APPLICATION OF FSE DESIGN METHODOLOGY TO THE RESTORATION AND EXPANSION OF A MODERN HISTORIC BUILDING

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ABSTRACT

An application example of the Fire Safety Engineering to the ongoing design of the restoration and expansion of a modern historic building in the central Tokyo is introduced. Design results are compared between the engineering-based strategic design and a straight application of the conventional specification-based fire safety regulation. Use of engineering concepts leads to a full restoration of the interior design of the original building, while direct application of the specification standard has resulted in spoiling the design features of the historic landmark.

Keywords: modern historic building, smoke filling, evacuation.

BACKGROUND AND OUTLINE OF THE PROJECT

The Japan Industrial Club Building, a five-story handsome reinforced concrete building located between the Imperial Palace and the Tokyo Central Station, Tokyo's most authentic business center, has been a social center of the Japanese business circles since its completion in 1920, and has been known for the decorative auditorium, dining room, lobbies and stairwell. Since most of architecture built in the center of Tokyo before the Kanto Earthquake(1923) do not survive any longer, the building is considered as a valuable historic landmark in the central Tokyo.

However, the building was designed before the introduction of modern building regulation in Japan, and is facilitated with only poor fire safety measures. Especially the five-story tall unprotected stairwell connected to decorative lobbies, the most significant architectural feature of the building, is considered as a potential route for the smoke propagation to the whole building in the event of a fire. Also it has been pointed out at structural diagnosis of the building that recovery from the structural damage caused by the Kanto Earthquake was not enough to withstand a big earthquake anticipated in Tokyo area in future. With these conflicts, there has been some strong limitation for the use of the building as a public building since the regulations for smoke control and seismic performance was strengthened in the late 1960s to the 1970s.

Active movement has been organized by civil and cultural societies and architects to save the building since redevelopment of the block surrounding this building began to be considered in the early 1990s. Partly for the need of seismic protection of the building and partly for the redevelopment of the surrounding block, it has been decided to reconstruct load bearing structural members of the major part of the building and build a high rise office behind the building, while the most interior design of the building has been decided to be restored. The building was closed in early 2000, and the design for the restoration and expansion is going on since 1999. Figures 1 and 2 are the recent view of the building and planned view of the expansion project. Floor plans of the present and renovated building are as shown in (a) and (c) of the Figures 3 through 7. Approximately one fifth of the present building, the part containing the major functions such as main dining room and the auditorium, will be totally restored, and additional around 50% of the present building, including the open stairwell, will be rebuilt for structural reasons but its interior and exterior design are planned to be restored. Rest, 30% of the building, consisting of relatively small compartments behind the open stairwell, will be removed and replaced by a part of the high rise office building.

Figure 1 Recent View of the Japan Industrial Club Building

Figure 2 Plan View of the Restoration and Expansion Project

Figure 3(a)

1st Floor
Present plan
S 1/750

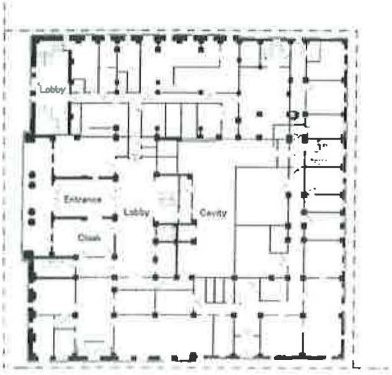


Figure 3(b)

1st Floor
Designed according to
Specification Regulation
S 1/750

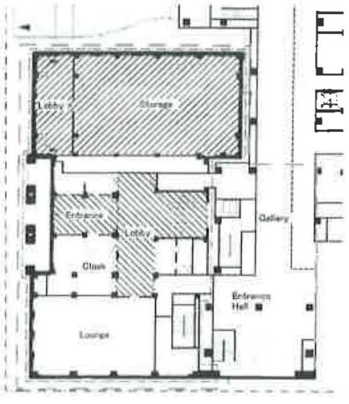
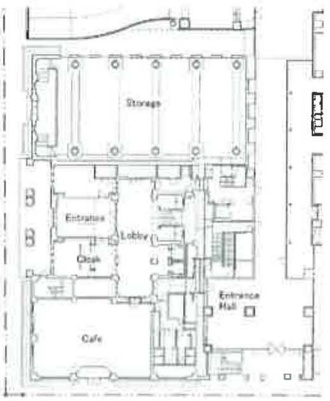


