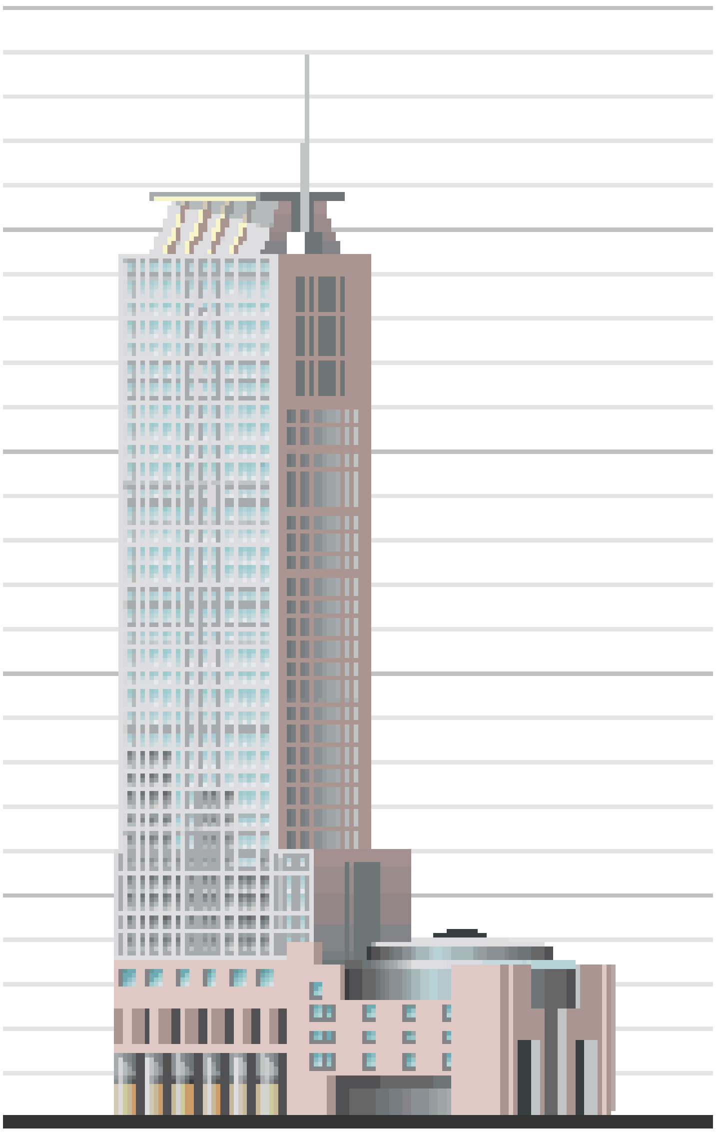
REPORT ON THE FIRE WHICH OCCURRED AT CHINA TELECOM TOWER, CHANGSHA, CHINA ON 16 SEPTEMBER 2022



By Frances Maria Peacock

FCIAT, CBuildE FCABE, IHBC, MIFireE, MSFPE, PG Cert., BSc, Dip. HE

Chartered Architectural Technologist, Chartered Building Engineer and Fire Engineer

September 2022

Introduction

1.1 On 16 September 2022, a serious fire occurred in an 43-storey high-rise office building in Changsha, the capital city of Hunan province of China. Although the fire spread was rapid, the flames fortunately did not spread beyond the side of the building where the fire started, even though the entire front face eventually became engulfed in flames. The cause and origin of the fire is still under investigation at the time of writing, but it is thought that the fire may have been started by a faulty air conditioning unit on the exterior of the building. The type of materials on the façade have not yet been confirmed, but are thought to be Aluminium Composite Material (ACM) panels which can be found on many high-rise buildings within China and many other countries throughout the world.

