NEW VISION OF PROVISIONS IN IRAQI CODE OF PRACTICE FOR FIRE PROTECTIONS IN BUILDINGS (646) TO REGULATE THE USE OF ALUMINUM COMPOSITE PANELS (ACPS) IN BUILDING FACADES

Ahmed A. Alfakhry
Architectural Department, College of Engineering,
University of Mosul, 41002, Mosul, Iraq
Email: ahmedabdulwahab1963@gmail.com

ABSTRACT

In the last decade in Iraq, The Aluminum composite panels (ACPs), known locally as Alucobond have been used as a cladding of multi-story building facades instead of the local traditional finishing materials. The use of this material have a role in the fire spreading in the building through the façade material. Moreover, the absence of local fire safety legislations for limitation of this new material. However, the increasing of using the (ACP) is a result of availability in the local market, which led architects to re-think about facades' building in term of quality material and design to reduce the expansion of fire. Therefore, new provisions in the local regulations and code of practice should be developed to regulate the use of these materials in the facades. The aim of current study is to propose new provisions in the Iraqi code of practice of fire protection in buildings (646). In order to define and regulate the use of Aluminum Composite Panels (ACPs) in the design of facades, based on the international building regulations and codes rules of practice, which have been updated due to disastrous building fires caused by the (ACPs).

Key words: aluminum composite panel, fire safety, building regulation

INTRODUCTION

When there is a fire case in a building, the facade can be one of the quickest spreading pathways. Moreover, the fire could move to the nearby structures. Therefore, the using of Aluminum Composite Panels (ACP-PE) in the façade can increase the speed of spreading. In this case, this material is a support factor to spread of fire faster. The radiation heat flux can be very intense due to the risk for material and human losses; the use of combustible materials in exterior wall has been restricted by buildings codes in most countries.

SPREAD OF FIRE THROUGH THE FACADES

The facades materials is one of the factors that increase the spreading of fire over the building. However, three situations can lead to spread the fire through the facades:

1) Fire start from the outside through hot coals, either by a fire in a nearby building or flames of wooded area.
2) Fire start because of an element that burns in the front of the facade (garbage container, furniture, etc.).
3) Fire originated in a compartment of the building, which spreads outwards through the windows.

The facade is the linking point between the inside and outside. Therefore, it is a rich area that facilitate the dynamics of fire. These factors are the unlimited amount of oxygen; the verticality of the surface; the pressure difference between inside and outside; the wind, etc. For this reason, the vertical spread of fire occurs even when the cladding materials of the facade are non-combustible. In the case of the facades with combustible materials cladding, the risk increases (Giraldo, Avellaneda, Lacosta, & Rodri, 2012). In the fair case, the heat flux intensity and speed of fire spread may be in high value, which the fire spreads not only vertically, as normally occurs, but may also spread horizontally due to the flammability of the cladding (Oleszkiewicz, 1990).

Two options of passive fire protection could be considered to limit the spreading of fire through combustible cladding facades, which are:

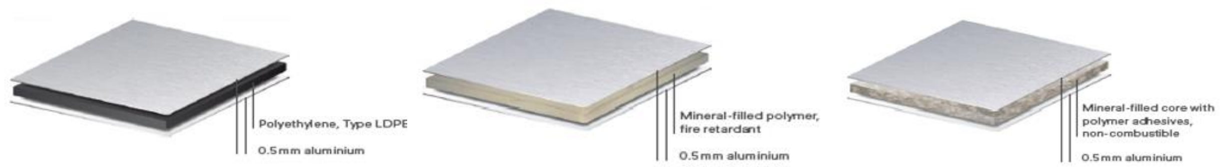
1) Flame retardant treatments to improve the reaction of fire performance of the cladding material.
2) Through the design and geometry of the façade by using construction elements capable to avoid the contact between the fire plume and the combustible cladding. Providing deflector elements to change the trajectory of the flames and prevent its passage into other compartments (Giraldo, Avellaneda, Lacosta, & Rodri, 2012).

However, the first option is the focuses of the current study, which will concerned in the objective and analysis of the study.

ALUMINUM COMPOSITE PANELS

External wall systems are assemblies of building products, which often provided by multiple manufacturers. Nowadays, these materials are the essential elements that form the facades of majority commercial and residential buildings. One of these materials is widely used in external wall systems as a cladding assemblies made of metal composite materials (MCMs) or more commonly aluminum composite panels (ACPs). The (ACP/MCM) assemblies can installed on new and existing building facades to improve the energy efficiency, weather ability (air /moisture), and aesthetics. Although, ACP assemblies are also used in internal wall and building roofing systems. The primary application is in the external wall systems (Agarwal, 2017). To examine the fire hazards related to ACP assemblies, it is essential to understand the components and usual installation practices. As shown in figure (1), ACP panels are essentially composite panels, which consist of a core material sandwiched between two thin layers of Aluminum (or other metal) sheets. While, the thickness of the Aluminum is usually on the order of (0.5 mm). The total thickness of the panel is generally (3 to 6 mm). Aluminum facers are covered with durable and weather – resistant coatings (Guillaume, Fateh, Schillinger, & Chiv, 2018).