Figure 3(c)

1st Floor
Designed with FSE
concepts and tools
S 1/750



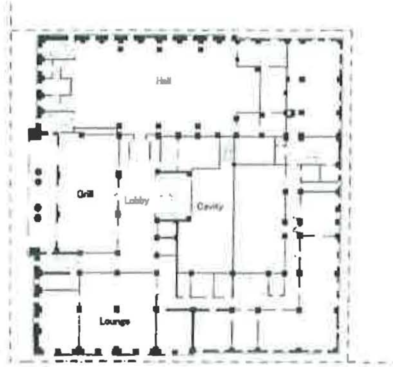


Figure 4(a)

2nd Floor
Present plan
S 1/750

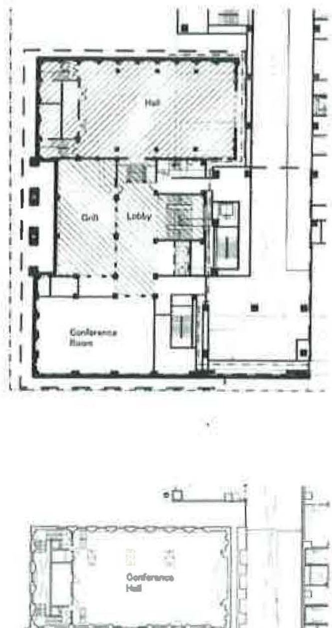


Figure 4(b)

2nd Floor
Designed according to
Specification Regulation
S 1/750

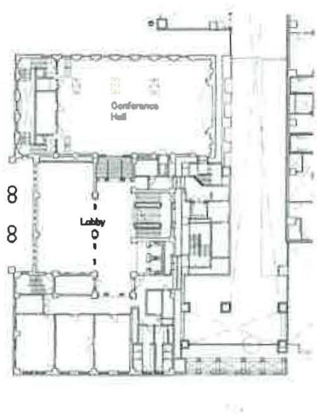


Figure 4(c)

2nd Floor
Designed with FSE
concepts and tools
S 1/750

Figure 5(a)

3rd Floor
Present plan
S 1/750

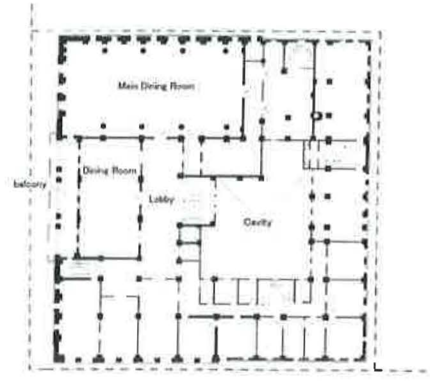


Figure 5(b)

3rd Floor
Designed according to
Specification Regulation
S 1/750

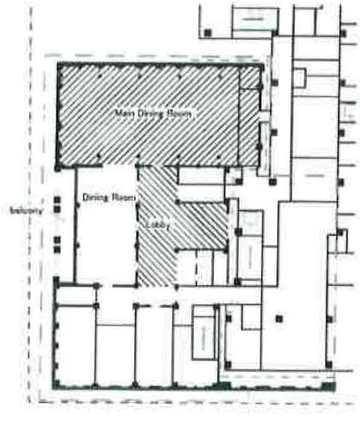


Figure 5(c)

