

One Year Since the High-Rise Fire in London

– What the Grenfell Tower fire alerted us to –

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1. Introduction

I was awoken by the repeated ringing of the telephone around 4:00 a.m. on June 14, 2017 (around 11:00 a.m. the same day in Japan). It was an NHK news reporter gathering information. At that time, I was staying in a hotel in Lund, a college town in Sweden. The reporter suddenly told me about a fire in the UK, but I had not heard about it until then since I was staying in Sweden attending an international fire research symposium and it was



Photo 1. Grenfell Tower in flames up to the upper stories

Source: Natalie_Oxford (2017) https://twitter.com/Natalie_Oxford/status/874835244989513729/photo/1

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late at night. Knowing that I was in Sweden, the reporter pointed out that broadcasts in Europe should be more detailed than the BBC international news (British Broadcasting Corporation, which corresponds to NHK in Japan) which was running in Japan, and asked me to respond to an interview after watching the broadcasts as much as I could. I turned on the TV right away. Indeed, the BBC's live broadcast was reporting the fire situation without interruption.

Because of this call, I got the opportunity to watch the live broadcast for several hours continuously starting from about two hours after the fire. On TV, scenes of flames rising along the exterior walls of the high-rise apartment building and fire rapidly spreading upward, reports of sightings or witnesses of escape, and many possible fatalities were shown.

This fire, known as the Grenfell Tower fire, occurred at a high-rise apartment building near London. Watching the live broadcast, I quickly understood that the fire was similar to other fires with an upward fire spread due to rapid burning of the exterior wall surfaces, which have also recently often occurred in other countries. Then, I commented responding to the NHK news interview as follows. I first pointed out that as a characteristic of this fire, the exterior wall material used for insulation or decoration burned and caused rapid upward fire spread, which must have made the escape difficult and expanded the damage. I also pointed out that on the other hand, in our country, few exterior walls of high-rise buildings are insulated and few flammable materials are used for exterior walls, moreover most of high-rise apartment buildings in Japan are built in accordance with special standards for apartment houses by the Ordinance of the Ministry of Internal Affairs and Communications No. 40 of 2005, and fulfill the installation of a fire compartment for each dwelling unit, an open corridor and an open staircase, alternative escape routes, and balconies, so that they have less risk of the same upward fire spread. These comments were based on the limited information I had gained just by watching the news broadcast on TV, but I think even now that they could make a clear point.

Since the Grenfell Tower fire happened in the middle of the International Association of Fire Safety Science (IAFSS) symposium, where many fire researchers had gathered, the fire accident attracted a great deal of global attention. However, the UK, possibly in view of the gravity of the situation, subsequently seems to be working on the accident investigation very carefully. Therefore, even at the end of March 2018, no formal final report from the UK Government or authority has been issued. Only the interim report of the Independent Review of Building Regulations and Fire Safety¹⁾ was released in December of the last year. Although I also asked some fire researchers I knew in the UK whether there were any documents, they gave me the same answer and said that they were eagerly waiting for the final report of Independent Review expected to be compiled this spring.

So, in this report, I would like to review this fire afresh based on the documents available at this time when nearly one year has passed since the Grenfell Tower fire, and to organize the challenges to which this fire has alerted us. I should clarify that in the following, the UK denotes England unless otherwise noted.

2. Overview of the Grenfell Tower fire

(1) Outline of the building and repair work to its exterior walls

The fire occurred at a high-rise apartment building (hereinafter called Grenfell Tower) in North Kensington of west London. Grenfell Tower is a 24 stories low-class council apartment building (with a height of 67 meters and a total of 127 dwelling units), completed in 1974. It is a type of high-rise apartment building often employed for low-class council accommodation known as tower blocks in the UK.

The owner of the building is an autonomous body in London, the Royal Borough of Kensington and Chelsea. The building management organization is a private management institution commissioned by the autonomous body, Kensington and Chelsea TMO. The four floors from the first floor to the fourth floor above ground were used for offices and day-care centers while the fifth and higher floors were used for dwellings. At the time of the fire, about 600 people lived in this building. According to residents' witnesses, people of various nationalities lived in this tower.

