial stages of this study indicated that mid- to small-sized office buildings cannot secure sufficient security load either because of insufficient financial capacity or because of cost reduction measured in the design phase. The security load capacity was limited to powering computer servers and building security systems during a power failure. BCPs are in place for large-scale, luxury or higher class buildings and those used as the headquarters of major corporations as well as buildings with important uses such as financial institutes. These buildings had both BCPs and measures to ensure security load to allow continuation of important business tasks to a certain degree. Even if the measures were insufficient, management were aware of the requirements and were trying to work toward these goals.

Therefore, in the present study, the survey was limited to the major business districts of Tokyo and Osaka, which are the major commercial centers of Japan, and a field survey on emergency power supply facilities was conducted with regard to emergency power supply in buildings. Previous studies provided statistical data on emergency power supply after completion of construction. However, there have been few studies in which the area of survey was limited to major business districts representative of those in Japan to determine the capacity of the emergency power supply facility, including the capacity for security load in buildings with higher performance requirements and buildings of higher grade. This is an important distinction of this study.

3. Survey Overview
3.1 Survey method

This survey included areas in Japan where the offices of major corporations are concentrated. The survey was conducted in the limited areas around Tokyo.
station (including Otemachi, Marunouchi, Yurakucho, Uchisaiwaicho), as well as the Midosuji area of Osaka (including Yodoyabashi station and Honmachi station) (Fig.1.). Buildings with relatively small floor size (14,000 m² or less in Tokyo, 3,300 m² or less in Osaka) were excluded from Yurakucho and Uchisaiwaicho in Tokyo as well as Midosuji area in Osaka. The survey method involved a direct visit to each building, explaining the purpose of the study, and distributing a questionnaire to the building management with a request to return the responses by mail or fax. The survey was conducted in 2006.

3.2 Survey items

The survey items are as listed below. As this was a survey of facilities to secure power supply in an emergency, the number of items was kept to a minimum. (Table 1.)

3.3 Survey results

The numbers of completed survey questionnaires are shown below.

* Tokyo area: 47 of 119 buildings (39%)
* Osaka area: 22 of 47 buildings (47%)
* Overall: 69 of 166 buildings (42%)

The three main reasons why the surveys could not be completed by the building management were as follows.
- The building management do not respond to any type of survey as a matter of policy due to security and safety concerns.
- The responses could not be given because answering the survey may cause problems for the business strategies of the companies in the building.
- Cannot complete the survey because they were not the owner of the building.

The buildings for which responses were available in Tokyo area consisted of 18 buildings owned by the occupying company, 9 rented buildings, and 20 rented and owned by a company occupying part of the building. In Osaka area, the buildings included in the survey consisted of 7 buildings owned by the occupying company, 11 rented buildings, and 4 rented and owned by a company occupying part of the building.

The classifications for building use and functionality are listed below (Table 2.).

An internet exchanges (IX) are facilities that exchange internet traffic between networks of different internet service providers.

Headquarter office buildings, rented office buildings, financial buildings, and lifeline/infrastructure buildings in Tokyo and Osaka are listed separately according to geographic location. The geographic location is not indicated for survey results regarding other classifications as these were only available in Tokyo.

4. Survey Results

4.1 Analysis based on the total floor area

Analysis was performed based on the total floor area of the buildings.
The relationships between the total floor area and the contract demand (Fig.2.), annual electrical power consumption (Fig.3.), emergency power supply capacity (Fig.4.), storage battery capacity (Fig.5.), and the maximum operation time using only the emergency power supply (Fig.6.) are shown in the figures indicated.

Contract demand (Fig.2.), annual electrical power consumption (Fig.3.), and emergency power supply capacity (Fig.4.) were generally proportional to the total floor area. Facilities such as data centers, broadcast/IX facilities, financial institutes showed exceptionally large values that did not correspond to the proportional relation, and these buildings were all considered important facilities by the Central Disaster Prevention Council of Japan.

No clear proportional relationship was seen with storage battery capacity (Fig.5.) but the maximum value was approximately 3,000 Ah in all types of facility. The headquarters building for an IT company in Osaka had an exceptionally large storage battery capacity. There was no proportional relationship with maximum operation time using only the emergency power supply (Fig.6.), but the operation time was less than 24 h in most of the buildings included in the analysis. Therefore, if a power failure continues for longer than 24 h, business continuity may become impossible. Most of the companies with a maximum operation time using only the emergency power supply of over 24 h are financial institutes, disaster prevention facilities, company headquarters, infrastructure companies, and those considered important facilities.