3rd Floor
Designed with FSE
concepts and tools
S 1/750

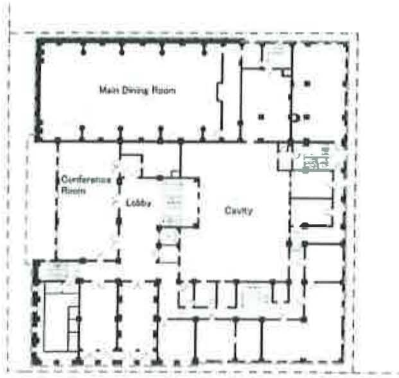


Figure 6(a)

4th Floor
Present plan
S 1/750

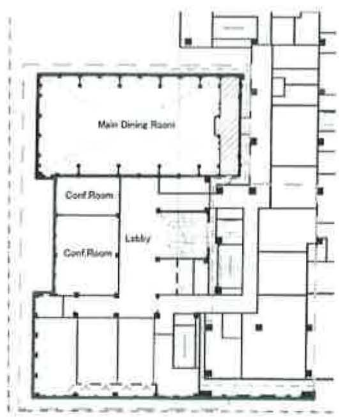


Figure 6(b)

4th Floor
Designed according to
Specification Regulation
S 1/750

Figure 6(c)

4th Floor
Designed with FSE
concepts and tools
S 1/750

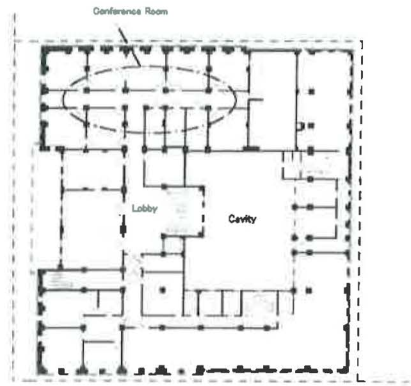


Figure 7(a)

5th Floor
Present plan
S 1/750

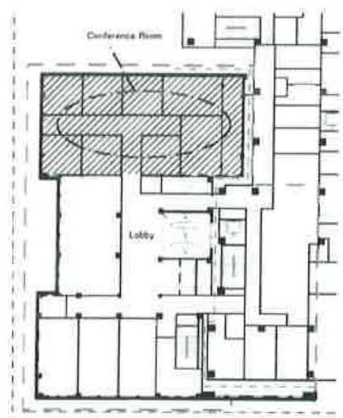


Figure 7(b)

5th Floor
Designed according to
Specification Regulation
S 1/750

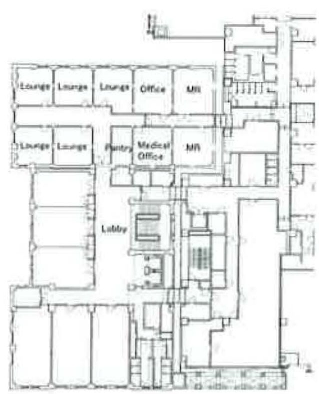


Figure 7(c)

5th Floor
Designed with FSE
concepts and tools
S 1/750

One of the most important aspects of the design of this project is fire safety design to achieve fire safety consistent with the restoration of the main part of the building. Fire safety design based on the conventional specification-based Building Standard Law was first attempted earlier in 1999, which resulted in the plan as shown in (b)s of the Figures 3 through 7. This design however resulted in spoiling considerable architectural features in the lobby of each floor and the stairwell by introducing shutter guide rails on the border between the stairwell and the lobby on each floor and by making the stairwell a rather "staircase" by extending its sidewalls to the lobby side. In addition to the change in the floor plan, the ceiling of the lobby had to be lowered for the installation of smoke ducts. Stained glass window in the stairwell on each floor was to be replaced as a conflict against the requirement for evacuation stairwell. Application of the smoke and evacuation regulations to the main dining room and the auditorium seemed to need additional exits and change of the interior finishing of these rooms. Evacuation route from the auditorium, especially the one connecting to the lobby, was still suspected to conflict with the regulation. These contents of the restoration plan were not supported by the owner and civil and architectural societies.

The authors were invited to the fire safety design of this project in order to resolve such conflicts between the specification standards and restoration of historic design features through introducing Fire Safety Engineering tools. The fire safety design is not yet completed, and it is not yet possible to report design results. However, this paper intends to introduce technical concepts for the fire safety design with some prediction results of smoke movement.