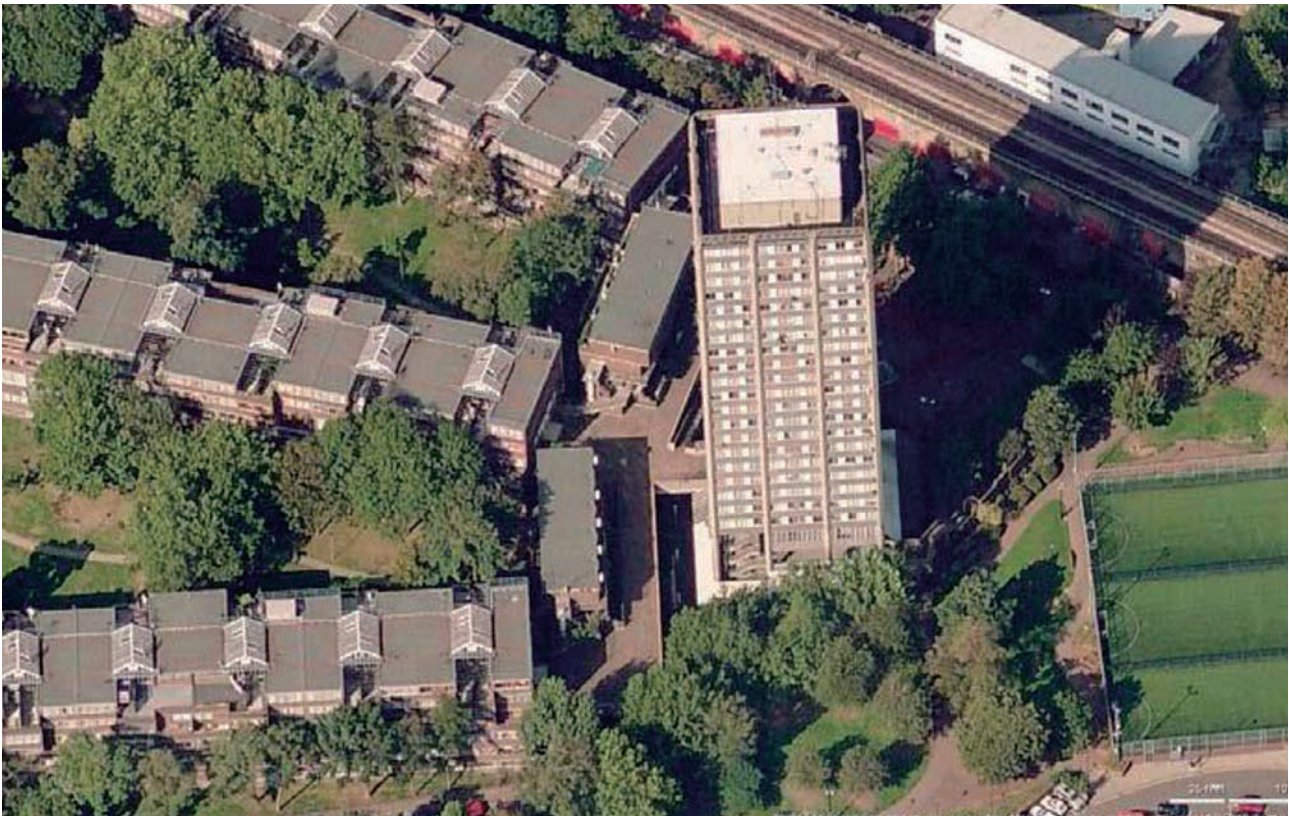


Figure 1. Full view of Grenfell Tower before the fire

Source: 2) Grenfell Tower Regeneration Project – Design and Access Statement

Note. The fire started on this side (the east façade) on the building's eighth floor above ground in the photo and spread upward.

Between 2015 and May 2016, large-scale repair work for the council building as a whole was implemented with a budget of 8.6 million pounds (about 240 million yen). As part of this repair work, the exterior walls were insulated for energy saving purposes, and the insulating material used here caused the fire to spread. I will discuss exterior wall insulation and its effect on fire spread in the following sections.

(2) Outline of the fire

○ Time of the fire outbreak

The fire occurred around 1:00 a.m. on June 14, 2017 (around 9:00 a.m. the same day in Japan). To be exact, the time of fire call to the fire service was 0:54 a.m., so the time of outbreak may have been slightly earlier.

○ Start and cause of the fire

The fire started in the kitchen of a dwelling unit on the fourth level of the housing section (the eighth floor above ground if counted by the Japanese way of defining the ground floor as the first floor). According to the Metropolitan Police, the fire was caused by an electrical fault at the refrigerator. Figure 1 is a full view of Grenfell Tower.²⁾ The fire broke out in the dwelling unit on the eighth floor on the northeast edge of the east façade of the building.

○ Process of the fire spread

The most important point in this fire is that the insulating material of the exterior walls, which was used in the repair work a few years earlier, rapidly burst into flames and caused the extremely fast upward fire spread. This made it difficult for residents to escape and is the greatest factor to many fatalities.

Figure 2 shows photos from the BBC News site,³⁾ which demonstrate the process of the exterior wall surfaces burning and the upward fire spread in the Grenfell Tower fire. These photos were probably taken from the northwest corner side of the building. The fire started in a dwelling unit on the eighth floor on the opposite side (northeast corner) to the shooting position. From the photo taken at 01:30, about 30 minutes after the start, it can be seen that the flames along the exterior wall have already reached the top floor though that cannot be squarely

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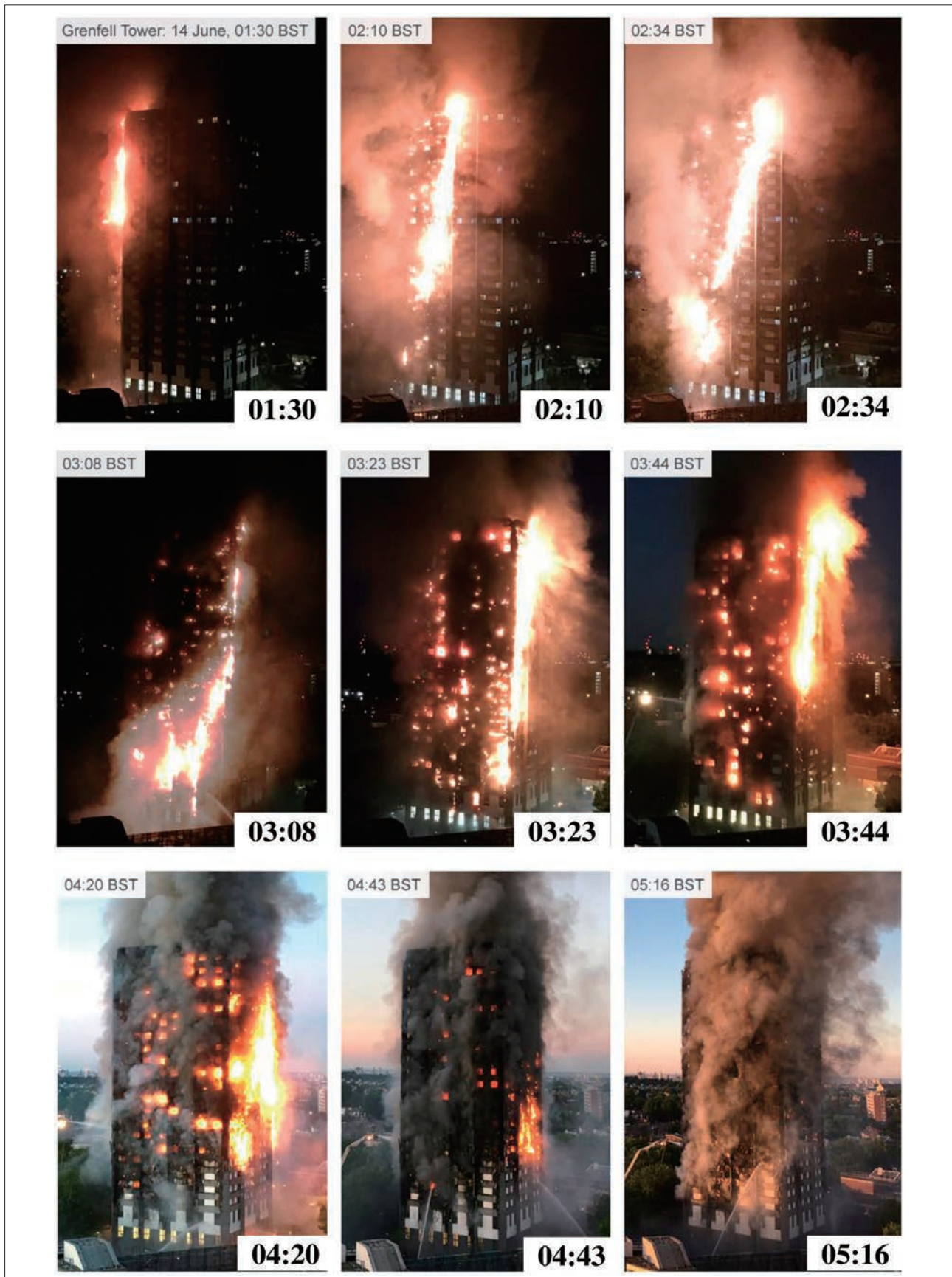