1.2 This is a preliminary report based on what is known so far and is written with the aim of enabling those with an interest in fire safety, building design and engineering to understand how the fire was able to take hold on the building face and spread in the way it did. This report also draws upon my research into the relationship between building design and fire spread, carried out following the Grenfell Tower fire in June 2017 to explain how the fire was able to spread so rapidly and ferociously around all four sides of the building, tragically claiming 72 lives. That research was able to identify specific fire phenomena associated with particular geometric shapes, forms and features, and therefore allow the fire dynamics as they affected Grenfell, to be properly explained. Details as to how a copy of the report on this research – which was released in October 2019 – can be obtained, are given in Appendix A along with details of other reports I have written.

1.3 Overall, there is much to be learned from this fire, not just in China, but in other countries too, including the UK. It is only by learning the lessons from such events that changes can be made to prevent similar disasters occurring in the future. Fortunately, it seems that there were no casualties in this case, although the situation could have been worse if this had been a residential buildings and the fire had occurred at night when people were asleep. Nevertheless, its use as an office building would have meant that the number of occupants was high, and we could have been looking at a very different outcome if the fire had affected more of the building and the people had not been able to evacuate as promptly as they did.

Building Description

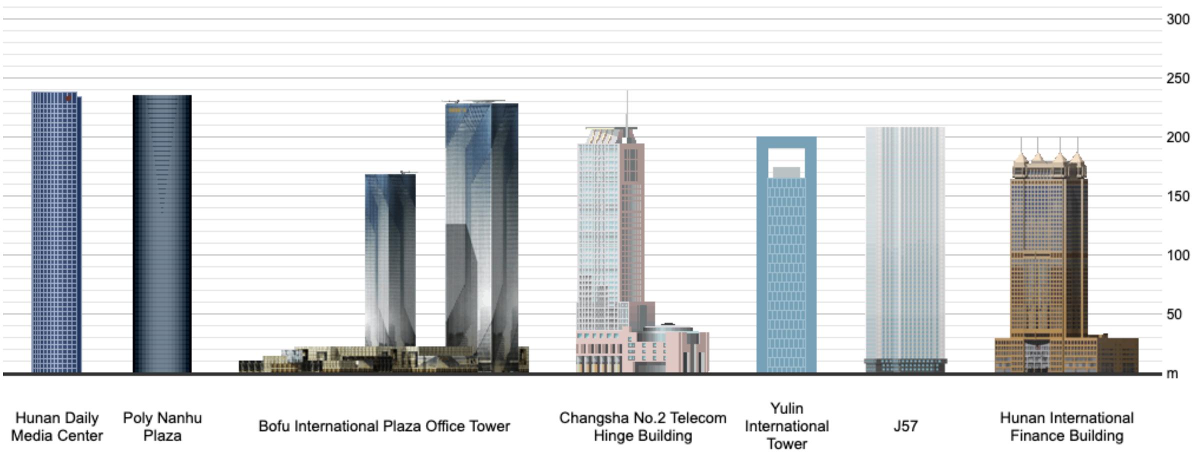
2.1 According to the database on The Skyscraper Page, the China Telecom Tower has 43 storeys including the ground floor and two floors which are below ground level. There are therefore 41 floors above ground level; the Ground Floor which is Level 0, plus forty others which are numbered from 1-40. This has led to much confusion in press reports about the fire, some of which state that the building has only forty floors; this being because they are not counting the ground floor or the subterranean floors. Others are saying that there are 42 floors, but this is because they are unaware that the ground floor is Level 0 and are adding the two floors below ground to the forty floors above the ground floor, which gives a figure of forty-two.

If the floor designation system employed in North America is used, the ground floor is Level 1 rather than Level 0, and this will give forty-one floors above ground level. Adding on the two below ground gives the correct total of 43. In the UK, we use a similar system when we are referring to a building having storeys rather than floors. Consider a low-rise domestic house; if it is a bungalow, it is referred to as being a single storey; if it is a two-storey house, there will be a ground floor plus a first floor above, if it is a town house, it will be have a ground floor (Level 0) plus two floors above (first and second), but three storeys. It is a common problem which tends to confuse the press and it is something I have encountered with every fire I have ever dealt with.