FIRE SAFETY DESIGN STRATEGY FOR THE OPEN STAIRWELL AND LOBBIES

In order to restore all the design features of the open stairwell and the lobby, a new design concept was proposed under the following strategy:

1. The stairwell shall not be considered nor used as an evacuation route in the case of fire. Occupants are to evacuate through other protected staircases.
2. Incombustible flexible screen shutter is to be used for the fire and smoke separation between the stairwell and the lobby on the fourth and fifth floors. The screen shutter is to be operated automatically by the activation of smoke detectors in the lobbies on any of the floors connected to the stairwell.
3. The stairwell is left open to the lobbies on the first, second and third

floors. Fire and smoke separation is to be made between the lobby and other rooms such as dining rooms on these floors.

4. Smoke exhaust is to be installed in the stairwell.

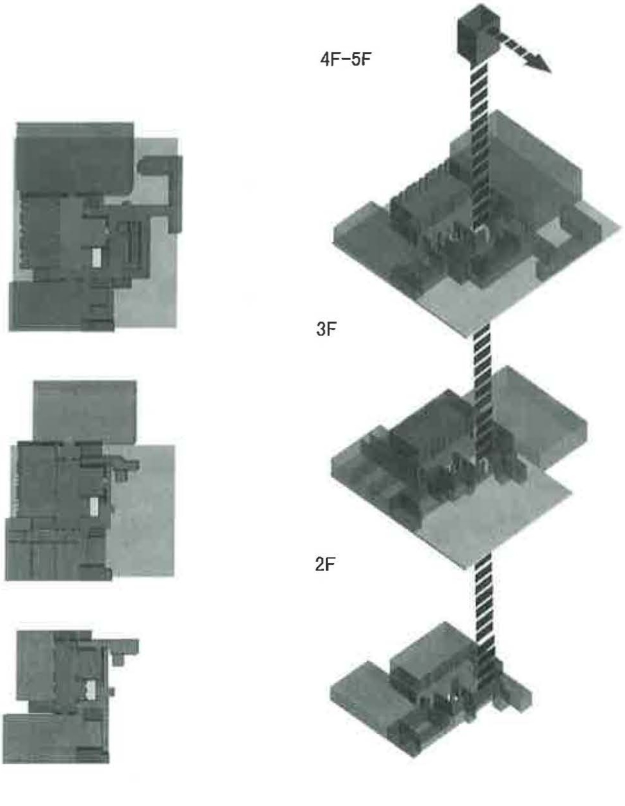


Figure 8
Smoke Extraction from the Stairwell

Figure 8 is a summary of this strategy, and the resultant floor plans are shown in (c)s of the Figures 3 through 7. The upper part of the stairwell is planned to function as a smoke reservoir by closing automatically the border on the fourth and fifth floors by the screen shutter when smoke due to a fire on any of the floors penetrates into the stairwell. With this design strategy, potential area of smoke penetration is limited to the stairwell and the lobby on each floor and occupants in all rooms can evacuate safely through the routes protected from smoke and fire from the stairwell and the lobby. The lobby on each floor is connected to such evacuation routes at two exits so that those remaining in any lobby at the event of fire can escape to the main evacuation routes within several seconds.