Figure 2. Conditions of the fire spread over the exterior wall surfaces in the Grenfell Tower fire
Source: 3) BBC News (London fire: A visual guide to what happened at Grenfell Tower)
<http://www.bbc.com/news/uk-40301289>

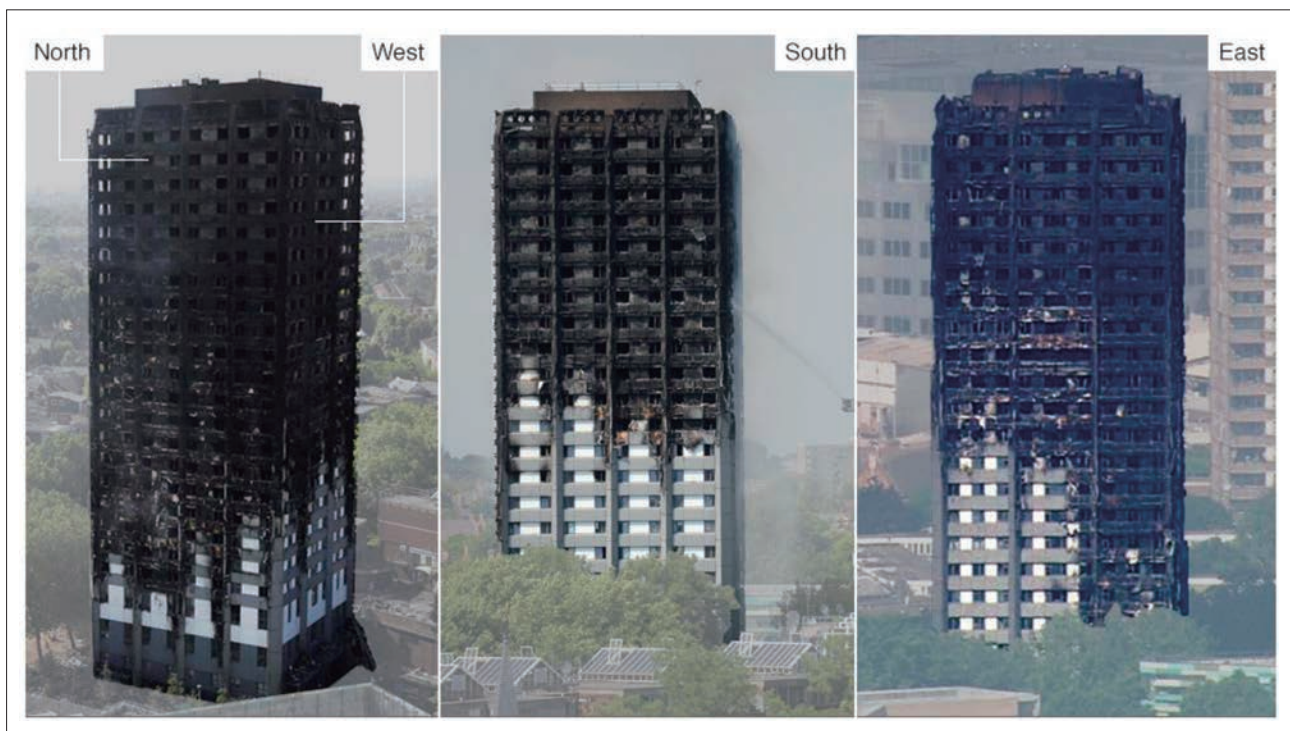


Figure 3. Condition of the exterior wall surfaces of Grenfell Tower after the fire
Source: 3) BBC News (London fire: A visual guide to what happened at Grenfell Tower)
<http://www.bbc.com/news/uk-40301289>

seen. The fire spread over the wall surface was soon propagated to the north façade and to each wall surface in the pattern of an upward fire spread like a fan in the upward direction.

In the photo taken two hours after the start of fire (at 03:08), the flame has spread to almost the entire north façade. About three hours later (in the photo taken at 04:20), fire was also spreading over all of the west façade. From the photos after the fire had been extinguished³⁾ (Figure 3), showing the conditions of the upward fire spread, all of the section of the fourth and higher floors above ground at the northeast edge, where the fire started on the eighth floor above ground, has been completely burned, while it appears that the fire spread did not reach part of the south side, west side and east side on the tenth and lower floors above ground. Depending on each dwelling unit's position on each floor or story, the danger level and the easiness of escape seem to have varied.