The full name of the building is **Changsha No.2 Telecom Hinge Building** which is occupied by the state-owned telecommunications company, China Telecom. It is around twenty years old, having been completed in 2003, after a six-year construction period which commenced in 1997. The gross internal floor area is a generous 89 828m^2.

As has been the case with the number of floors, there has also been confusion regarding the height of the building, with figures which appear to be estimates being put forward. Referring to the respected skyscraper database known as the Skyscraper page, the architectural height is given as 189m (620 ft) to the roof, and the overall height as 218m (715 ft) to the top of the spire. The latter figure has been frequently quoted in the press, although figures of 525m and

656m which do not appear to equate to anything, have also been given. It's height makes it the fourth shortest skyscraper in the city out of a total of twenty-five (*Fig.1*). The tallest is the Wharf IFS Tower No.1 which has 94 floors and stands at 452.1m high, making it a supertall skyscraper. For a skyscraper to be considered *supertall*, it must have a height of at least 300m. The threshold is 600m for a building which is *megatall*.



<u>Figure 1</u>: The Changsha No.2 Telecom Hinge Building set in the context of other high-rises in the city. The lowest is the Hunan International Finance Building on the left. *Drawing: The Skyscraper Page*

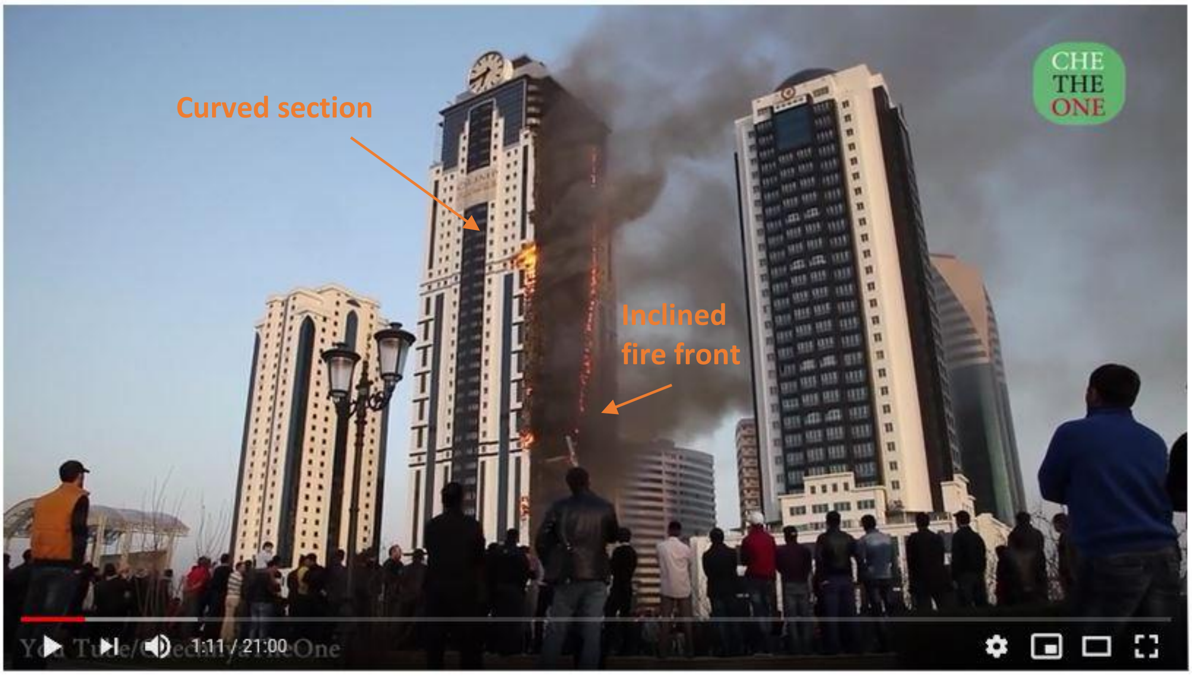
It is worth noting at this point that few details are ever disclosed about fires which occur in Chinese buildings, and therefore it is not possible to provide any details on the passive or active fire protection in the building. Apart from the videos which find their way onto social media and photos which are picked up by the press, no other information is usually forthcoming. It is for this reason that I have been unable to find a photograph of the building in its pre-fire state despite an extensive search. Even Google Street View does not include footage of Chinese streets. Therefore, I have had to use an image drawn by Andrew Macey which is shown above in *Figure 1* and on the cover of this report.

