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THE ISSUE OF VERTICAL SPREAD OF FIRE THROUGH FLAMMABLE CLADDING AND FACADES IN INDIA:

A comparative regulatory review and suggestive guidelines

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Abstract: The building industry has seen a shift towards energy efficiency in last few decades. This shift in combination with requirements of aesthetics, low cost, easy installation, and low maintenance have resulted in the use of claddings (such as ACP) and ventilated (rainscreen) façade system. It is evident from recent fire events globally that vertical spread of fire through these claddings and facades can be extremely rapid leading to insignificant time for evacuation, ultimately to loss of lives and property. There has been considerable research on the topic. However, the available knowledge is not being implemented and there is insignificant work regarding codes and regulations in many counties.

Indian building industry has outgrown in last few decades with many high-rise buildings coming-up and Aluminium Composite Panel (ACP) has become a popular material for cladding. Production and use of ACP is increasing in an unregulated manner. Furthermore, Indian climate has promoted the use of ventilated façade in many of its cities, which in combination with the ACP can intensify the rapid vertical spread of fire in high-rise buildings. All of these presents sufficient fire risks in near future, which must be considered.

This paper examines the sufficiency of Indian building codes and regulations to tackle the issue and presents its comparative analysis with codes and standards of other countries (UK, UAE, Australia, and International Building Code) where regulatory changes and code modifications have been carried out regarding flammable facades and cladding. The paper ultimately presents a set of suggestive guidelines that can address the issue in India. The guidelines have been drafted on the basis opinion, comment and suggestion of experts from Bureau of Indian Standards, fire committee of National Building Code of India, fire safety service consultant, academic experts involved in similar research in the form of semi-structured interview. The guidelines also incorporate learning taken from review of other codes.

***Index Terms*–Vertical Spread of Fire, Flammable Cladding and Facades, Aluminium Composite Panel (ACP), Ventilated (rainscreen) Façade, India.**

I. INTRODUCTION

The façade system in high-rise buildings has been reformed in the last few decades. The industry has seen great emphasis on energy efficiency, green and sustainability concepts (McKenna et al., 2019; Nguyen, Weerasinghe, Mendis, & Ngo, 2016; Peng, Ni, & Huang, 2013). Moreover, other factors such as cost, aesthetics, lighter weight, low maintenance, insulation, rain and dust protection have given rise to the use of many flammable cladding materials (such as ACP or Aluminium Composite Panel) and systems, such as rainscreen or ventilated façades(Gandhi et al., 2017; McGuire, 1967; Paff, 2018; Peng et al., 2013). This façade system and material was used in the Grenfell Tower, London. The building's façade gave rise to the most dreadful incident of fire killing 72 people (McKenna et al., 2019). Several fire incidents in high-rise buildings around the world took horrific shape due to severe and rapid fire spread through cladding, with loss of lives and property. Thus, emerging cladding has become an area of concern and a critical element in passive fire protection for high-rise buildings.

ACP is composed "of two thin sheets of aluminium that sandwich a polymer core" (Paff, 2019, p. 53). Polymer is highly flammable and poses a great risk of spread of flame because of its chemical composition (Group, 1984). Furthermore, (Paff, 2019, p. 53) claims that polyethylene (core material in most ACP) has an ignition temperature of around 350^{o}C and ACP cladding has an "energy density similar to that of gasoline". Thus, this kind of material poses high fire risks in buildings.

India is witnessing a tremendous increase in number of high-rise buildings (Kavilkar & Patil, 2014) and industrial statistics shows a great increase in Aluminium Composite Panel demand and manufacture in the country. Its insulating property makes it suitable for the tropical and sub-tropical climate of India, while its other properties like low cost, easy and fast installation, low maintenance makes it suitable of

a developing country like India. Furthermore, the tropical climate in the majority part of India, dust and pollution have created the demand for special energy efficient envelopes that could provide insulation, as a result ventilated façade is becoming popular in various cities across the country. The use of ACP or similar flammable cladding materials and design of façade system in buildings must be regulated to mitigate the risk of fire events.

