أكاديمية الشارقة للبحوث
Sharjah Research Academy

CONFERENCE
OMAINTEC
2016
EXHIBITION

Maintenance, Sustainability & Fire Performance of Cladding: An Overview

Prof. Mufid Al-Samarai

Outline

- Sharjah Research Academy
- Introduction to Cladding
- Cladding Types and Systems
- Fire Performance of Cladding and Thermal Insulation Products
- Fire and Life Safety Code and Testing
- Sustainability and Life-Cycle of Different Cladding systems
- Maintenance, Repair and Retrofitting
- A Case Study
- GFRC is it one of the Solutions
- References
- Observation

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Cooperating Universities and Institutes

Sharjah Seed Bank and Herbarium	The Royal Botanical Gardens Kew - UK
Sharjah Desert Development Institute	Desert Research Institute in Nevada - USA
	University of Arizona Tucson-USA
Sharjah Engineering Research Institute	OMAINTEC Institute
	URUK
	Carlton University - Canada
	University of Toronto - Canada
Sharjah Institute of Environmental Research	Fraunhofer Gesellschaft Munich-Germany
	Colombus University - USA
	University of Ottawa- Canada
Sharjah Institute of Renewable Energy	University of Toronto - Canada
	Fraunhofer Gesellschaft Munich-Germany
	Cape town University – South Africa
Sharjah Institute for Arabian Ornithology	
	University of Queensland - Australia
Sharjah Institute for Marine Studies	
	York University Toronto - Canada
Sharjah Institute for Social Research	

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Sharjah Engineering Research Institute

- Studies on sustainable design practices in construction and maintenance
- Reviews and conducts assessments and evaluations of existing conditions for infrastructures and set out rehabilitation and maintenance strategies
- Performs risk analysis imposed by seismic activities
- Quality control on specifications for construction, restoration and reconstruction of cultural heritage
- Foundation design and construction, as a part of soil mechanics research
- Carries out traditional materials analysis flowing the international standards on site, site laboratory and central laboratories
- Conducts condition surveys and provided consultation on conservation and adaptive reuse plans

Vision

To set high standards in the region in research and education by adapting interdisciplinary efforts in engineering and technology.

Mission

Focusing on research to explain not only fundamental principle of science but also on solving real-world problems by incorporating both technical and non-technical perspectives for broader approach. Provide service to the public, industry, and government through excellence in knowledge development and promoting research with a greater understanding of the impact of technology on society.

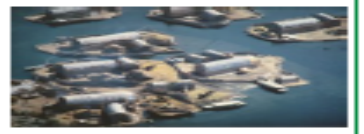
Sponsored Research Activities

Bridges and Building Maintenance

Concrete and steel are the major materials for bridge construction. They are subject to several forms of attack, which threatens its long-term durability. . In the assessment of bridge some of the parameters that need to be looked into would be: strength and uniformity of the concrete, the corrosion of reinforced steel due to penetration of chlorides and carbonates, condition of reinforcing steel and cracks. Maintenance has consistently been treated as the poor relation" of the construction industry, attracting only a tacit recognition of its importance, both within the industry and amongst concerned institutes.

Low Cost Housing Utilizing Indigenous Building Materials

An extensive research has been carried out in the marshes of Iraq to utilize palm trees, papyrus and reeds as building material for low cost housing .The implementation of this technology in one of the villages of Iraq shows that it is possible to produce building elements with reasonable strength and durability at a low cost using locally available material.



Effect of Hot Weather on Sustainability of Concrete in the Gulf Region

Concrete durability issues in hot weather region are very complex. Increase in temperature increases the number of cracks in concrete. The effects of repeated re-tempering on the slump loss characteristics and on the strength and elastic properties of concrete were studied thoroughly by SERI.

Geology and Seismology in the Gulf Region

SERI conducted an integrated field investigation survey on geological history, ancient sediments and land formation in UAE and the mineral potential in the northern emirates. One of the most important factors in assessment of seismic hazard.