○ Fatalities

According to the announcement by the Metropolitan Police on November 16, 2017,⁴⁾ there were 71 fatalities from this fire, including the unfortunate case of a stillbirth from a rescued woman. This number became the largest in the UK after World War II. The building completely burned and it took more than 24 hours to extinguish the fire. The Metropolitan Police said they had performed safety tests on the exterior material and the insulating material to find that both failed to reach the reference value. They also said that they were deliberating bringing a case on charges of manslaughter, etc.

(3) Escape

In this fire, the extremely fast upward fire spread due to the burning of the flammable insulating material of the exterior walls as well as the staircases in the center of the floors which allowed early smoke and heat penetration due to the incomplete compartmentation made the escape difficult. In addition, unlike in Japan, the building lacked balconies outside the dwelling units and had just a single staircase at the core. The structure did not provide alternative escape routes.

It has also been pointed out that a sign recommending residents to stay in their dwelling units if a fire occurs outside their home was put up as an evacuation instruction under the guidance of the London Fire Brigade. So,

some residents may have failed to escape by following this instruction. Also, at other council high-rise apartment buildings managed by the same building management institution near Grenfell Tower, as a fire action, the following evacuation instruction is posted, “There is a ‘stay put’ policy for residents unless the fire is in or affecting your flat.” This recommends that residents should stay in their dwelling units in the absence of other instructions except in the case of a fire in their homes or a fire affecting their homes. Besides, “stay put” means “stay still.” Such recommendation is said to be the norm in large-scale apartment buildings in the UK.

(4) Fire alarm system and sprinkler system

In Grenfell Tower, each dwelling unit had a fire detector, but the common use area was not equipped with any fire alarm system nor was there an alarm system for the entire building. It has also been pointed out that this resulted in delayed escape.⁵⁾

In the UK, there is an obligation to equip a building with a sprinkler system if the building is 30 meters high or higher and newly built in 2007 or later, and this has no retroactive application to existing buildings. In addition, the repair work had been too small in scale to require installation of a sprinkler system, so that Grenfell Tower, despite its height of 67 meters, was not equipped with a sprinkler system.

However, in the case of the spread and expansion of flames along exterior walls as with this fire, the fire extinguishing effect of a sprinkler system could not be expected to be very high. Sprinklers, originally aimed at indoor initial fire extinguishing, are inadequate for preventing exterior fires spreading on such a scale as the fire spreads upward. However, if each dwelling unit had been equipped with sprinklers, it should have had an initial fire extinguishing effect in the dwelling unit where the fire broke out or an effect of localizing the fire, and the results may have been different.

(5) Firefighting activity

According to press information,⁶⁾ when the initial fire brigades arrived at the scene, the fire was only in the dwelling unit where the fire broke out, and they did extinguish the refrigerator fire in the dwelling unit once. They believed that the fire was confined to a single dwelling unit because the dwelling units in high-rise buildings like tower blocks were protected by a fire compartment. As witnessed, they told the residents of the apartment that the fire had been extinguished. They must not have expected any further upward fire spread. However, they saw flames rising along the exterior wall surface like a jet as they were leaving the building believing they had completely extinguished the fire.

It seems that there were multiple barriers to the firefighting activities after that. One of the barriers was that radio communication did not work effectively between the firefighters entering the building to provide evacuation guidance for the residents, and the commander outside of the building. The firefighters told the residents to stay in their dwelling units in accordance with the conventional “stay put” policy. It is said that if the firefighters had been accurately informed of the exterior fire situation over the radio, they would have urged the residents to escape as quickly as possible and more residents would have been saved. Other barriers were: 1) the single staircase made it difficult for the firefighters to stretch the hose because it became an obstacle to the flow of the evacuation, 2) the staircase was filled with smoke and the firefighters could not carry out their activities unless they were always wearing breathing equipment, which placed constraints on their activity times, etc. It is also said that many firefighters, having suffered trauma from these bad experiences, do not want to talk much about their firefighting activities.

3. What were the problems during this fire?

The greatest factor to many fatalities at the high-rise building in London was without any question the rapid upward fire spread due to the intense burning of the exterior walls. However, I think there were some other critical problems during this fire. These can be summarized as follows:

- 1) Rapid upward fire spread due to intense burning of the exterior walls,
- 2) Evacuation problems such as the lack of alternative escape routes, and

Table 1. Past cases of high-rise building fires with upward fire spread due to burning of exterior wall material

Building name	Building use	Year of occurrence	City/Country	Number of stories	Outline of the fire
Hiroshima Motomachi High-Rise Apartments	Apartment building	1996	Hiroshima/Japan	20	The fire spread from the 9th floor to the top 20th floor in about 25 minutes due to burning of the balcony acrylic wall material.
Beijing Television Cultural Center	Commercial and office building	2009	Beijing/China	30	The fire spread over all of the building in about 30 minutes after the exterior wall sandwich panels caught fire, which started near the rooftop.
High-rise apartment building for retired teachers	Apartment building	2010	Shanghai/China	28	The building was completely burned because the polyurethane exterior insulation material used as part of energy-saving repairs caught fire during the work (about 60 fatalities).
Wooshin Golden Suites	Apartment building	2010	Busan/South Korea	38	The fire spread to the top 38th floor in about 20 minutes after the sandwich panels of the exterior walls caught fire which had started at the garbage collection point on the 4th floor.
Torch Tower	Apartment building	2015	Dubai/UAE	79	The fire started at a balcony on the 50th floor and rapidly spread upward along the exterior walls covered with sandwich panels.
Ten-story apartment building in Uijeongbu	Apartment building	2015	Uijeongbu/South Korea	10	The fire, which had started in a parking lot on the first floor, jumped to the sandwich panels of the exterior walls and spread to the top floor and also an adjoining building (5 fatalities).

3) Pollution of the staircase and corridors due to the incomplete compartmentation

In addition, the current status of building standards and regulations, ambiguous responsibility for inspections and verifications of building repairs and maintenance, etc. have been pointed out in the UK. Though these have become matters of serious concern requiring improvement, in this report, I would like to focus on the three points above and explore each problem.