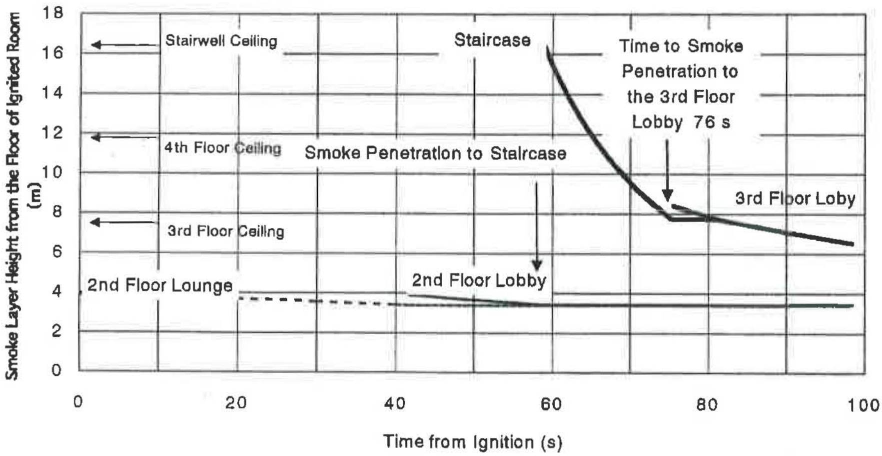


Figure 9 Predicted Smoke Filling in the Stairwell due to a Fire in the Lounge on the 2nd Floor

Figure 9 is a result of smoke filling calculation using a two-zone model for the stairwell and the adjacent lobbies assuming a fire source on the second floor and no-smoke extraction in the stairwell. A standard fire source which has been used for FSE oriented fire safety design in Japan, as shown in Figure 10, is assumed, as the fire load in the 2nd floor lobby is rather limited. Even if the smoke extraction in the stairwell does not operate, penetration of the smoke to the 3rd floor lobby occurs only 76 seconds after the initiation of the fire and the height of the smoke layer on the 3rd floor reaches 2m from the floor at around 100 seconds.

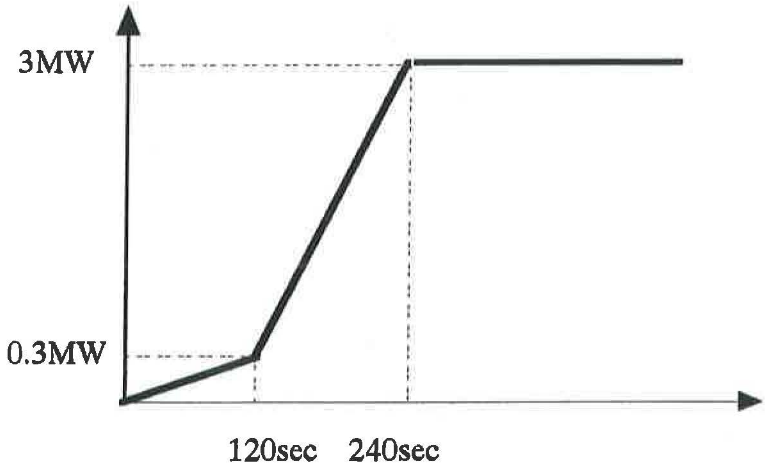


Figure 10 Standard Fire Source Heat Release Curve

These should be enough for the evacuation of all those in the lobby to the corridors if they are properly informed of the emergency. Layout of the evacuation staircases has been studied for the economy of the number of staircases since the resignation of the stairwell as the evacuation route may automatically need a substitute staircase. Figure 11 is the result of the rearrangement of the evacuation routes on the 3rd floor, in which even the evacuation routes in the high rise building part is rearranged for the harmonization of the evacuation planning of the restored and newly developed parts of the building. Such rearrangement of the evacuation routes on each floor, without using the stairwell, has finally led to rather decrease of necessary staircases as seen in Figures 3 through 7.

SMOKE AND EVACUATION IN THE MAIN DINING ROOM AND THE HALL

Resolution of the conflicts of the main dining room and the hall with the evacuation regulations has been attempted with evacuation planning using the smoke filling prediction for the determination of the critical time for the room evacuation. Figures 12 and 13 are the calculation result of the descent of the smoke layer in the two rooms with the Japanese standard fire source curve,

Figure 10, without consideration of the operation of smoke control. The evacuation criticality for both rooms is determined by the smoke layer temperature, which was calculated ignoring the conductive heat loss as seen in the Figures. The calculated time for evacuation criticality is over twice longer than the estimated time to evacuation from the room, and is still 40 - 70 seconds longer than the time to evacuation including the time to the start of evacuation behavior determined according to the current rule of evacuation design guide for high rise buildings.