Figure 1: Aluminum composite panels types (Giraldo, Avellaneda, Lacosta, & Rodri, 2012)



The core material of the ACM panel usually defines its combustibility. Three types of ACM cladding; ACM with polyethylene dominated core referred to "ACM-PE" (100% combustible); fire retardant ACM cladding with a better fire performance referred to as "ACM-FR" (70% non combustible mineral fill added to the combustible thermoplastic core); and ACM cladding with a mineral core filling of limited combustibility referred to as " ACM-A2" (90% mineral fill added to the combustible core) (Agarwal, 2017, p. 3) (Guillaume, Fateh, Schillinger, & Chiv, 2018, p. 2). A2 is the second class of the EUROCLASS classification of the materials combustibility.

The cladding are installed using joint system, such as, brackets, channels, or other attachment system to the substrate, thereby creating an air cavity directly behind the cladding the air cavity allows the rainwater to drain down the building. The upward airflow within the cavity during hot weather facilitates removal of any remnant moisture, thereby keeping the façade ventilated. The air cavity thickness behind the cladding is typically (25 to 100 mm). In a fire case, both external flame spread on the cladding and internal cavity fire spread can cause vertical flame propagation on a building façade (Agarwal, 2017, pp. 2-3). Unfortunately, there is no exact fire incidents statistics for building used the ACPs cladding in Iraq, but there have been several significant fires over the last decade involving the use of combustible ACPs cladding all over the world which have been involved in massive fatalities and property losses (See table 1.).

Table 1. Recent facades fire events involving ACPs claddings (Guillaume, Fateh, Schillinger, & Chiv, 2018, p. 2).

Date	Place	Circumstances and Consequences
1/10/2010	Wooshin Golden Suites, Busan, South Korea	No fatalities, 5 injured. Fire from apartment, propagated by the façade.
14/5/2012	Roubaix, France	Dwelling building fire, 1 fatality, 20 apartments (over 94) destroyed. Initiated from apartment fire, propagated through decorative ACM panels on balconies
17/7/2012	Polat Tower, Istanbul, Turkey	Fire caused by a faulty air conditioning unit, no fatalities.
18/11/2012	Tamweel (Al Seef) Tower, Dubai, UAE	No fatalities. The building was made uninhabitable by the fire and is expected to be reconstructed
3/4/2013	Hotel and Business Center, Grozny, Chechnya	Fire completely destroyed the plastic trimming used on the building's exterior, but the interior remained untouched.
25/11/2014	Lacrosse Tower, Melbourne, Australia	No fatalities or serious injuries. Levels 6 to 21 were affected by fire, and many more were affected by water damage.
21/2/2015	Marina Torch Tower, Dubai, UAE	7 injuries. The fire started in the middle of the building and spread rapidly due to falling flaming debris and high winds. External cladding was charred from the 50th floor (over 82) to the top of the tower
19/5/2015	Dwelling building, Baku, Azerbaijan	16 fatalities, 63 injuries. Fire propagated on façade after a renovation.
1/10/2015	Nasser Tower, Sharjah, UAE	19 injuries. Fire started on the third storey and moved up through the façade.
31/12/2015	Hotel The Address, Dubai, UAE	No fatalities. Fire started outside the 20th floor of the hotel but did not spread inside.
14/06/2017	Grenfell tower, London	71 fatalities. Initiated from an apartment fire, rapid propagation to the façade and penetration from the outside to the other storeys
4/8/2017	Marina Torch Tower, Dubai, UAE	Second fire on the same tower. No fatalities. Debris from the fire falling to the ground and starting a second fire in the streets below.
22/12/2017	Dwelling building, Jecheon, South Korea	29 fatalities. Initiated from a car fire in underground car park, then propagated to the cladding