Nevertheless, despite these limitations, I have enough information from the photos and videos out in the public domain to allow me to examine the architectural design and geometric form of the building as well as, perhaps most importantly, observe the spread and behaviour of the fire.

The location of the tower is in the centre of Changsha, as seen in *Figure 2* below.

<u>Figure 2</u>: A Google image showing the tower from above and giving a good view of its geometric profile which had a profound influence on the way in which the fire spread and behaved. Of particular note is the curved section on the front elevation of the building which forms a vertex at the points where it joins with the main building face.

The design of the building is in some ways similar to that of the Olympus Tower (now known as the Phoenix Tower) in Grozny, the capital of the Russian province of Chechnya (*Fig.3*). That also has curved sections which form vertexes (also known as introverted corners) at the points where the curved sections meet with the main building faces. However, although the Changsha Telecom building (a shortened name by which the building will be referred to for the purposes of this report) had a curved section on one side only, the Olympus had a curved section on each of its four sides. The Olympus also had a roof-top rim and horizontal string courses at lower levels, although it appears that no such features (or equivalent) were present at the Changsha Telecom building. Horizontal features play a key role in transferring a fire from one side of a building to another.



Пожар в Грозный Сити Полная версия Fire in Grozny City

<u>Figure 3</u>: My knowledge of Cyrillic alphabet allows me to read the wording below the image, which literally says "*Požar v Groznji Citi Polnaya verciya*". This translates as "Fire in Grozny City Public version" or simply "Fire in Grozny City," as shown. This photo shows the fire at a relatively early stage where only one of the faces has been affected. The flames would eventually spread to all four sides of the building.

Design, Geometry & Fire Phenomena

3.1 The design of the Changsha Telecom building is fortunately relatively simple, and consists of a tower set above a large podium several storeys in height at the base. Yet, despite this relatively straightforward design, there are several features present which have the potential to promote fire spread, and control the way in which the fire behaves as it spreads across the façade. Before launching into further discussion, it is necessary to set out the principles I have developed with a definition of each, defining the fire phenomena derived from the specific fire dynamics associated with each overall shape, geometric form and architectural features which may be relevant to a building with combustible material on its façade.

Upward Fire Spread

- <u>Upward vertical fire spread</u>: *The rapid spread of fire up tall uninterrupted vertical bands of cladding or some other flammable material on the building façade;*

- Feature influenced upward fire spread: *The tendency for the fire to concentrate itself on a vertically orientated projecting features; this will enhance the rate of flame spread;*

- Corner influenced fire spread: *The extension of flame height which occurs when the fire becomes confined to an introverted corner (vertex) on a building face;*

- The Trench Effect: *Occurs in recesses where the fire becomes confined and increases in intensity as the recess acts as a vertical trench;*

- Upward fire spread with an inclined front: *Caused by curves on a building face distorting the fire front;*

Downward Fire Spread

- Downward vertical fire spread: *The downward spread of fire affecting continuous bands of cladding due to the flowing and dripping of molten burning material. The does not involve projecting features;*

- Downward fire spread with an inclined front: *Initiated by fire spreading along a horizontally orientated feature at the top of a building;*