II. NEED OF THE RESEARCH

Fire protection in buildings has two ways of achieving it – Passive Fire Protection and Active Fire Protection (Congress, 2011). Passive fire protection focuses on planning and design intervention to cease fire and preventing its spread by isolation of the active area through compartmentalization and other methods (Group, 1984). Flammable cladding is a threat to this passive fire protection in any building. As seen in many incidents globally, a small controllable fire can take horrific shape and can spread vertically in the whole building within minutes because of flammable cladding on the external wall (Chen, Yuen, Yeoh, Yang, & Chan, 2019). Residents are left with inadequate evacuation time and suppression of fire by fire tenders becomes difficult.

III. EXISTING STUDIES ON FLAMMABLE CLADDING AND FAÇADE

The earliest literature on the topic was published in the 1960's, predicting the upcoming problem with combustible cladding and facades. McGuire (1967, p. 137) says "It might well prove convenient to use combustible materials, but for high rise buildings, this might constitute a fire hazard". The topic was dormant for many decades and transpired in the last decade, especially after the incident of the Grenfell Tower, London in 2017.

3.1 MATERIAL

Sufficient research (such as Chen et al. (2019), Paff (2019), and Darmon (2012)) has been done regarding material properties of ACP. These papers also discuss about which materials shall be used for cladding and which should be avoided. Bradley (2019) acknowledges the research on a new material which has insulating properties and is non-combustible.

3.2 FAÇADE SYSTEM

Furthermore, there are researches (Gandhi et al., 2017; Gonzalo, McCann, & Paurine, 2018; Kinowski, Sędłak, & Sulik, 2016; McKenna et al., 2019; Wang & Hu, 2019) suggesting the type and details of façade system to be used to inhibit the vertical spread of fire. Kinowski et al. (2016) focus on the risks associated with falling parts of cladding during fire and conclude, based on experiments, that cladding fixed mechanically are safer than those fixed with adhesive, as adhesive loses its property at high temperature. Glass façade is the "weakest section of building envelope", which may break during fire and increase the problems many folds (Wang & Hu, 2019, p. 1). Wang and Hu (2019) show experiment results on laminated glass, which is increasingly used in high-rise buildings, and concludes with what type of laminated glass best suited for fire resistance. Tall window performs better in reducing the thermal exposure of cladding. Height-width ratio of window governs the shape of plume, "tall windows tend to project flame away from the wall" (Oleszkiewicz, 1990, p. 374). Rainscreen or ventilated façade system has cavity between the main external wall and cladding.The cavity enhances the energy efficiency of building while this can spread fire rapidly, which can be very dangerous (Gonzalo et al., 2018).Thus, cavities in the facade should be avoided. Giraldo, Lacasta, Avellaneda, and Burgos (2013) claims that the chimney effect inside the cavity may cause the flame to extend up to ten times greater than the normal scenario and thus suggests the use cavity barriers.Peng et al. (2013) suggests use of fire barriers and Darmon (2012)suggests to use a mix of cladding materials by providing non-combustible continuous strip of mineral wool to restrain a fire spread. It is evident that there are many solutions and suggestions worked out in earlier researches to address the problem of vertical spread of fire through façade.

3.3 TEST METHODS

A substantial literature have focused on test methods to predict the behaviour of material and system in building. Oleszkiewicz (1990) compares different test methods and concludes that full-scale test is the most appropriate to predict the fire behaviour of materials and assemblies. Nishio, Yoshioka, Noguchi, Ando, and Tamura (2013) have developed a new test method for evaluation propagation of flame. Nguyen et al. (2016) focuses on understanding principles of different test methods recognised by NCC, ADB and the IBC. Chen et al. (2019, p. 7) designates full-scale fire testing as very costly and destructive, henceforth suggests numerical simulations as a cost-effective method to "bridge the knowledge gap and explore the system sensitivity". Testing cladding material and façade system before installation can reduce the fire risk considerably.