ARCHITECTS AND FIRE SAFETY CODES

Architects make numerous design decisions, which considered various functional and aesthetic features needs to satisfy reach the clients' needs and stakeholders, as well as compliance with building codes and regulations. Fire safety is a necessary need, although it sometimes has a lower priority than other design objectives due to its intrinsic nature and the low level of risk perceived from fire. Fire safety features do not generate any explicit benefits such as comfort, convenience, or aesthetic pleasure, it only useful for a fire incident. Considering the widely perception that architects place more importance on artistic and aesthetic expression in building design (i.e., form over function), a lack of focus on fire safety may not be an exaggerated concern (Isaac S, 2013). However, a proper level of fire safety should be provided to all buildings regardless of the design priority of architects. Therefore, fire protection measures have been enforced in the form of regulations, commonly via building codes and standards, in which various requirements are listed. Although the design concept may originate from visual sense or aesthetics of buildings attributes, which are not subject to the building codes (Rounce G. Quality, 1998). The architects' design decisions may need to be changed to satisfy the codes. This may be one of the reasons that some architects perceive code requirements as design constraints (Cornick, 1991) (Happold, 1986).

THE IRAQI CODE OF PRACTICE 646

The Iraqi code of practice of the fire protection in buildings No. 646 issued in 1996 by the central organisation for standardization and quality control, ministry of planning consists of five chapters:

The first Chapter includes the classification of fires and the risk categories of buildings. While, Chapter two explains the basic considerations in planning and design of buildings and providing save and easy access to the fire fighters and their equipment to the site, and the escape route design and their requirements within buildings. Chapter three deals with the characteristics, uses, and behavior of the building materials when exposed to fires, such as, steel, aluminum, cement, brick, stone, etc. While, chapter four includes the minimum requirements that must be met in structural building elements to resist the effect of fire. In order to ensure construct buildings, which have full safety components to their occupants (building structural elements means structural floors, internal and external walls, doors, windows, etc.). Lastly, chapter five includes fire alarm and detection systems, fire suppression systems (dry and wet pipe systems, external fire hydrants, automatic sprinkler systems) (Central Organization For Standardization And Quality Control (C.O.S.Q.C.), 1996).

Chapters three and four does not contain the new building materials and their characteristics, because this code was issued at a time when these materials were not available in the local markets. Despite the fact that the governmental regulatory control represented by the General Directorate Of Civil Defense has given clear and stringent instructions to prevent the use of Aluminum Composite Panels and Sandwich Panels in building facades because they are combustible materials (Hasan, 2019). Periodic studies should be done on building materials that available in local market and it durability, performance, fire safety characteristics. In Order to conducting or adapting, the reliable fire tests according to international codes. Moreover, update should be done to the currently provisions of this code either by introducing new paragraphs within its chapters concerning these new building materials. In addition, updating the information it contains as needed, similar to what have been done with other international building regulations and codes.

OBJECTIVE

The objective of the current study is to develop a proposal contains description, types, and provisions of using ACP panels in terms of performance and ability to spread fire in building facades. Moreover, to include them in the Iraqi code of practice for Fire Protection in Buildings No. 646 based on rules of international building regulations and codes of practice, which have been updated due to disastrous building fires using the cladding material recently. In order to draw out a guidelines adopted by local architects of using these panels in designing process of building facades.

BUILDING REGULATION REQUIREMENTS CONCERNING FACADES CLADDINGS:

Range of regulations and building codes around the world have been reviewed by the researcher. Some prescriptive requirements relating to combustible wall assemblies and materials have been focused and identified:

U.A.E.: The U.A.E. fire and life safety code of practice determined in chapter one named (CONSTRUCTION) in clause 4.6. , the core specifications of the (metal composite materials and panels MCM, ACP) are illustrated in two provisions under the specific requirements:

- *4.6.3.3. MCM / APCs core shall not be of foam plastic insulation or LDPE (low-density polyethylene) or any such expanded plastic having density less than 320 kg/m^3.*
- *4.6.3.4. MCM / ACP core shall be tested and evaluated separately. core (exposed without skin) used in cladding and façade panels can be of plastic or mineral or combination of such material having flame and smoke spread*

characteristics as per test one in accordance with table 2 and table 3 test requirements (UAE Fire & Life Safety Code of Practice, 2019).

Table 2. MCM and ACP on Non-fire Resistance rated and Non-load Bearing Exterior Wall Coverings-Test Requirements (UAE Fire & Life Safety Code of Practice, 2019).