- Feature influenced downward fire spread: *The tendency for the fire to concentrate itself on a vertically orientated projecting feature; this will interrupt the diagonal pattern if the fire is spreading with an inclined front;*

Horizontal Fire Spread

- Standard horizontal fire spread: *The very slow spread of fire in a lateral direction. It does not necessarily involve a projecting feature, although it may be encouraged by contours on the building face;*

- Feature enhanced horizontal fire spread: *Occurs when the flames become concentrated on a horizontally orientated projecting architectural feature. The rate of flame spread is much more rapid than for standard horizontal spread. If the feature forms a ledge upon which molten material can collect, the fire spread will be further enhanced;*

- Perimeter/roof-top fire spread: *This is essentially Feature Enhanced horizontal fire spread which occurs at roof level, involving a parapet, crown or rim around the perimeter of a building. It may also affect features which sit on top of the roof and is influenced by exposure of the architectural feature;*

- Rotational fire spread: *The action of the fire transferring around the corners of the building without the aid of roof-top features. It generally occurs at lower levels and is influenced by* *the shape of the building's corners and any other feature connected to or close to the corners, such as string courses and cornices;*

Other

- Cross-radiation: *Occurs when re-entrant corners are present. These have an angle greater than 180° and if there are two inward facing surfaces, cross-radiation will occur and the fire will intensify;*

Of the phenomena listed above, the following types occurred:

Upward Vertical Fire Spread;

Corner Influenced Fire Spread;

Upward Fire Spread with an Inclined Front;

Downward Vertical Fire Spread;

Standard Horizontal Fire Spread.

The Development and Spread of the Fire

Although the materials used on the façade of the building have not been confirmed, it can be assumed with a high level of probability that the cladding panels which cover the exterior are of Aluminium Composite Material (ACM). The ACM forms the outer layer of a rainscreen cladding system. Not only has this material used abundantly, as is the case in many other countries, but the behaviour of the panels as they burned was highly typical of ACM. As the fire approached unburned panels, they began to crumple and distort due to the heat. Once ignited, the cores of the panels melted and molten polyethylene (PE) dripped and flowed down the building face. Although the core material has not been confirmed, the behaviour of the panel cores during the fire is indicative of PE. Many of the panels were seen to detach, sending flaming debris downwards.

Perhaps most notable of all was the thick black smoke (*Fig.4*) which is a defining characteristic of fires involving ACM panels. This was emitted, in a quantity which was so great that it was visible right across the city in all directions and beyond, whilst obscuring much of the building face as it burnt. This smoke would have been highly toxic to any person or animal if they inhaled it. *Figure 4*, and all other photographs used in this part of the report, are in the public domain and have been taken from various newspapers. Other images have been captured as still images from video footage.

<u>Figure 4</u>: A distant view of the burning tower showing the huge cloud of dense black smoke being ejected hundreds of metres into the air above the building.

According to statements released by the fire service, the first call was received at 15.48 local time. Just thirty-two minutes later, at 16.20 hours local time, it was announced that the fire had been extinguished. My first thought upon hearing this was that the entire incident was over remarkably quickly and therefore there must have been some mistake in the reporting, or else the severity of the fire was being deliberately played down. However, upon further investigation, I concluded that this indeed may actually have been the case. The short duration of the fire and its limited amount of spread would have greatly reduced the likelihood of casualties, and although not yet officially confirmed by the Hunan Province authorities, it seems likely that the claim of there being no deaths or serious injuries is correct.

The firefighting response to the incident was substantial, with around 280 personnel from seventeen local fire stations being dispatched to the scene. The intense heat caused many of the windows in the tower to fail in a rather spectacular fashion, with eyewitnesses describing windows as “exploding” in the heat. When this happens, the internal compartmentation upon which the building relies in order to keep its occupants safe, is breached. The failure of any element, whether it be the windows, doors or anything else which makes up the fire-resisting box around the compartment, will result in the compartmentation being undermined and therefore no longer intact. It is at this point that a threat to the safety of occupants is threatened. At Grenfell, the compartmentation was breached at multiple levels by the fire spreading up and across the building, then re-entering compartments via the windows.