(1) Past cases of upward fire spread due to rapid burning of the exterior walls

More recent cases of fires involving upward fire spread along the exterior walls are shown in Table 1. Although there have also been cases at other times in other countries, the better-known cases are listed here. As one case in Japan, the Hiroshima Motomachi High-Rise Apartment Building fire (1996) can be listed, in which the acrylic blindfold boards of the balconies became the route for the upward fire spread. However, a few other cases of rapid upward fire spread due to burning of exterior walls have occurred in Japan.

On the other hand, in Asia and the Middle East, there has been no end of fire cases of upward fire spread involving the burning of insulated exterior walls or exterior walls covered with sandwich panels*¹ (laminated composite material). From Table 1, it can be seen that such rapid upward fire spread has often occurred in buildings with exterior walls covered with inexpensive and highly workable sandwich panels which are heavily used not only as insulating material but also as exterior decorative material.

Most high-rise building fires have occurred in Asia and the Middle East because high-rise apartments and super-tall buildings are originally concentrated in these regions while sandwich panels are often used for insulation or for the decoration of exterior walls. In the TVCC (Television Cultural Center) fire in 2009 in Beijing, China, and the Wooshin Golden Suites (high-rise apartment building) fire in 2010 in Busan, South Korea, although the buildings were 30 or more stories high, the fire spread over all stories rapidly in around 20 or 30 minutes.

I should add that such rapid upward fire spread along flammable exterior walls is not a target in conventional fire prevention measures for high-rise buildings. The main conventional measures to prevent upward fire spread are: 1) installation of spandrels and eaves on each story to prevent upward fire spread due to ejected flames from a window, 2) fireproofing of exterior wall frames, 3) completion of the vertical shaft compartment to prevent smoke and flame propagation, 4) installation of sprinklers for initial fire extinguishing, etc. In addition, speaking of spandrels, the current Japanese building regulation legitimates exterior wall surfaces even when covered with plastic insulating material or flammable material including wood, if their frames are non-flammable concrete walls. This is because the legal requirements for fireproofing exterior walls have focused only on the prevention of burnout in the horizontal direction of members or into the exterior walls, and have overlooked the risk of fires with an upward fire spread due to burning of surface members. To cover this legal deficiency, some measures for regulation of the use of flammable surface members are needed.

At any rate, these existing fire prevention measures are unable to exert any effect on fires that have a rapid upward fire spread due to burning of flammable exterior walls as was the case here. Simply stated, such fires should be recognized as a new fire pattern which cannot be prevented, unless the use of such exterior wall surface members is banned, or measures to prevent fire spread including firestops are required.

(2) Upward fire spread along exterior walls in this fire

The diagram of Grenfell Tower’s exterior wall area in a document from the Grenfell Tower owner, the Royal Borough of Kensington and Chelsea⁷⁾ is shown in Figure 4. A layer of 150-mm urethane insulating material (orange part in the diagram) covers the outer side of the concrete exterior wall (250 mm thick), and an aluminum sandwich panel with a core material of polyethylene resin is set as the outermost exterior material for weather protection (blue part in the diagram). Between the urethane insulating material and the sandwich panel, there is a 50-mm gap to prevent dew condensation, but the surface of the urethane insulating material was just covered with aluminum foil and lacked a metallic covering. It is supposed that this weakness was exposed to the ejected flames from the window of the dwelling unit where the fire had started and allowed the flames to rapidly penetrate, causing the urethane insulating material to catch fire and burst into flames, which led to the rapid upward fire spread.

In fact, more than 30 years before the Grenfell Tower fire, some experts pointed out that the flammability tests for exterior wall materials were performed with small-size test units in a laboratory, which were not suitable for proper evaluation of burning properties at actual scale according to installation specifications for exterior material.⁸⁾ However, until this fire, the government offered little response.

Until 1986, the exterior wall materials of all the buildings in London must have had fire-resistance performance of over an hour in accordance with the London Building Act. However, under the Thatcher Administration’s policy of promoting deregulation, this rule was replaced by the National Building Regulations. As a result, the requirement for fire-resistance performance of over an hour was abolished. Later, the need for fireproofing was eliminated if certain conditions were met. In a sense,

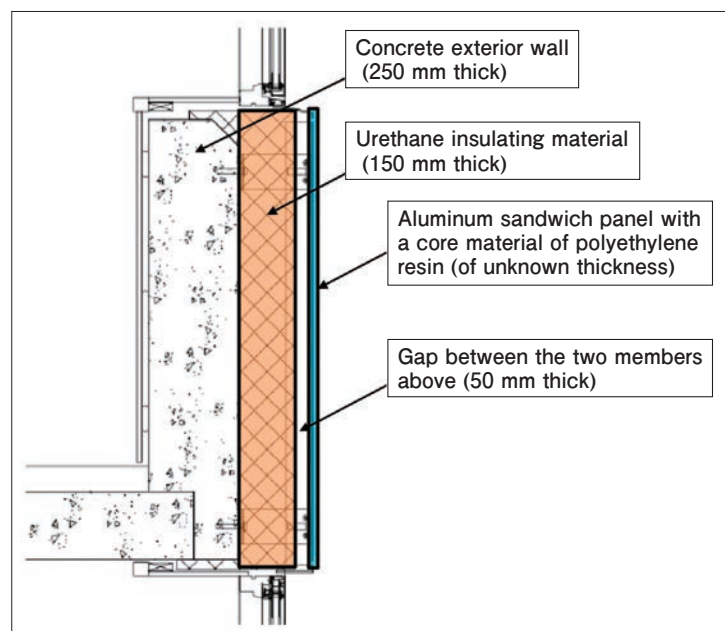


Figure 4. Cross-section showing the insulation status of the exterior wall face
Source: 7) Grenfell Tower Regeneration Project – Sustainability and Energy Statement
Note. A layer of 150 mm urethane insulating material (orange part) covers the outer side of the concrete spandrel wall face.

this fire can be said to be an accident that occurred in the aftermath of deregulation. This is also backed up by the severe criticism from the public.