OCCUPANCY AND TYPE OF BUILDING	TEST 1 MCM/ACP CORE AND PANEL ASPRODUCT	TEST 2 MCM/ACP PANELS AS WALL ASSEMBLY
1. SUPER HIGH-RISE BUILDING 2. HIGH-RISE BUILDING 3.MALLS 4. THEME PARKS 5. SCHOOLS 6. HOSPITALS 7. ASSEMBLY	i. Core shall be mineral core, OR non-combustible core, tested with the thickness intended to the following criteria. AND ii. EN 13501-1 Core, metal skin and adhesives shall be tested With pass criteria A1 OR A2-s1-d0 AND iii. ASTM D1929 With pass criteria, MCM/ACP shall have self-ignition temperature of not less than 3430C	iv. BS 8414 –1 Or 2 With pass criteria as per BRE 135 OR v. NFPA 285 With pass criteria “Pass” OR vi. FM 4881 With pass criteria “Pass” OR vii.ISO 13785-2 With pass criteria “Pass”
8. LOWRISE BUILDING 9. MIDRISE BUILDING 10.WAREHOUSE 11. INDUSTRIAL	i. Core shall be mineral core, OR non-combustible core, tested with the thickness intended to the following criteria. AND ii. EN 13501-1 Core, metal skin and adhesives shall be tested With pass criteria B-s1-d0 AND iii. ASTM D1929 With pass criteria, MCM/ACP shall have self-ignition temperature of not less than 3430C.	iv. BS 8414 –1 Or 2 With pass criteria as per BRE 135 OR v. NFPA 285 With pass criteria “Pass” OR vi. ” FM 4881 With pass criteria “Pass” OR vii. ISO 13785-2 With pass criteria “Pass”

Table 3. MCM and ACP on Fire Resistance Rated Exterior Wall Coverings-Test Requirements (UAE Fire & Life Safety Code of Practice, 2019).

OCCUPANCY AND TYPE OF BUILDING	TEST 1 MCM/ ACP CORE AND PANEL AS PRODUCT	TEST 2 MCM/ ACP PANELS IN WALL ASSEMBLY
1. ANY BUILDING WITH ANY HEIGHT AND ANY OCCUPANCY HAVING REQUIREMENT OF FIRE RESISTANCE RATED EXTERIOR WALL CONSTRUCTION, WHERE REQUIRED BY OTHER SECTIONS OF THIS CHAPTER.	i. Core shall be mineral core, OR non-combustible core, tested with the thickness intended to the following criteria. AND ii. EN 13501-1 Core, metal skin and adhesives shall be tested With pass criteria A1 OR A2-s1-d0 AND iii. ASTM D1929 With pass criteria, MCM/ACP shall have self-ignition temperature of not less than 3430C	iv. ASTM E 119 With pass criteria “1 Hr or 2 Hr OR 3 Hr as per required fire rating of the wall. OR v. UL 263 With pass criteria “1 Hr or 2 Hr OR 3 Hr as per required fire rating of the wall. OR vi. EN 1362-3 With pass criteria “1 Hr or 2 Hr OR 3 Hr as per required fire rating of the wall. OR vii. EN 1362-4 With pass criteria “1 Hr or 2 Hr OR 3 Hr as per required fire rating of the wall.

England: The building regulations establish requirements for specific aspects of building design and construction. The approved documents then provide guidance for satisfying those requirements in common building situations.

The potential for fire in a multi-story buildings to break out through the façade and then to rapidly spread across external cladding is addressed in Approved Document B. this states that "*The external envelope of a building should not provide a medium for fire spread if it likely to be a risk to health and safety. The use of combustible materials in the cladding system and extensive cavities may present such a risk in tall buildings*". Limited combustibility can be demonstrated in two ways:

Complying with the criteria set out in the approved document B, paragraph 12.6. To 12.9. Ensuring the cladding system as a whole (rather than individual components) meets the criteria set out in BS 8414 Fire performance of external cladding systems , and satisfying the performance requirements set out in BR 135 Fire performance of external thermal insulation for walls of multi-story buildings (ACM cladding, 2018).

Sweden: the Swedish building regulations (BBR) requirements is found for external walls and facades, regarding exterior walls, BBR specifies *"Facade linings must only develop heat and smoke to limited extent in case of fire"* which means that it must provide satisfactory time for evacuation and fire fighting (Anderson, Boström, & McNamee, 2017, p. 11).

Australia: The Australian Building Codes Board primarily considers the class of external cladding products that contain some combustible material. Under the National Construction Code (NCC) Volume One,2016, Section C , Fire resistance, Performance Requirement CP2 requires that a building must have elements which will avoid the spread of fire in a building, in a manner appropriate for that building. This requirement is met, in part, under a Deemed-to-Satisfy Solution for buildings of Type A and Type B construction by non-combustible external walls (Specification C1.1 Clauses 3.1(b) and 4.1(b)). A non-combustible external wall inhibits fire-spread via the external face of the building, thereby contributing to compliance with Performance Requirement CP2. An external cladding product that does not comply with these requirements can only be used where it can be demonstrated through a Performance Solution that the relevant NCC Performance Requirements can be met ((ABCB), 2016, p. 6). (Type A construction in this code means the most fire resistant and type C is the least fire resistant of the types of constructions)

USA: The International Building Code (IBC) is a model building code developed by the International Code Council (ICC). It has been adopted throughout most of the United States. NFPA 5000 is an alternative building code to the IBC but it is not adopted by most states. Some detailed differences in the requirements of exterior walls between these two codes; however, they are similar in terms of the types of testing that are required.