The question which must now be asked is what the internal layout was like. As the building was used as offices, it is strong possibility that it may have been open plan, in which case the occupied area of entire floors may have been exposed to the fire once the windows failed. In such a setting, only stair and lift lobbies along with toilet and refreshment areas would have been separated from the general office space.

Development of the fire stage by stage

1. Fire breaks out at the top of the podium. It is not clear whether the fire began in the podium itself, or whether it began on one of the lower floors of the tower close to the top of the podium.

2. The fire spreads rapidly upwards. Although there are no projecting features, there are narrow uninterrupted vertical bands of cladding which concentrate the flames within a limited area, thus allowing heat to build and the fire to spread more rapidly. This is known as *Upward Vertical Fire Spread*.
3. Some of the flames also become confined to the vertex where the protruding curved section meets with the rest of the building face. The limited amount of oxygen causes the flames to elongate in search of a better supply, and in doing so, they increase the heating of the fuel ahead of the burning zone, resulting in rapid fire spread. This is known as *Corner Influenced Fire Spread*.
4. During this phase of the fire, there is little opportunity for horizontal spread, especially as there are no horizontally orientated architectural features present on the building face.
5. As the fuel becomes consumed and the upward progression slows, the opportunity for some lateral creep arises. Some of the flames begin to spread along the window ledges taking the fire with them. This is known as *Standard Horizontal Fire Spread*.
6. The intense upward fire spread causes the cores of the ACM panels to melt, and the molten PE flows down the building face taking the fire with it. This is known as *Downward Vertical Fire Spread*. Some of the molten material collects on window ledges, starting secondary fires which begin to spread upwards again as the flames finds new sources of fuel. This is particularly noticeable on lower levels of the podium.
7. Each time the fire encounters a new vertical section of unburnt cladding, it follows the vertical line of that section, spreading upwards with increased speed. This process continues until there is no more fuel to burn.
8. As the fire front passes over the curved section in the middle of the building face, it becomes distorted as is starts to follow the curvature, leading a differentiation in speed between the upper and lower ends of the front. The front becomes inclined and a diagonal pattern appears due to the upper end of the front moving faster than the lower end. This is known as *Upward Fire Spread with an Inclined Front* and is a comparatively rare phenomenon which was also witnessed at the Olympus Tower in 2013, Grenfell Tower in 2017 and Taksim Ilk Yardim Hospital in Istanbul in 2018. The diagonal pattern can also be caused by downward fire spread – which may also have occurred here – and is known as *Downward Fire Spread with an Inclined Front*.

9. If points 5 and 6 above had not occurred, then the fire may have burnt itself out, as was nearly the case at the Olympus Tower in Grozny until it latched onto horizontally orientated string courses at intermediate levels of the building, the line of which it began to follow. This is known as *Feature Enhanced Horizontal Fire Spread*. It is for this reason that the fire was able to spread to all four sides of the Olympus Tower. The fire also began to follow a projecting roof-top rim once it reached the top of the building, this too enabling the fire to spread to all four sides. This is known as *Perimeter/Roof-top Fire Spread*. There were no roof-top features at the Changsha Telecom building.
10. Two factors are necessary to enable a fire to transfer from one side of a building to the next. The most dominant of these is the presence of horizontally orientated features as described in point 9 above. The other is the presence of wind, which may blow the flames around the corner. The action of the flames progressing around the corner (by whatever means) is known as *Rotational Fire Spread*. Without these factors, the fire will tend to stop at the corners and there will be a clean line between the damaged cladding on one face of the building, and the undamaged cladding on the other. It is due to the absence of horizontally orientated features at the Changsha Telecom Building that the fire remained confined to the side where it started.
11. There is some photographic and video evidence that there was a strong wind blowing at the time of the fire, but the absence of horizontal features and the relationship of the air movement to the position of the building face, meant that it could not blow the flames around the corner. Another thing worth noting is that building geometry has much more of an influence on fire spread and behaviour than wind or any other type of air movement. I am conducting further studies on this, but some fires, especially that which occurred at the Olympus Tower in 2013, have shown that the fire can progress into an oncoming wind; in other words, the flames progress in the opposite direction to that from which the wind is blowing, thus defying the logic that the wind always blows flames from behind, helping them progress in the same direction at the air movement.
12. The fact that the fire remained on one side of the Changsha Telecom Building only (for reasons given in points 10 and 11 above), explains why it was able to be extinguished by firefighters just over half an hour after it started. Fuel gets used up very quickly in