IV. RESEARCH GAP

Sufficient research has been done on the problem of cladding and façade, also possible solutions to arrest the spread of fire have been presented (refer *Section 3.1* to *Section 3.3*). Additionally, the world has seen many recent terrifying events of fire involving cladding and facade. However, there are still many building wrapped in these flammable façade in developed countries, like UK (Stone, 2019) and a lot more coming up both in developed and developing countries, like India. There is an appreciable gap between the knowledge available (researches) and its implementation (regulations), refer *Figure 1*. After some recent fire events due to cladding there has been certain modifications in regulations of some countries, such as Australia (Gapes, 2018). This shows a great need for comparative review of Indian regulatory provisions against other countries (like Australia, UAE, UK and International Building Code), where building code and other regulatory modification are being implemented to address the problem of flammable cladding.

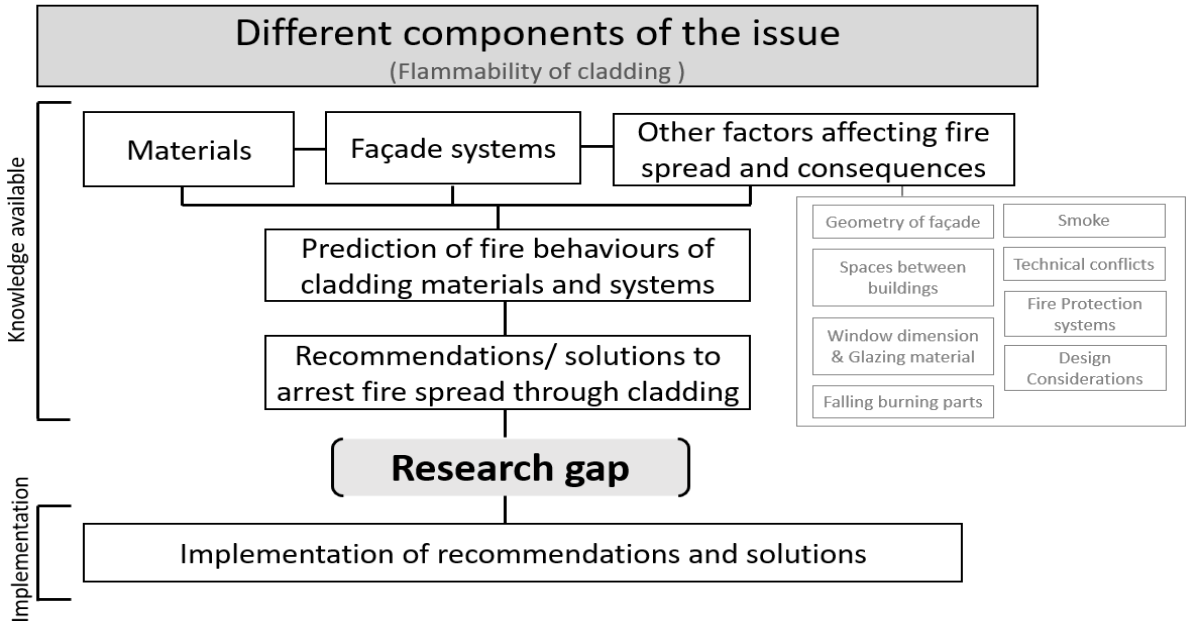

Figure 1 Flow chart showing research gap

V. AIM OF THE RESEARCH

This research aims to examine the regulatory sufficiency regarding flammable cladding in India, in comparison to modifications and initiatives taken globally and to develop a suggestive guideline to address the issue of flammable cladding and facades in India.

VI. OBJECTIVES

The aim of the research has been achieved with help of following objectives –

1. To review regulatory changes and code modifications being carried out regarding flammable façades and cladding around the world.
2. To explore code development/ modification procedure in India and the sufficiency of Indian codes to address problem of flammable claddings.
3. To develop a suggestive guideline to address the issue of flammable cladding in India.