The IBC requires compliance with the full-scale test NFPA 285 for buildings greater than 12.192 m in height. However there are number of specific exceptions to permit different types of materials without full-scale tests based on small scale tests, mainly the ASTM E84 or UL 723 flame spread test and the ASTM D 1929 ignition temperature test. NFPA 5000 generally requires compliance with the full-scale test NFPA 285, regardless of height. However, there are specific exceptions to permit different types of materials without full-scale tests based on the same small scale tests as the IBC (for example metal composite panels installed to a maximum height of 15 m). The exceptions permitting small scale testing rather than full-scale testing in the IBC and NFPA 5000 are complex to read and understand which could possibly lead to miss-interpretation and poor compliance (White & Delichatsios, 2014, p. 41).

Buildings in (IBC) are classified into 5 different types of construction having a decreasing level of fire resistance in the following order; Type I, Type II, Type III, Type IV and Type V (See table 3.). Building classes having lower levels of fire resistance are limited to low building heights. Type V construction has the lowest fire resistance and is typically timber framed construction (White & Delichatsios, 2014, p. 108).

Table 3. Specify ICC reaction to fire requirements for MCM wall panels, summery ICC reaction to fire requirements for MCM wall panels (White & Delichatsios, 2014, p. 110).

Type I, Type II, Type III and Type IV Buildings	
Height	Requirement
Installed to a maximum height of 12.19 m (40 ft)	• Flame spread index of ≤ 75 and a smoke developed index of ≤ 450 (ASTM E 84 or UL 723) • Cover < 10% or exterior wall area where the horizontal separation from the boundary is ≤ 1525 mm, or • No Limit on area where. horizontal separation from the boundary is > 1525 mm
Installed to a maximum height of 15.24 m (50 ft)	• Continuous areas of panels must not exceed 27.8 m2 and must be separated from other continuous areas of panels by at least 1220 mm; and • Have a self ignition temperature ≥ 343 °C (tested to ASTM D 1929 standard test method for determining ignition temperature of plastics); and; • Flame spread index of ≤ 75 and a smoke developed index of ≤ 450 (ASTM E 84 or UL 723)
Installed to a maximum height of 22.86 m (75 ft) or	Option 1 • Not permitted for building classes A-1, A-2, H, I-2, I-3 • Not permitted on exterior walls required to have a fire resistance rating (by other provisions of code) • Flame spread index of ≤ 75 and a smoke developed index of ≤ 450 (ASTM E 84 or UL 723) • Have a self-ignition temperature ≥ 343 °C (tested to ASTM D 1929)

unlimited height if building is sprinkler protected	• Be either CC1 (burn length ≤ 25 mm and self-extinguishment) or CC2 (burning rate of ≤ 1.06 mm/min) when tested to ASTM D 635 • Than maximum area of exterior wall covered by MCM panels must be limited as stated in Table B -10 or the maximum area of unprotected openings permitted (whichever is less). The maximum area of single MCM panels and minimum separation distance between panels must be limited as stated in Table B -10 • For sprinkler protected buildings the maximum area of exterior wall covered and maximum area of single panels may be increased by 100%. However maximum area of exterior wall covered must not exceed 50% of the area of unprotected openings permitted (whichever is less)
	Option 2 • MCM must not be installed on any wall where separation distance <9.144 m or, Separation distance < 6.096 m for sprinkler protected building • Flame spread index of ≤ 75 and a smoke developed index of ≤ 450 (ASTM E 84 or UL 723) • Have a self ignition temperature ≥ 343 °C (tested to ASTM D 1929) • Be either CC1 (burn length ≤ 25 mm and self extinguishment) or CC2 (burning rate of ≤ 1.06 mm/min) when tested to ASTM D 635 • The area of exterior wall covered shall be ≤ 25%. The area of a single MCM panel 1 story or more above grade shall not exceed 1.5 m2 and the vertical dimension of a single MCM panel shall not exceed 1.219 m. • Vertical separation between panels shall be provided by flame barriers which extend 762 mm beyond the exterior wall or a vertical separation distance of 1.219 m. • If the building is sprinkler protected then the area of exterior wall covered shall be ≤ 50% and there is no limit to single panel size and no requirement for vertical separation of panels.
Any height	• Compliance with NFPA 285 full scale façade test, And; • Flame spread index of ≤ 25 and a smoke developed index of ≤450 (ASTM E 84 or UL 723). • Separated from building interior by approved thermal barrier 12.7 mm Gypsum wall board or equivalent. Thermal barrier not required if MCM system tested and approved to either UL 10 40 or UL 1715
Type V Building	
Requirement for any height	Flame spread index of ≤ 75 and a smoke developed index of ≤ 450 (ASTM E 84 or UL 723)