a façade fire involving highly combustible materials like ACM. When the fire at the Olympus Tower was timed, each section of cladding was completely consumed within an average time of around three minutes, from when it first ignited to when the flames died down. Therefore, because the fire at the Changsha Telecom Building was unable to get around the corners, all the fuel on the side of the building where it started was rapidly consumed, and with nowhere else for the fire to go, the firefighters were able to fully extinguish the it within a relatively short space of time.

Below are a series of photographs which illustrate the comments and observations I have made above:

<u>Figure 5</u>: A series of three photos which show the fire at different stages of its development. The photo on the left shows a view of the building from the side, and apart from a slight blackening of the pinkish coloured cladding panels due to sooty deposits from the smoke, the fire has not been able to progress around the corner. The middle photo along with one on the right, show the podium on fire at lower levels with a column of flame spreading vertically upwards. The fire is also affecting the curved section in the middle of the tower and the front is diagonally inclined due to a differentiation in speed between the upper end of the fire front and the lower end of the fire front as the flames follow the line of curvature. The more pronounced the curve is, the greater the angle of inclination will be.

Figure 6: The photo on the left shows that fire has spread unseen through the inside of the cladding system and broken out through the joints near the top of the building. The joints of all the panels on the upper section – which are light grey rather than the pinkish brown on the rest of the tower – are blackened from the smoke and heat, which is also causing the skins of the panels to wrinkle. In this photo, it appears that smoke is actually emanating from the roof, to which the fire must have spread from the front side of the building where it started. The intensity of the heat at roof level is such that it has caused melting of the panels and a small amount of downward spread on other sides of the tower, although this did not spread beyond the top section. Fortunately, there is no roof top feature present which could have carried the fire from one side of the building to the next.

The photo on the right shows the combustible cladding panels erupting into flames as the fire spreads rapidly up the building. The fire began on the left side of the building and worked its way across in a similar way to Grenfell, but without the aid of a roof-top architectural crown, even assuming a distinctive diagonal pattern as it did so. As the fire front moved across the building, it caused the glazing to fail, as has been revealed in its wake, thus breaching the compartmentation on multiple floors.

Figure 7: The fire began at the top of the podium on the left side of the building face as shown here. The cladding panels burned fiercely, producing a thick cloud of black smoke as the fire spread rapidly upwards and then across the building towards the other corner before it was finally extinguished. Many of the panels detached from the building as they burned and debris can be seen falling downwards.

Figure 8: The photo on the left shows the fire at mid-stage of its development where the Coanda effect is also visible, which causes hot gases and smoke to be drawn back against the building face, as was also seen at

Grenfell Tower. It may be because of this effect and the currents generated that the smoke plume is being deflected to the right, which is also the direction in which the fire is progressing.

The middle photo shows the fire in its later stages where it has spread right across the building face leaving blackness and severe damage behind it. The flames have concentrated themselves on the window ledges which assisted the flames in their effort to spread sideways. The Coanda effect is still visible, but to a lesser extent.