VII. METHODOLOGY

This research is of exploratory nature and aims to investigate a problem that is not clearly defined in the context of India. Hence, the research has been designed in a way to better understand the problem and redefine it with emerging codes/ themes during the data collection and analysis. Interviews, document review and desk research has been selected as data collection methods owing to its exploratory nature. Furthermore, this research follows the critical realistic paradigm. Hence, the research is expected to reach a good approximation of reality but could not fully comprehend the issue due to limitations (Collier, 1994).

Step 1 –Review of codes and other regulatory documents relevant to façades and cladding from Australia, UAE, UK, India and also International Building Code.

Step 2 –Interview experts for their opinion and suggestion on sufficiency of Indian code and standards to address the problem of flammable cladding and façade, the questionnaire for the interview to address the themes identified from document review (in step 1).

Step 3–Draft a set of suggestive guidelines for India, to address the issue based on recommendations extracted from code review (step 1) and on the opinion and suggestions of the experts (step 2).

VIII. DOCUMENT REVIEW

"Document analysis is a systematic procedure for reviewing or evaluating documents -both printed and electronic material" (Bowen, 2009, p. 27). Document analysis requires data to be examined and interpreted in order to extract meaning, get understanding of the facts and to develop knowledge (Corbin & Strauss, 2008). Organizational and institutional documents have been used in lots of research for many years and now it is regarded as part of methodology (Bowen, 2009).

8.1 SAMPLING AND DATA COLLECTION

For the purpose of this research codes and other relevant regulatory documents from Australia, UK, and UAE have been reviewed as there has been recent modifications in these countries to include the issue of cladding and façade fire. Furthermore, International Building code has also been reviewed as it of international repute and has been revised in 2018 to include a chapter on the issue(Council, 2018). National Building Code of India has also been reviewed against previously mentioned codes to establish its comparative sufficiency or insufficiency. Documents considered from each country are as follows:

1. Australia – National Construction Code (NCC), 2019
    a. Western Australia - Building Regulation 2012, Building Amendment Regulation (No. 2) 2018
    b. Victoria - Building Act amendment 2018 (VIC), Building Regulations, 2018 (VIC)
    c. Queensland - Building Regulation 2006, Building regulation amendment 2018, Building and other legislation (cladding) amendment Regulation 2018.
    d. New South Wales - Building Product (Safety) Act 2017 (NSW), Home building regulation 2018, Environment Planning and Assessment Amendment Regulation 2018

    National Construction Code of Australia gives performance-based requirements and thus each of its state has its own regulatory documents giving more prescriptive ways of achieving those requirements. Hence the above-mentioned documents, which contain the relevant matter on the issue, have been reviewed.

2. UAE - UAE Fire and Life Safety Code, 2018.

3. UK - Building Regulations 2010, Building (Amendment) Regulations 2018, Approved Document 7 (Material and Workmanship), Approved Document B (Fire Safety).

    The Building Regulation, UK is a performance-based document. The Approved Documents provides guidance for how the building regulations can be satisfied (a more prescriptive approach).

4. India – National Building Code, 2016.

    In case of fire codes in India, the mother codes have not been revised but the revision has been done in the NBC. The original codes based on which the NBC is prepared as a code of practice, continue to be old.

5. International Building Code.

8.2 ANALYSIS

The documents were analyzed by thematic analysis. The thematic analysis is a type of analysis used to identify patterns and themes within qualitative data (Maguire & Delahunt, 2017). The priory codes or themes to start with thematic analysis have been derived from literature study, and those are:

- Materials
- Façade system
- Test methods

During the analysis new codes/ themes emerged (refer *Section 8.3* for details), which guided the further steps of the research.