CHANGING BUILDING REGULATIONS PROVISIONS TO ADDRESS FIRE HAZARD DUE TO ACPS CLADDING USE

Building and safety regulations are reviewed critically and in some cases have been changed to address the fire and safety hazard, as following:

- The United Arab Emirates including Dubai has changed regulations due to recent fires, which terminated the use of combustible ACPs in the facades. Nowadays, the requirement for the fire codes are a full scale façade test, in addition to small scale tests that were previously required for buildings (at least 15m high or less than 3m) for the high rise building property line.
- Saudi Arabia has recently started requiring the retrofitting of any high-rise buildings, which have combustible exterior sandwich panels, including ACP.
- Within two weeks of the Grenfell Tower Fire, the U.K. required all registered owners to identify all buildings with ACPs more than 18m high. The ACPs must be tested before to ensure that it has limited combustibility and /or be at least Euro class A2 rated panels. ACPs with combustible insulation are no longer accepted for new construction and building regulations are in the process of being improved (Allianz Global Corporate & Specialty, 2017, p. 4).
- Australia no longer accepts ACPs with combustible insulation in construction as a result of a residential high rise building fire in 2015 (Allianz Global Corporate & Specialty, 2017, p. 4). In the same context, in March 2018 the New South Wales Government flagged the potential introduction of a building product use ban for the use of aluminum composite panels (ACPs) under the Building Products (Safety) Act 2017 (the Act). The Ban prohibits the use of ACPs with a core comprised of greater than 30 percent polyethylene (PE) by mass in any external cladding, external wall, external insulation, façade or rendered finish in buildings of Type A and B Construction as defined in the Building Code of Australia (NHS, 2018).
- Combustible ACPs have been banned as exterior cladding for several years in building constructed over 10m high in some countries, including the USA. However, the panels are in common use in low-rise public, commercial and industrial buildings, such as, gas stations and bank branch offices. The suitability is also being studied for installations on sport stadiums, hospitals, and buildings occupied by persons with limited mobility.
- In Germany, combustible ACPs have been classified as "flammable" for several years. Germany has had some of the strictest building regulations in the world for decades and it does not have a significant loss history involving ACPs (Allianz Global Corporate & Specialty, 2017, p. 4).

It is critical that the fire hazards presented by combustible ACPs continue to be recognized and addressed.

Four main points Concluded from above review, which are:

(1) All building regulations and code of practices concentrate on a fact that cladding to building facades must be non-combustible materials or being a medium for fire spread from one story to another.
(2) All building regulations specify or adopt a classification of materials combustibility act as a reference when they are setting the related provisions.
(3) Most countries that suffered from tragic fires due to the use of aluminum composite panels as a cladding in building facades, banned the combustible type ACP-PE at least in buildings with more than 15 m height.
(4) In general, most of the building regulation requirements, which addressed the external facades claddings, are too complex and scientific. It should be straight to the point. Also, should contains basics and minimum requirements so that everyone from the designer to the builder and the end user can understand them and implement them easily.

THE PROPOSED PROVISIONS

Before setting the proposed provisions of the ACPs, It is necessary to add the (cladding) definition and (combustibility classes) of building materials, which are not exist in the recent Iraqi code and to be a reference to all building material cladding in future.

Cladding: *The term cladding refers to components that are attached to the primary structure of a building to form non-structural external surfaces. This is as opposed to buildings in which the external surfaces are formed by structural elements, such as masonry walls*. The combustibility classes were adopted from the known EUROCLASS EN13501-1 combustibility for construction products (InnoFireWood)(which has been set to facilitate the trade of building products between the member countries of the EU by removing trade barriers due to differences in test methods and classification system), because:

(1) This classification was based on four test methods other than floorings:
- The non-combustibility test EN ISO 1182
- The gross calorific potential test EN ISO 1716
- The single burning item (SBI) test EN 13823
- The ignitability test EN ISO 11925-2

(2) This classification were adopted from many European union countries and many construction products manufacturers, the new Chinese GB-8624-2006 was also based on it(Peng, Ni, & Hung, 2013), that makes this classification more confident.
This classification consist of seven classes on the base of their reaction to fire properties, which means that it cover a large spectrum of construction products, and more detailed among other combustibility classification. Table (4) shows the proposed materials combustibility classification.