The photo on the right shows the blackened frontage of the Changsha Telecom Building after the fire has been extinguished, with wisps of black smoke still rising from the charred remains of the rainscreen cladding system. As most of the windows have failed and the flames and smoke have been able to enter the interior, the internal damage must be extensive.

Figure 9: The fire can be seen here at a well-developed stage where it is affecting all levels on this side of the building. A diagonal front moves across the central curved section and flaming debris falls from the smoke cloud. The fire is following the line of the window cills and has caused the windows to fail at multiple levels.

Conclusion

Although externally only one side of the building was affected, this was a serious fire, the consequences of which could have been far worse if it was a residential building, especially if the fire had occurred at night. The fact that the windows failed and the fire was able to enter the building on multiple levels - thereby breaching the compartmentation - bears an uncomfortable similarity to Grenfell where simultaneous entry of the flames into flats on multiple floors undermined the compartmentation and put residents' lives at risk. Seventy-two people sadly lost their lives. The pattern exhibited by the flames with a horizontally moving inclined fire front, which left behind a trail of destruction in its wake, is also reminiscent of Grenfell.

Sadly, the fire is not unique and is another one in a long line of many; not only those which have already occurred, but those which are still to come. The fire risk from combustible materials on the facades and in the external walls of high-rise buildings is a global one, which can be recognised from the fact that these fires are happening all over the world; from the UK, to the UAE, to China, Australia, France, Italy, Russia and many more. The number of buildings which are unsafe due to the use of combustible materials runs into many thousands and it will take several decades before this problem is rectified, if ever at all. Certainly, such is the extent of the problem, that many of us currently working in the fire and construction sectors will not live long enough to see this goal achieved within our lifetimes.

It is for this reason that some companies, academics, experts and engineers have come together to look at alternative ways of reducing the risk, all of which are less costly and time consuming. With the application of these solutions, it will be possible to reduce the risk to an acceptable level without necessarily removing all of the cladding. A report on a mitigation strategy which brings together a selection of outstanding innovations, such as the fire resisting window pod, is aimed at achieving an effective reduction in risk using other methods and copies can be obtained by visiting www.intelliclad.co.uk The report is called, *Remediation or Mitigation? Developing a Strategy for Unsafe Buildings*. Unless greater action is taken, it will only be a matter of time before a disaster on the scale of Grenfell occurs somewhere in the world.

References

Technical Reports:

Peacock, Frances Maria, *The Relationship between Building Design and Fire Spread: How the Shape, Form & Features of a building can influence the behaviour of fire*, October 2019;

Peacock, Frances Maria, *Remediation or Mitigation? Developing a Strategy for Unsafe Buildings*, April 2022;

Media Reports:

Associated Press (AP), *Fire engulfs 42-storey Building in China; no deaths reported*, ABC News, 16 September 2022;

Global Times, *China Telecom investigates fire in Changsha building; no casualties reported*, September 2022;

New York Post, *Massive Fire in Changsha, China, engulfs office building*, September 2022;

Sands, Leo, *China Fire: Skyscraper engulfed in massive flames*, BBC News, 16 September 2022;

Stambaugh, Alexandra, *Major Fire breaks out at 42-storey skyscraper in Changsha,* China, 16 CNN News, September 2022;

The Guardian, *Major fire engulfs skyscraper in Changsha, central China*, September 2022;

Databases:

www.skyscraperpage.com

About the Author and Contact Details

Frances Maria Peacock is a Chartered Architectural Technologist and a Chartered Building Engineer. She is also a Fire Engineer and works for Intelliclad, a company which has developed a unique façade-based fire detection and fire alarm system, capable of detecting a cladding fire at the earliest opportunity, and then warning residents. Frances is also a Fire Engineer at Olympus Fire Safety, an organisation she established in her capacity as an independent nationally and internationally recognised expert, through which she carries out technical research and publishes reports. Olympus is also partnered with Intelliclad. She can be contacted by email: frances@intelliclad.co.uk or olympusfiresafety@gmail.com