(3) Evacuation problems such as the lack of alternative escape routes

In addition to the speed of upward fire spread, it would be necessary to mention evacuation problems in this fire. Figure 5 shows the floor plan of a standard dwelling floor in Grenfell Tower. From this floor plan, it can be seen that this high-rise apartment building has just a single staircase that functions as an escape route and no balconies which can be used for another escape route. Furthermore, both the staircase and the elevator shaft face the central hall, and there is no attached room to a staircase that functions as a buffer zone from smoke penetration. Therefore, in this fire, the currents of smoke and heat from the room where the fire started, running off to the shared hall at the center of the floor, flowed into the staircase at a very early stage, which would have got in the way of any escape.

It is unthinkable in terms of common sense in Japan that despite a high-rise building being 24 stories high, there is only one staircase and no alternative escape route, while the current standards in the UK permit a single staircase at this height and the number of residents per floor. However, experts in fire protection in the UK did make a recommendation to the government before the fire that this evacuation risk should be eliminated as soon as possible.

In a document by Professor Edwin Galea⁵⁾ from the University of Greenwich, an authority on evacuation studies in the UK, it is pointed out that there were two evacuation problems besides the lack of alternative routes. One of the two was the problem with the alarm system. In Grenfell Tower, each dwelling unit had a fire alarm, while there was no alarm system for the common space and for the entire building. The other was the aforementioned traditional evacuation instructions such as the “stay put” policy. The former may have made the residents who were possibly sleeping at night fail to notice the fire. The latter may have caused the fire brigade's decision to provide evacuation guidance to the entire building to be delayed for a total of 113 minutes after the start of the fire.

Professor Galea severely points out that the rapid upward fire spread due to the burning of the exterior walls was certainly one of the causes of great damage, but the cause of this many victims in the Grenfell Tower fire was the deficiencies in evacuation measures from high-rise buildings in the UK, which are less advanced than in other countries, because fires involving an upward fire spread in other countries did not claim so many victims as the Grenfell Tower fire.

An example supporting this is the account of a person who had been on the tenth floor and had barely escaped death, which was featured on the NHK program (“Never forget you – the high-rise tower fire in London” on BS 1) broadcast on February 25, 2018. This man, told about the fire by a cell-phone call from his son an hour after the fire started, did not notice the fire until he saw a photo of the flames outside shown on the mobile phone screen. This reveals that there was no announcement or fire warning in the building. He tried to escape by opening the door, but the smoke was so thick and hot that he gave up trying to

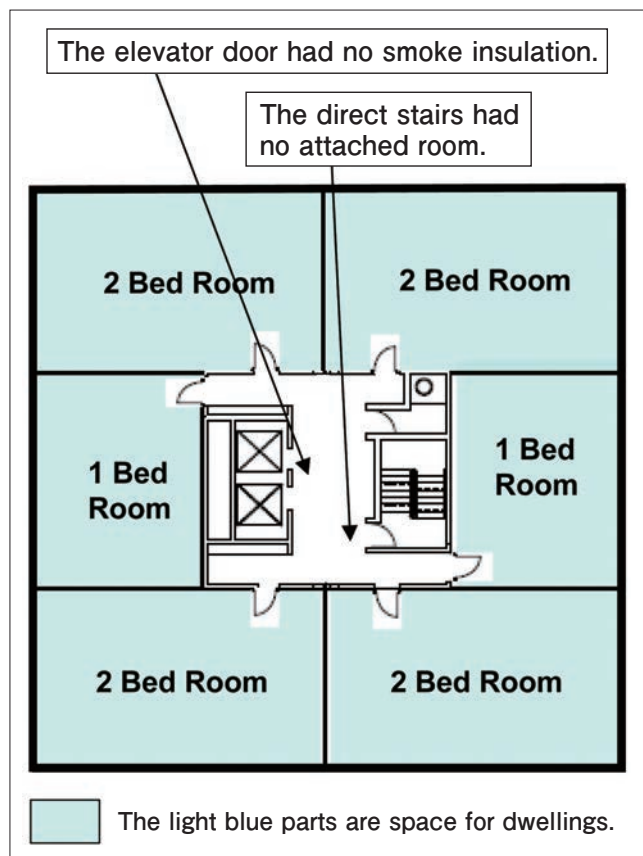


Figure 5. Floor plan of a standard dwelling floor in Grenfell Tower (This figure was made based on the plan shown in the Grenfell Tower Regeneration Project.)

escape. He closed the door and decided to stay in his dwelling unit. This means that at least an hour after the fire, the elevator hall was filled with smoke and heat, so that residents could not escape.

Hearing shouts and screams from the staircase, he kept staying in his unit and waited for rescue. After six hours, the door was beaten down and a firefighter came to rescue him. However, this is simply because his dwelling unit just happened to be located well out of the fire spread in terms of the floor level and room orientation. There must have been many other residents who lost their lives while waiting for rescue in the same way. The TV program also featured people who died sending e-mails to their family members or friends from their smartphone.

(4) Protection of the vertical shaft compartment (the staircase became a smoke propagation route.)

From the viewpoint of fire protection and evacuation in high-rise buildings, besides the problems of upward fire spread and of escape routes, there also arises the problem of how to control smoke spread. The importance of this problem is obvious from the many fatal fires in the past, where more people died having no access to an escape route due to smoke spread before the spread of the fire itself, such as the Sennichi Department Store Building fire (with 118 fatalities, in 1972), the Taiyo Department Store fire (with 104 fatalities, in 1973), and the Shinjuku Kabukicho multitenant building fire or the Myojo 56 building fire (with 44 fatalities, in 2001) in Japan. Just as happened in the London fire, these buildings were filled with smoke because the staircases, elevator shafts, etc. which were to function as escape routes became routes which allowed the rapid, upward spread of smoke. In Japan, since these fires, the protection of such a vertical shaft from smoke has been emphasized.