Table 4. The proposed materials combustibility classification, adopted from EUROCLASS EN 13501-1

	class	*Performance description*	*Examples of products*
1	*A1*	*No contribution to fire*	*Products of natural stone, concrete, bricks, ceramic, glass, steel, and many metallic products.*
2	*A2*	*No contribution to fire*	*Products similar to those of class A1, including small amounts of organic compounds.*
3	*B*	*Very limited contribution to fire*	*Gypsum boards with different (thin) surface linings. Fire retardant wood products.*
4	*C*	*limited contribution to fire*	*Phenolic foam, gypsum boards with different surface linings (thicker than in class B)*
5	*D*	*Acceptable contribution to fire*	*Wood products with thickness ≥ 10 mm and density ≥about 400 kg/m^3 (depending on end use)*
6	*E*	*Acceptable contribution to fire*	*Low density fiberboard, plastic based insulation products.*
7	*F*	*No performance requirements*	*Products not tested (no requirements)*

The current study divided the proposal into four parts: description of the ACP panels, the known types, the uses of such cladding materials in external and internal walls, and finally the proposed provisions, exactly similar to the description of other building materials in chapter three of the Iraqi code of practice (646).

Description: *Aluminum Composite Panels (ACP) is a type of flat panel that consist of two thin aluminum sheets bonded to non-aluminum core, typically between 3 and 6mm thick. The panels can have a painted or metallic finish (e.g. copper or zinc effect) it can be differentiated from solid aluminum sheet by looking at a cut edge whereby the lamination is visible .*

Type: *There are three types of (ACPs) cladding according to their core material as shown in table (5):*
Table 5. The three types of (ACPs)

	Name	Core material
1	ACP-PE	Polyethylene (100% combustible)
2	ACP-FR	Fire retardant (70% non combustible mineral fill added to the combustible thermoplastic core)
3	ACP-A2	(90% mineral fill added to the combustible core)

Uses: *The (ACPs) assemblies can be installed on new and existing building facades to improve their energy efficiency, weatherbility (air/ moisture) and aesthetics, also can be used in internal wall systems and building roofing.*

Provisions

1) *ACP-PE and ACP-FR Aluminum Composite Panels can be both used for cladding all types of building facades up to height (15m) above the street level (or the level reached by firefighting equipment when using their full length ladders).*
2) *If the building height exceeds (15m) above the street level, only ACP-A2 type allowed.*
3) *If the building height is above (15m), ACP-PE panels are not allowed to use under the (15m) height, then using ACP-A2 panels type over (15m) height, i.e. mixing between two types cannot be allowed.*
4) *Bad quality ACP panels are not allowed to be used for cladding , i.e. their core are made of recycled plastic materials and must be of genuine origins and satisfy the known international fire safety tests and specifications (like NFPA 285).*

Note: Do not list all national test standards within this scope of provisions, because they are not directly comparable to each other

5) *The use of horizontal projections from non-combustible material over windows in building using ACP panels for cladding with at least 75cm width can reduce the vertically spread of fire through building facades. Furthermore, the use of vertical louvers from non-combustible material on both sides of the windows (for thermal requirements) can channel the fire facilitating its spread.*
6) *If the emergency stairway forms part of the external wall or projects beyond it, only the ACP-A2 panels should be used as cladding, whatever the building height is. Either the external wall of the emergency stairway or the wall connected to it should be imperforated (i.e. no openings) within not less than (3m) from any side to keep the emergency stairway fully protected.*
7) *Do not install external lighting or LEDs on the combustible cladding APC-PE or passing the electrical cabling through the cavity between the ACPs and the structural wall.*

.

CONCLUSIONS AND RECOMMENDATIONS

1) Architects sometimes did not care about investigating of fire material properties; therefore, there is lake of choosing the suitable building finishing materials. Architects care more about functional and aesthetic features as well as compliance with local building codes and regulations.
2) Local building codes does not reviewed periodically to consistent with the high acceleration of building materials in the local markets. Especially the tests, the characteristics concerning fire and life safety and legislate the suitable provisions that regulate their use, i.e. There is an urgent need to update the building regulation and the local code of practice in form of publishing short term and long term changes to address the rapid changes in the construction products market.
3) Some of the building materials suppliers imports cheap and bad quality commodities and drowned the local market with large quantities because of lack of governmental commercial and quality control which result to the well known economical fact that "bad money drives out good" (Gresham law). The governmental authorities should announce a list with the most reliable fire testing bodies and enforce suppliers importing construction products with high standards and to ensure not to incentivize them to choose the most lenient testing bodies.
4) These proposed provisions concerning the use of ACPs should apply not only to new buildings but also to existing buildings over 15 m height as well as those currently under construction, in both public and private sectors especially buildings where there is a particular and significant risk to life such as residential buildings, hospitals, student accommodations and hotels. People need to have certainty that their premises are safe.