8.3 RESULT AND DISCUSSION

In order to establish a comparative analysis, one point was given to each provision or step taken by the countries to combat the problem of flammable cladding and facades. Thus, for the purpose of this paper country scoring least was considered to be insufficiently addressing the issue. Major recommendations and code provisions extracted from the documents are –

1. Australia –ACP has been identified as a critical material in the country and states (such as Victoria and Western Australia) are conducting cladding audit on existing buildings with ACP to assess the risk and authority will take necessary action as per the audit reports. Furthermore, there has been ban on some particular type of ACP in some of the states (such as New South Wales) of the country. Use of Cavity Barrier has been mandated by NCC, 2019 if the façade has cavity. Further, the code recommends construction of horizontal projection of non-combustible material above windows and other opening to avoid fire to reach the cladding. The codes and other regulatory documents focus on many other aspects such as façade sprinklers, full-scale testing, and penalties in terms of fine and imprisonment.

2. UAE – The country is now cautious about the cladding materials and Dubai Civil Defence now holds survey for all existing towers and building to check the quality of materials used on facades and balconies. UAE Fire and Life Safety Code, 2018 necessitates that existing towers will have to comply with new code when the buildings are due for maintenance. The use of any cladding material with flammable element, have been banned on floors above 10^{th} floor. The code focuses on provisions regarding fire barriers, cavity barriers, exterior sprinklers, continuous inspection and special inspections by third-party, responsibilities of stakeholders, design approval requirements, consultant's qualification and monetary penalties.

3. UK – There has been a ban on the use of combustible material in façade of buildings of height more than 18 meters. The Ban does not apply to existing buildings; however local authorities provide support to carry out emergency work of removal unsafe ACP claddings if necessary. The approved documents pose the requirements of cavity barriers, thermal breaks, separation distance. The code poses other requirements such as material and assembly testing.

4. International Building Code, 2018 – The code includes a section on the issue and provides sufficient number of provisions focusing on the aspects like material, cavity, vertical separation, opening protection and full-scale test.

5. India – Unlike above codes, NBC 2016, considers the problem of vertical spread of fire through cladding and provide requirements only regarding the materials to be used in facades and as cladding. The code classifies surfacing materials in terms of the rate of spread of flame as follows –
    a. Class 1 – surfaces of very low flame spread
    b. Class 2 – surfaces of low flame spread
    c. Class 3 – surfaces of medium flame spread
    d. Class 4 – surfaces of rapid flame spread

    Materials of class 2, 3, and 4 are not suggested to be used for facades and cladding of external wall by the code.

As a comparative analysis UAE scored maximum number of points as it addresses maximum number of aspects of the issue in terms of code provisions and measures being taken. Whereas, India scored least in the comparison as it touches upon only material of the cladding in the National Building Code.

The new themes/codes (apart from already identified from literature study) immerged from document review are -

- Audit/ Inspection
- Existing Buildings
- Allocation of Responsibilities
- Financial support
- Qualification of Façade consultants
- Penalties
- Design and Specification Approvals

IX. SEMI-STRUCTURED INTERVIEW

"Interview is a flexible tool for data collection" and "a powerful implement for researchers" (Cohen, Manion, & Morrison, 2018, p. 349). For the purpose of this research semi-structured interview was carried out. This kind of interview is flexible and dynamic. Although, it has a pre-designed questionnaire but some question may be modified or added during the interview depending on the response of the interviewee (Taylor & Bogdan, 1998).

9.1 SAMPLING

The Interview targeted the experts from Bureau of Indian Standards (National body that frames building codes and regulations), fire committee for NBC, fire safety service consultant, academic experts involved in similar research. Five experts were targeted; however, the saturation was achieved beforehand and the interview was restricted to three interviewees. Glaser and Strauss (1973) defined the theoretical saturation as a point in the research at which the data becomes repetitive and no significant new insights are gained. Since, experts were difficult to approach Snowball and Convenience sampling methods were adopted.