In the witness of a firefighter who engaged in rescue work at the Grenfell Tower fire,⁹⁾ the firefighter confesses that they could not carry out their activities unless they were always wearing breathing equipment, because the staircase was filled with smoke. More time was spent to getting to and from the upper floors where the people were waiting for rescue and the firefighters regretted that the allotted time for rescue work was restricted. If any activity base and access route for the firefighters had been secured, the firefighters might have been able to save more of the people that needed rescuing. This can be also learned from the NHK program described above. If the staircase and the elevator shaft had not faced the hall directly, the smoke would not have penetrated into the staircase for some time longer and those trying to escape by running down from floors higher than the floor where the fire started could have escaped in safety for a longer period of time.

4. Reaction in individual countries after the London fire

4.1 Reaction in the UK

The most important measure taken by the British Government after the Grenfell Tower fire is the Independent Review of Building Regulations and Fire Safety, set up by Prime Minister Theresa May in July 2017. This review panel is entrusted with deliberating various problems involving building regulations and fire safety, which the Grenfell Tower fire alerted people to, as well as recommendations for improving future building regulation systems. The Independent Review works in parallel with the Grenfell Tower Inquiry.¹⁰⁾

This Inquiry, led by Sir Martin Moore-Bick, a retired judge, also appointed by Prime Minister May, is to organize the process, causes and problems behind the accident primarily through interviews with survivors and stakeholders. For the Grenfell Tower Inquiry, nine experts in various fields were selected as expert witnesses, each of whom is to submit their opinions which can help elucidate this fire. I know some of the researchers who are included well. Therefore, I am also interested in the Grenfell Tower Inquiry's report, which will be issued in April 2018 around the same time as the final report of the Independent Review.

To get back to talking about the Independent Review of Building Regulations and Fire Safety, its interim report¹⁾ was submitted to the British Parliament in December 2017, and announced by the Ministry of Housing, Communities and Local Government on December 18. This is the only official report on the Grenfell Tower fire investigation that the British Government has announced at this time. Here, I would like to summarize the key points in this report. Figure 6 is the front cover of the report, which is constituted of the following chapters.

Foreword: A personal view from the Chairperson of the Independent Review
Summary: Summary of the interim report
Chapter 1: Findings and direction of travel
Chapter 2: A brief history of the current regulatory system
Chapter 3: The current regulatory landscape
Chapter 4: Gathering stakeholder evidence
Chapter 5: International systems for building regulation and fire safety

Dame Judith Hackitt, appointed as Chairperson of the Independent Review by Prime Minister May, has 15 years of work experience at ExxonMobil, a major oil corporation, and has a long career as an engineer in the chemical industry. Accordingly, she is not necessarily familiar with high-rise buildings or building fires, however, she was the Chair of the Health and Safety Executive, the UK Department of Health, in 2007-16. Prime Minister May possibly expected her to review problems from an objective perspective staying slightly away from building regulation and fire safety. However, in the UK, building safety including fire safety, as well as living environment and working environment safety are all originally under the jurisdiction of the Health and Safety Executive. So, the appointment of this person as the Chairperson of the Independent Review can also be said to be quite natural.

In the foreword of the interim report, Dame Hackitt raises an alert over the current building regulations and their current status in the UK, and emphasizes that in order to radically improve fire safety measures for high-rise buildings and rebuild security for residents, it is required to “change the culture in the construction industry or in building administration systems across the board.” This is backed by remorse for the decision to change the exterior wall insulating material to illegal, highly combustible material, which caused the rapid upward fire spread in the Grenfell Tower fire, as part of the process, instead of using insulation according to the design, as well as the irresponsible systems which lacked an overall supervisory system to check them and were unable to clarify where the responsibility lies. The interim report then identifies the following as reform items:

- 1) Building regulations and design guidelines should be risk-based, and their ambiguity must be eliminated;
- 2) The roles and responsibilities of stakeholders involved in building safety assurance need to be clarified;
- 3) Improve competency of engineers and technicians in the construction industry;
- 4) Compliance and enforcement of laws and regulations, as well as improved surveillance;
- 5) Establish a clear, quick and effective route to listen to residents (including victims of this fire); and
- 6) Improve quality assurance, testing and marketing of building materials used for construction purposes.

4.2 Reaction in other countries

(1) The United States of America

In the United States, unlike Japan, the federal government has no organization to take responsibility for building regulations while the local governments have jurisdiction over building administration systems. Therefore, in the United States, no noticeable change in building regulations has been made as any direct effect of the Grenfell Tower fire so far. However, the most popular building model codes in the United States: International Building Code (IBC) is now in process of regular revision, and it is probable that there will be some changes in the fireproof performance testing methods for flammable materials used for exterior walls and regulations on the use of flammable materials.



Figure 6. Front cover of the Independent Review of Building Regulations and Fire Safety interim report

(2) Hong Kong

Hong Kong is one of the countries (areas) that had some movement after the Grenfell Tower fire. In Hong Kong, like Japan, the installation of spandrels of 0.9 meters or more is required to prevent fire from spreading between stories. The use of flammable materials (e.g. polyethylene insulating material, etc.) on the spandrel surfaces is not approved, while for exterior walls other than spandrels, the installation of aluminum composite sandwich panels is permitted. If a fire in a room reaches its peak and the ejected flames stretch beyond the spandrel, there is a possibility of upward fire spread along the exterior wall face.

After the Grenfell Tower fire, the fire authorities conducted an area-wide survey on buildings with curtain walls, and those curtain walls suspected of using aluminum composite sandwich panels were decided to be reported to the building administration authorities for additional inspection and testing. In addition, it was decided that the materials for curtain walls must be specified in the building design, and all curtain wall panels now need to receive a verification test on their fireproofing, carried out by a qualified test laboratory, before installation.

(3) South Korea

In South Korea, the Building Act within the jurisdiction of the Ministry of Land, Infrastructure and Transport (corresponding to the Ministry of Land, Infrastructure, Transport and Tourism in Japan) defines buildings 30 stories/120 meters high or higher as high-rise buildings. Among these high-rise buildings, for those buildings which use flammable exterior materials, “fire safety performance evaluations” are planned to start in April 2018 as a result of the Grenfell Tower fire. In these evaluations, specialized agencies are to evaluate the fire protection systems, finish materials, escape performance, fire compartment, etc. of buildings which use flammable exterior materials, and grade their fire safety performance. The Ministry will release the results to the building residents and fire stations for them to be utilized in the management of fire risk in the buildings.