4.2 Analysis using contract demand

Analysis was performed based on contract demand. The relationships between contract demand and the annual electrical power consumption (Fig.7.), emergency power supply capacity (Fig.8.) are shown in the respective figures. (Buildings indicated as 0 in the figures are those for which sufficient data could not be obtained.)

Contract demand is directly proportional generally to both annual electrical power consumption (Fig.7.) and emergency power supply capacity (Fig.8.).
figures show two types of slope: one for data centers, broadcast/IX, disaster prevention facilities and financial institutions, and another for office buildings that are rented out to other companies.

The discussion above outlined the relationship between the survey items using the total floor area and contract demand as references. A proportional relationship was generally observed on the whole in analysis using the total floor area as a reference, but the results suggested a clearer relationship reflecting the characteristics of the facilities if the contract demand was used as a reference. Further analyses were performed focusing on the performance of the emergency power supply, which will be discussed in the following sections.

4.3 Analysis using percentage of emergency power supply capacity in contract demand

This section discusses analysis of each item based on the percentage of emergency power supply capacity in contract demand. The equation to calculate the percentage of emergency power supply capacity in contract demand is shown below:

Percentage of emergency power supply capacity in contract demand (%) = Capacity of the emergency power supply (kVA) × Power factor (0.8) × 100 / Contract demand (kW)

The relationships between the percentage of emergency power supply capacity in contract demand and the total floor area (Fig.9.), annual electrical power consumption (Fig.10.), and maximum operation time using only the emergency power supply (Fig.11.) are shown in the respective figures. (Items indicated as 0 in the figures are for buildings for which sufficient data could not be obtained.)

Instead of a proportional relationship, each type of facility showed a specific trend in the distribution of the total floor area (Fig.9.) and the annual electrical power consumption (Fig.10.). The percentage of emergency power supply was over 40% for important corporations, such as data centers, broadcast/IX,
disaster prevention facilities, and financial institutions.

Two government-related disaster prevention facilities showed a value of approximately 90%. The values in offices in Tokyo were around 20% regardless of total floor space, while those in Osaka were around 40–50%. These relatively low and limited capacities of the emergency power supply in offices in Tokyo were thought to be because they were designed only to supply power for common spaces.

The majority of the buildings showed a maximum operation time using only the emergency power supply of less than 24 h (Fig.11.) as shown in the other analysis. (Fig.6.) Certain trends were observed for each type of facility.

The buildings that had a relatively large capacity of over 50% as well as long operation time were disaster prevention facilities, infrastructure companies in Osaka, financial institute buildings in Osaka, and headquarters of financial institutes in Tokyo. Other facilities considered to be highly important also have relatively large capacities of over 50%.

However, important facilities in the area around Tokyo station, such as data centers and broadcast/IX companies, showed relatively short operating times compared to their large percentage emergency power supplies. Business continuity would be impossible to achieve in the case of a power failure lasting for over 24 h. However, restoration of the electrical infrastructure in these areas and in these important facilities by related public and private sectors is likely to have a high priority in the event of a disaster, and the management may have taken this into consideration when designing the maximum operating time on the emergency power supply.

4.4 Analysis using running time equivalent to full-load operation

4.4.1 Running time equivalent to full-load operation

The "project promoting the implementation of building and energy management systems" of the New Energy and Industrial Technology Development Organization (NEDO) defines and discuss running time equivalent to full-load operation as an index approximating the operating time of a building. Some of the characteristics of this index related to this study are listed below:

- There were no significant differences in equivalent full-load hour between buildings of different sizes, but differences were observed between buildings with different uses.
- The equivalent full-load hour for offices was within a certain range, and tended to become longer as the building size increased.

Equivalent full-load hour is defined as the time required to consume the annual electrical energy consumption if power was consumed at the rate of contact demand.

Running time equivalent to full-load operation [h/yr] = annual power consumption [kWh] / contract demand [kW]

4.4.2 Analysis using running time equivalent to full-load operation

This section focused on the lack of significant differences between buildings of different sizes, while there were differences between buildings with different usages, as described in the previous section. In this section, analysis was performed using running time equivalent to full-load operation.