9.2 QUESTIONNAIRE DESIGN AND INTERVIEW ANALYSIS

The questionnaire was designed addressing all the themes identified from literature study and code and standard review. Interviews were recorder and transformed into word for word transcript and was then analyzed by thematic analysis. The thematic analysis is a type of analysis used to identify patterns and themes within qualitative data (Maguire & Delahunt, 2017). The priory codes for this interview and its analysis were based on outcomes/ results of document analysis (code and standard review and literature study). Aim behind this interview and the thematic analysis is to know the sufficiency of Indian standards in the opinion of experts, and to understand how learning from other country can be incorporated to improve codes in India.

9.3 RESULT AND DISCUSSION

In the opinion of BIS (Interviewee number 1), the National Building Code, 2016 address the issue of flammable façades and cladding. As NBC, part 4 gives the fire resistance rating requirement for external wall, and cladding or façade forms a part of external wall. However, the review of NBC, 2016 carried out and other two interviewees does not seem to completely agree with the opinion of BIS. The issue has been touched by mentioning the material to be used on façade or cladding. The code also poses other requirements (administrative) implicitly and a generalized requirement for external wall, but it is of concern that with these incidents happening all around the world more elaborate explanation and requirements should be given. The aspects of cladding and façade need to be included exclusively with better clarity. New standard is being processed regarding material properties for ACP. While the other installation/ design solutions and other regulatory recommendations still needs to be incorporated. Other aspects of the issues were also discussed in the interview which is reflected in the suggestive guidelines. Refer *Section 10.1*.

X. SUGGESTIVE GUIDELINES

These guidelines can be helpful to the relevant authorities in the country as it has been drafted taking references and suggestions from sufficient width of research. The guidelines have been drafted on the basis of opinion, comment and suggestion of experts from Bureau of Indian Standards (National body that frames building codes and standards), fire committee NBC (National Building Code of India), fire safety service consultant, academic experts involved in similar research in the form of semi-structured interview. The guidelines

also incorporate learning taken from review of codes of other countries. Furthermore, the guidelines mainly focus on points which can be summarized as-

1. What materials should be allowed,
2. Façade details to prevent vertical spread of fire,
3. What can be done to existing building with flammable cladding and façade, and
4. How these measures can be implemented through other regulatory obligations.

10.1 GUIDELINES

Material

1. Metal Composite Panels with Polyethylene core or any similar material which are combustible should not be used on building facades.
2. Any material, which becomes part of façade, should have fire resistance rating equal to or more than that of the external wall.

   For example, if any building requires (according to its type of construction) its external wall to have a fire resistance rating of 240 minutes, the cladding material and the whole façade system should have a fire resistance rating of more than 240 minutes.

Façade System

3. Metal Composite Panels (such as Aluminium Composite Panel) or any other similar material which can be combustible shall not be used as a continuous cladding on the entire façade of building.
4. A mix of materials shall be used. For example, continuous strips of sufficient width of non-combustible material all around the building can be used to discontinue the combustible material on the external wall.
5. Horizontal projection of sufficient depth shall be provided above openings to throw the fire plume away from the building surface.
6. Balconies and other relevant places shall have sprinklers mounted on external walls to extinguishes the fire started in claddings/ façade.

Façades with cavity

7. Cavity in façade shall be avoided.
8. If cavity is unavoidable, cavity barrier system with proper material and design must be incorporated to stop fire spread through the cavity.
9. Location and material of the barrier and size of the cavity shall be designed in a manner to satisfy the performance requirement of the guideline number 2 in the previous section.
10. The cavity barrier system shall have provision to vent-out accumulated hot gases inside the cavity.

Existing Buildings

11. All the existing high-rise buildings having Aluminium Composite Panels or any other similar material on the façade shall be audited within the timeframe given by the relevant local authority.
12. A holistic third-party audit shall be conducted to all such buildings and report to be submitted to local fire authorities.
13. Based on the assessed fire risks through the audit, the authority should issue relevant order to the owner of the building.