ACKNOWLEDGMENTS
The researcher would like to acknowledge the University of Mosul, Engineering College, architectural department for the supporting to register of the current paper under the research plan in 2019.

REFERECES

(ABCB), T. A. (2016). *Non Compliant Use of External Cladding Products on Buildings.* Australia: Regulation Impact Statement for Consultation.

ACM cladding. (2018, Dec 7). *Designing Buildings Wiki*. (ACM cladding) Retrieved Jan 20, 2019, from https://www.designingbuildings.co.uk/wiki/ACM_cladding

Agarwal, G. (2017). *Evalution of the Fire Performance of Aluminum Composite Material (ACM) Assemblies Using ANSI/ FM 4880*. MA. USA: FM Global.

Allianz Global Corporate & Specialty. (2017). Aluminum Composite Panels. *Allianz Risk Consulting,Tech Talk, 20*, 3-32.

Anderson, J., Boström, L., & McNamee, R. J. (2017). *Fire Safety of Facades.* Brandforsk: RISE Research Institutes of Sweden.

Central Organization For Standardization And Quality Control (C.O.S.Q.C.). (1996). *Code Of Practice For Fire Protection In Buildings No. 646*. Baghdad, Iraq: Ministry Of Planning.

Cornick, T. (1991). Quality management for building design. *Butterworth Architecture*.

Giraldo, M. p., Avellaneda, j., Lacosta, A. M., & Rodri, I. (2012). Computer – Simulation Research On Building- Facades Geometry For Fire Spread Control In Buildings With Wood Claddings. *World conference on timber engineering Auckland* (pp. 11-18). Auckland: WCTE2012.

GmbH, C. (n.d.). *3A Composites*. (ALUCOBOND ALUCORE) Retrieved 12 22, 2018, from http://cms.alucobond.com/storage/uploads/2019/01/21/5c458260b7a9aALUCORE_TI_ProdInfo_GB_01-2019.pdf

Guillaume, E., Fateh, T., Schillinger, R., & Chiv, A. (2018). Study Of Fire Behavior Of Façade Mock-up Equipped With Aluminum Composite Material-based Claddings , Using intermediate –scale Test Method. *Fire And Materials, 1*(17), 1-17.

Happold, E. (1986). The role of the professional: an engineer's perspective. *Design Studies, 7*(3), 133-138.

Hasan, Z. A. (2019, January 14). Directorate of Nineveh Civil Defense , Fire Fighting and Safety Department , Mosul.

InnoFireWood. (n.d.). *EUROCLASS System.* Retrieved Dec 15, 2018, from http://virtual.vtt.fi/virtual/innofirewood/stateoftheart/database/euroclass/euroclass.html

Isaac S, N. R. (2013). A graph-based model for the identification of the impact of design changes. *Automation in Construction, 31*(0), 31-40.

NHS. (2018, Aug 15). *BAN ON USE OF COMBUSTIBLE ACPS STARTS*. (NHS) Retrieved Jan 2, 2019, from https://nhs.trade/ban-on-use-of-combustible-acps-starts-15-08-18/

Oleszkiewicz, I. (1990). Fire exposure to Exterior Wall and Flame on Combustible Cladding. *Fire Technology, 25*(4), 7-27.

Peng, L., Ni, Z., & Hung, X. (2013). Review On The Fire Safety Of Exterior Wall Claddings In High-Rise Buildings In China. *The 9th Asia-Oceania Symposium On Technology. 62*, pp. 663 -670. Procedia Engineering.

Rounce G. Quality. (1998). waste and cost considerations in architectural building design management. *International Journal of Project Management, 16*(2), 123-127.

UAE Fire & Life Safety Code of Practice. (2019). *UAE Fire & Life Safety Code of Practice _2017_Final.* Retrieved Jan 13, 2019, from https://www.scribd.com/document/362660557/UAE-Fire-Life-Safety-Code-of-Practice-2017-Final

White, N., & Delichatsios, M. (2014). *Fire Hazards of Exterior Wall Assemblies Containing Combustible Components, Final Report.* Massachusetts, USA: The Fire protection Research Foundation.