![Fig.12. Total Floor Area](image1)

![Fig.13. Emergency Power Supply Capacity](image2)

![Fig.14. Percentage of Capacity of the Emergency Power Supply in Contract Demand](image3)
The relationships between running time equivalent to full-load operation and the total floor area (Fig.12.), emergency power supply capacity (Fig.13.), percentage of capacity of the emergency power supply in contract demand (Fig.14.) are shown in the respective figures. (Buildings with a running time of 0 in the figure are those for which sufficient data could not be obtained.)

Certain trends were observed in the total floor area (Fig.12.) for each type of facility. There was no proportional relation to the total floor area, and this result corresponded with the previous observations referred to in the last section indicating that there are no differences in equivalent full-load hour between buildings of different sizes. Companies with long running time equivalent to full-load operation were data centers, broadcast/IX companies, disaster prevention facilities, and financial institutes, which are considered important bases and are highly computerized.

Emergency power supply capacity (Fig.13.) tended to increase proportionally after around 3,000 h/yr of running time equivalent to full-load operation.

In addition, to equalize the effect of the scale of the building on the emergency power supply, the emergency power supply capacity was divided by the contract demand to obtain the percentage of capacity of emergency power supply in the contract demand to be used in the analysis. The percentage of capacity of the emergency power supply in contract demand tended to increase as the running time equivalent to full-load operation became longer. (Fig.14.) There appears to be a correlation between the running time equivalent to full-load operation and the percentage of capacity of the emergency power supply in contract demand on the whole. In addition, certain trends were observed as clusters of distribution for each type of facility.

5. Conclusions

This study focused on electrical power systems in buildings and a field survey was performed on emergency power supply facilities to secure an emergency power supply in Tokyo and Osaka, which are the major business districts of Japan.

The survey results are significance as the survey included the emergency power supply capacity for security load for buildings in the central business district, which are higher grade buildings with high performance requirements. This is an important distinction of this study.

The survey was performed to understand the current conditions regarding emergency power supply capacity in buildings as well as to extract beneficial information to contribute to the establishment and development of future BCPs. The findings of this study can be summarized as follows.

1. The survey indicated that in the majority of the buildings, the maximum operating time on the emergency power supply is 24 h or less. Therefore, business continuity will be impossible if the power supply is interrupted for more than 24 h. The corporations with a maximum operating time of over 24 h are mostly corporations of importance, including financial institutions, headquarters of companies, disaster prevention facilities, and companies providing infrastructure.

2. The results regarding the percentage of capacity of the emergency power supply in contract demand indicated a specific trend for each type of facility. The percentage of emergency power supply in corporations of importance, such as data centers, broadcast/IX companies, disaster prevention facilities, and financial institutions was 40% or greater. Two government-related disaster prevention facilities showed a value of approximately 90%. The values in offices in Tokyo were around 20% regardless of total floor space, while those in Osaka were around 40–50%. These relatively low and limited capacities of the emergency power supply in offices in Tokyo were thought to be because they were designed only to supply power for common spaces.

3. The corporations with relatively large emergency power supply capacities of above 50% of contract demand and that have secured long maximum operating times on emergency power supply were disaster prevention facilities, buildings for infrastructure companies in Osaka, financial institutes in Osaka, and headquarters of financial institutes in Tokyo. Other facilities considered to be highly important also have relatively large capacities of over 50%. However, some important facilities, such as a data center located in the area around Tokyo station, had shorter maximum operation times despite the large percentage of emergency power supply in contract demand. In such cases, business continuity may not be possible if the electrical infrastructure is obstructed for over 24 h.

4. As an index to approximate the operation time of a building, this study focused on running time equivalent to full-load operation. The results of the analysis indicated that the percentage of the capacity of the emergency power supply in contract demand tends to be larger when running time equivalent to full-load operation is longer on the whole. There appears to be a relationship between the percentage of the capacity of the emergency power supply in contract demand and the running time equivalent to full-load operation. In addition, certain trends were observed as clusters of distribution for each type of facility.

Future studies should be performed to compare the levels of reliability required focusing on business continuity of the buildings and of the local areas using these field survey results as a reference. Further discussion is required regarding the challenges that must be overcome as well as challenges that are specific to a given local area. Further analyses regarding the relationship with the software aspect of
BCPs set by individual corporations and facilities are also important. Such continuing studies will help to improve the reliability of central business districts in major cities in Asia.

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Notes
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Noritsugu Yamada, Yukihiro Masuda, Nobuyuki Takahashi, Toshio Ojima. (2007) Field survey study of the emergency power supply capacity related to business continuity. Proceedings of the Annual Architectural Research Meeting, 2007, Architectural Institute of Japan, pp.843-844.

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