Allocation of responsibility

14. Responsibility of non-combustibility of the material lies with the manufactures. If a material does not perform according to its fire rating the manufacturer is liable to any penalty consequences.
15. Responsibility of specifying the use of certified materials (specification) for façade lies with designer (façade consultant/ façade designer or the architect).
16. Testing and ensuring fire resistance rating of the whole façade system lies with the façade consultant and contractor.

Qualification of consultant or contractor

17. Façade consultant or contractor shall have certification from relevant fire authority to practice design and construction of facades.
18. Requirements to get the certification must be clear, detailed and transparent in terms of technical knowledge and experience in the field.
19. Façade design and specifications given only by these certified consultants shall be approved.
20. Work of construction or installation of façades shall only be awarded to certified contractors.

Test methods

21. For checking the fire performance and approving of any façade system design, full-scale testing shall be preferred over lab testing (small or medium scale) or simulation.
22. All the tests must be performed according to relevant established codes, such British Standards or ISO.

23. Tests or audits shall be performed by third party organizations.

Inspection and penalties

24. Installation of Façade shall have regular inspection with additional third-party inspection at completion of every 20% of the total height of the façade.
25. Any deviation from the approved detail and specification must be mentioned in the third-party report. In such case, the local fire authority should be capable of taking action against, site supervisor, project manager or owner.

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REFERENCES

[1] Board, A. A. B. C. (2019). National construction code, Vols. 1-3. In.
[2] Bowen, G. (2009). Document Analysis as a Qualitative Research Method. *Qualitative Research Journal, 9*, 27-40. doi:10.3316/QRJ0902027
[3] Bradley, D. (2019). Fire-resistant cladding. *Materials Today, 23*, 6-7. doi:https://doi.org/10.1016/j.mattod.2018.12.029
[4] Chen, B. T., Yuen, C. A., Yeoh, H. G., Yang, W., & Chan, N. Q. (2019). Fire Risk Assessment of Combustible Exterior Cladding Using a Collective Numerical Database. *Fire, 2*(1). doi:10.3390/fire2010011
[5] Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (Eighth edition. ed.): Routledge.
[6] Collier, A. (1994). Critical realism: an introduction to Roy Bhaskar's philosophy.
[7] Congress, I. B. (2011). Manual of Fire Safety in Buildings.
[8] Council, I. C. (2018). Combustible Exterior Wall "Cladding" Systems: An ICC Perspective.
[9] Darmon, R. (2012). SUSTAINABLE FIRE SAFETY DESIGN FOR BUILDING FRONTAGES. *Journal of Applied Engineering Sciences, 2(15)*, 19-24.
[10] Defence, D. C. (2018). *UAE Fire and Life safety Code of Practice*.
[11] Gandhi, P., Jagdish, V., Karthikeyan, G., Chakravarthy, A., Nakrani, D., Ghoroi, C., & Srivastava, G. (2017). Performance of glass-ACP façade system in a full-scale real fire test in a G+2 structure. *Procedia Engineering, 210*, 512-519. doi:https://doi.org/10.1016/j.proeng.2017.11.108
[12] Gapes, M. (2018). New legislation enacted in Queensland to combat comustible cladding risks. *REIQ Journal*(Dec 2018), 34. Retrieved from https://ezp.lib.unimelb.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edsibc&AN=edsibc.184136726790119&site=eds-live&scope=site
[13] Giraldo, M. P., Lacasta, A., Avellaneda, J., & Burgos, C. (2013). *Computer-simulation study on fire behaviour in the ventilated cavity of ventilated façade systems.* Paper presented at the MATEC Web of Conferences.
[14] Gonzalo, C., McCann, F., & Paurine, A. (2018). *Improving the fire resistance of ventilated cladding systems via air cavity replacement*.
[15] Group, T. A. (1984). Fire and Building: A Guide for the Design Team. In: Granada Publishing London.
[16] ICC. (2017). *2018 International building code*.
[17] Kavilkar, R., & Patil, S. (2014). Study of High Rise Residential Buildings in Indian Cities (A Case Study-Pune City). *International Journal of Engineering and Technology, 6*(1), 86.
[18] Kinowski, J., Sędłak, B., & Sulik, P. (2016). Falling parts of external walls claddings in case of fire – ITB test method – results comparison. *MATEC Web of Conferences*, 02005. doi:10.1051/matecconf/20164602005
[19] Lalu, O., Anghel, I., Şerban, M., Mocioi, I.-A., & Branisteanu, B. (2017). Experimental researches on determining the fire action response of improved exterior cladding systems provided with incombustible barriers. *Energy Procedia, 112*, 287-295.
[20] Maguire, M., & Delahunt, B. (2017). Doing a Thematic Analysis: A Practical, Step-by-Step Guide for Learning and Teaching Scholars. *AISHE-J: The All Ireland Journal of Teaching & Learning in Higher Education, 9*(3), 3351. Retrieved from https://ezp.lib.unimelb.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edb&AN=126230319&site=eds-live&scope=site
[21] McGuire, J. (1967). The flammability of exterior claddings. *Fire Technology, 3*(2), 137. Retrieved from https://ezp.lib.unimelb.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edo&AN=ejs15125265&site=eds-live&scope=site
[22] McKenna, S. T., Jones, N., Peck, G., Dickens, K., Pawelec, W., Oradei, S., . . . Hull, T. R. (2019). Fire behaviour of modern façade materials – Understanding the Grenfell Tower fire. *Journal of Hazardous Materials, 368*, 115-123. doi:https://doi.org/10.1016/j.jhazmat.2018.12.077
[23] Nguyen, K. T., Weerasinghe, P., Mendis, P., & Ngo, T. (2016). Performance of modern building facade in fire: a comprehensive review. *Electronic Journal of Structural Engineering, 16*(1), 69-87.
[24] Nishio, Y., Yoshioka, H., Noguchi, T., Ando, T., & Tamura, M. (2013). Experimental study on fire propagation over combustible exterior facades in Japan. *MATEC Web of Conferences, 9*, 04001. doi:10.1051/matecconf/20130904001
[25] Oleszkiewicz, I. (1990). Fire exposure to exterior walls and flame spread on combustible cladding. *Fire Technology*(4). Retrieved from https://ezp.lib.unimelb.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edsgao&AN=edsgcl.155150025&site=eds-live&scope=site