CONCLUDING REMARKS

Restoration of modern historic buildings used for public functions may contain considerable conflicts with modern fire safety concepts and regulations. The experience introduced in this report seems to show that Fire Safety Engineering can be a useful means for the restoration of such buildings compatible with the achievement of fire safety.

Most of the fire safety design and simulations in this report are based on the protocols in the engineering fire safety design for the Construction Minister special approvals. This special approval will be effective only until June 2000 when the detailed enforcement orders and ministry notifications for the new Building Standard Law revised toward a performance-based regulation will become effective. Calculations will be reconducted to meet the new regulations, whcich result may lead to some change in the detail of the fire safety design. In order to validate the effectiveness of the design concepts and prediction method for the stairwell, a reduced-scale smoke experiments will be conducted shortly.

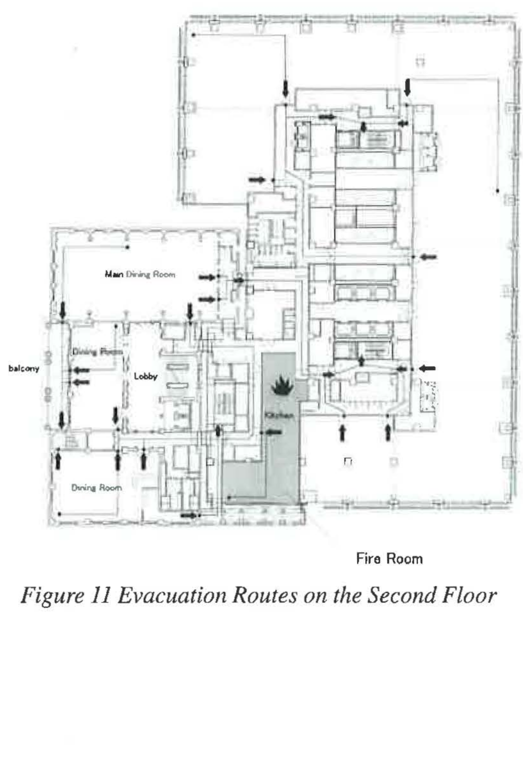
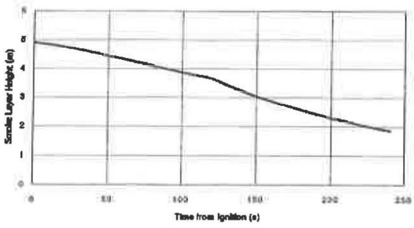


Figure 11 Evacuation Routes on the Second Floor

The authors wish to thank Mitsubishi Real Estate Co. for the invitation to the fire safety design of this

valuable historic monumnet.



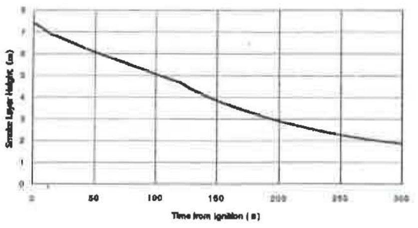
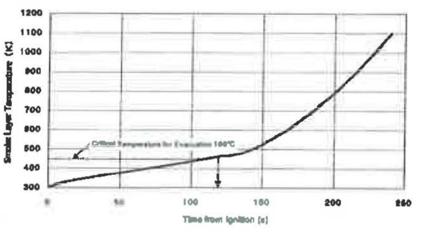


Figure 12(a)Predicted Descent of Smoke Layer in the Hall Figure 13(a)Predicted Descent of Smoke Layer in the Main Dining Room



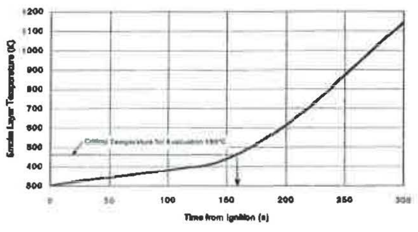


Figure 12(b)Predicted Smoke Layer Temperature in the Hall Figure 13(b)Predicted Smoke Layer Temperature in the Main Dining Room