Also in South Korea, there have already been some occurrences of fires with upward fire spread due to burning of exterior wall surfaces, so various measures have already been taken. For example, triggered by the Wooshin Golden Suites fire in Busan (2010), the regulation on exterior materials of buildings in the Building Act was strengthened. Also, after the apartment building fire in Uijeongbu (2015) with five fatalities, the regulation on fireproofing the exterior walls of buildings six stories (or 22 meters) high or higher was amended. In addition, the laws and regulations were strengthened and require sprinklers to be installed on all floors for buildings that are six stories high or higher, from January 28, 2018.

(4) Taiwan

In Taiwan, there is no ban on the use of flammable materials for the exterior wall surfaces of buildings. Therefore, not only the Grenfell Tower fire but also recently-repeated similar tall building fires with fire spread along the exterior walls are of deep concern, particularly to the media and to persons involved in disaster prevention. The Architecture and Building Research Institute, Taiwan, is conducting a research project on the fire safety of curtain walls and joining parts of them, aiming to develop a performance validation test method suitable for Taiwan while consulting the test methods used in the United States including ASTM E2307-15b and NFPA 285 (Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-Load-Bearing Wall Assemblies Containing Combustible Components).

4.3 Reaction in Japan

As listed in Table 1, since the 2000s, a number of fires have occurred with rapid upward fire spread due to intense burning of insulating materials or sandwich panels of exterior walls in Asia and the Middle East. Some of these fires have also involved many fatalities, and more than a few fire protection experts in Japan, recognizing this fire risk and paying attention to it, took action. For example, a group including Professor Takafumi Noguchi at the University of Tokyo have conducted field investigations into the TVCC fire in China and the Wooshin Golden Suites fire in Busan, South Korea, etc. prior to the Grenfell Tower fire. They set up a study group on fire

propagation over exterior walls of buildings to make efforts such as examining the flammability test methods for exterior wall materials of buildings used overseas.¹¹⁾

These efforts led to the establishment (2015) of JIS A 1310 (Test method for fire propagation over building facades) to evaluate the flammability of exterior wall materials of buildings in conditions close to actual installation conditions. This development is detailed in a special feature article of the Japan Association for Fire Science and Engineering (JAFSE) journal, issue 338.¹²⁾ In fact, JIS A 1310 does not specify any criteria for evaluation and determination of flammability based on the test results. Therefore, it is not enough just to establish this test method, but it is urgent to establish a system for fireproof performance evaluation which uses this test method. According to Professor Kyoichi Kobayashi at Tokyo University of Science, JIS for determination of JIS A 1310 test results is under consideration.¹³⁾

The Japan Conference of Building Administration, consisting of building administration staff from local governments, has provided guidelines which recommend the use of specific flameproof materials as insulating materials to be put on exterior walls. However, these guidelines are not a legal regulation and neither do they clearly stipulate the prevention of fires that spread to the upper floors along exterior walls.¹⁴⁾

In light of the London fire, the Ministry of Land, Infrastructure, Transport and Tourism conducted a fact-finding survey on insulating materials put on exterior walls in cool regions where insulating materials can be used for exterior walls, in July 2017. As a result, it was reported that out of 279 surveyed high-rise apartment buildings, only 3 buildings adopted exterior thermal insulation and 2 of them used fireproof rock wool as the insulating material, while at the other, organic material was used.¹⁵⁾ This building also has balconies to delay upward fire spread along the exterior wall surfaces. Therefore, it has been reported that our country has a low possibility of upward fire spread like in the Grenfell tower fire for the immediate future.

It has also been reported that a survey on “performance verification for prevention of fire propagation over exterior walls” is being conducted by experts as a research program in the project to promote building standards improvement, so as to study the usage of organic exterior materials for exterior insulation nationally as well as differences in the processes of fire propagation over exterior walls in cases of varying materials and construction conditions.

5. Conclusion: What are the challenges in Japan?

After reviewing the Grenfell Tower fire, I was once again made aware that this fire did not just raise the concerns over the risk of upward fire spread in high-rise buildings due to burning of exterior wall materials, but also triggered the deepest remorse for the fact that this risk, though having been often pointed out in the UK, has been neglected up until today. In the UK, the Independent Review is also discussing this seriously, thus other countries including Japan should not stay on the sidelines.

With trends moving toward global warming prevention and wood demand stimulation, green buildings (energy-saving buildings) have been recommended, and policies to increase the use of wood for interior and exterior wall insulation as well as structural members and exterior wall surfaces have been announced in our country as well. In a related development, on March 6, the Bill for Partial Revision of the Building Standards Law which revises regulations to ensure the safety of buildings and urban districts, utilization of existing building stocks, promotion of improving wooden buildings, etc. was approved in a Cabinet meeting to be submitted to this session of the Diet. This bill includes an item which allows buildings having four stories high or higher, which must have a fireproof structure, to be built using a wooden semi-fireproof structure by adding firefighting capabilities.

I have said so far that high-rise buildings and apartments in Japan are safer. However, I cannot deny the possibility of an increase in the use of materials such as various sandwich panels including wood for interior and exterior walls in the future. Seen in that light, it is more and more important to analyze fire protection challenges from the perspective of fire safety or firefighting activities with a clear head, and to appropriately present and point out problems as needed, while watching such trends.

Then, it would be important as an immediate specific challenge to examine how the use of exterior materials and insulating materials which may burst into flames with a large fire source, including sandwich panels with a core material of resin used as exterior wall surfaces, should be regulated, or to develop design guidelines on fire spread prevention measures, etc.

*1 Sandwich panels denote a panel-shaped building material in which an insulating material of resin, etc. is sandwiched between two thin metallic plates pushed together. They look like metallic panels but are light and have excellent insulation and workability, and are heavily used not only as exterior materials but also as interior materials for cold storage warehouses and low-temperature storage.

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(In alphabetical order of the country/region name)

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