[26] Paff, P. (2018). Tactics for Fighting Fires in Tall Buildings Clad with Aluminum Composite Panels. *Fire Engineering, 171*(1), 49-56. Retrieved from https://ezp.lib.unimelb.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=bcr&AN=129881986&site=eds-live&scope=site

[27] Paff, P. (2019). Aluminum Composite Cladding and Fire: Safety Takes a Team Effort*(1)*, 53. Retrieved from https://ezp.lib.unimelb.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edsbl&AN=RN618787805&site=eds-live&scope=site

[28] Peng, L., Ni, Z., & Huang, X. (2013). Review on the Fire Safety of Exterior Wall Claddings in High-rise Buildings in China. *Procedia Engineering, 62*, 663-670. doi:https://doi.org/10.1016/j.proeng.2013.08.112

[29] REGULATIONS, A. O. (2010). Building and buildings England and Wales. In.

[30] STANDARDS, B. O. I. (2016). *National Building Code of India* (Vol. 1).

[31] Stone, W. (2019). High-rises still at risk on fire safety and cladding. *Guardian (Sydney)*(1873), 12. Retrieved from https://ezp.lib.unimelb.edu.au/login?url=https://search.ebscohost.com/login.aspx?direct=true&db=edsaup&AN=edsaup.518971220299973&site=eds-live&scope=site

[32] Taylor, S. J., & Bogdan, R. (1998). *Introduction to qualitative research methods : a guidebook and resource* (3rd ed. ed.): Wiley.

[33] Wang, Y., & Hu, J. (2019). Performance of laminated glazing under fire conditions. *Composite Structures, 223*, 110903. doi:https://doi.org/10.1016/j.compstruct.2019.110903