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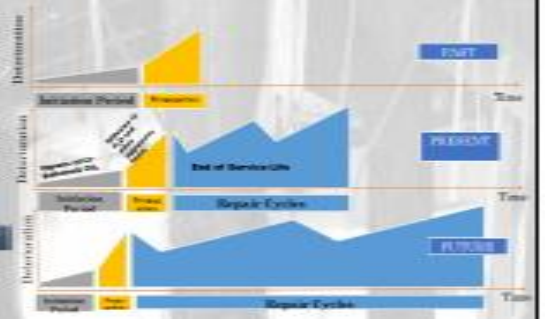
MAINTENANCE & REHABILITATION ACTIVITIES



CASE STUDIES

Multi-story Building

The building consists of a basement, ground and six floors with approximate area of 1100 m² for each floor.The building is structurally composed of reinforced concrete beams, columns, plane slabs, ribbed slabs and footings. It is intended to repair and maintenance after it was damaged by missiles.

Multi-story Commercial Building

The existing commercial building consists of basement, ground and mezzanine floors with approximate area of 500 m² for each floor. The building is structurally composed of reinforced concrete beams, columns, walls and footings. It is intended to add additional nine floors if it is technically feasible.

IN-SITU ASSESSMENT OF CONCRETE QUALITY

Half-Cell Potential Measurement

Ultrasonic Pulse Velocity

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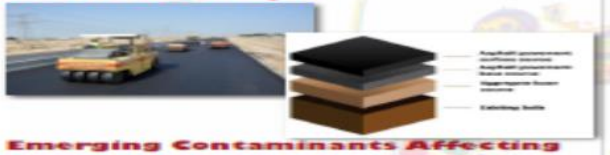
Main Research Activities

Improved Asphalt Mixes for Hot Weather in Sharjah



Maintenance & Rehabilitation

Emerging Contaminants Affecting Waste Water Reuse in Sharjah

Quality Control & Testing

Cladding: Maintenance, Sustainability & Fire-performance

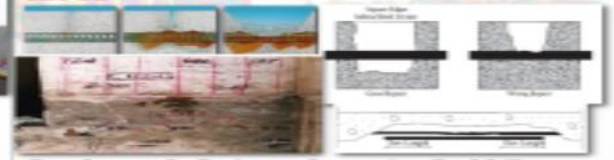
Low Cost Housing Using Indigenous Building Materials

Investigation of Concrete Cracks in Buildings

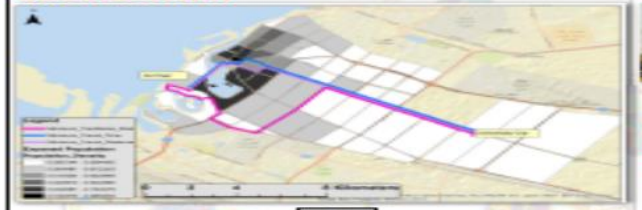
Effect of Hot Weather on High Strength Concrete in the Gulf Region

Durable Concrete Mixes in UAE

Evaluation, Testing and Repair of Corroded and Damaged Steel Structures



GIS Risk-based Routing for Hazardous Materials



Geology & Seismology in Gulf Region

Sustainability of Reinforced Structures in UAE

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Sharjah Engineering Research Institute (SERI)

"Low-Cost Housing"

Utilization of Reeds for Low-cost Housing

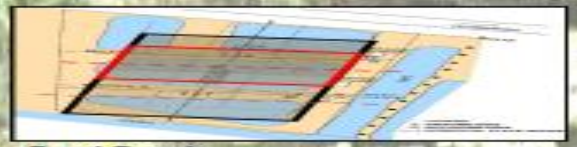
Extensive research has been carried out in the marshes of Iraq to utilize palm trees, papyrus and reeds as building materials for low-cost housing. The implementation of this technology in one of the villages in Iraq shows that it is possible to produce building elements with reasonable strength and durability at a low-cost using locally available material. Trial embankment and islands using reed reinforcement was proven to be very efficient.

•Marshes

The typical Mudief is built from cane skeleton, which consists of long and thick bundles making continuous columns and beams and thin bundles for purlins. The skeleton is covered with cane mats. The lower part of the Mudief is left open with cane grills to allow the air to pass through, during the summer and closed during the winter with reeds.

•Trial Embankment

A full scale fully instrumented trial embankment,90m long, 6.0m high, was constructed in marsh areas in southern Iraq, to assess high-way problems, such as: settlement, failure of embankments and rutting of pavements. The instrumentations included; piezometers, settlement profile gages, inclinometers and surveying and triangulation devices. The results of this research revealed that the excess pore pressure ratio was equal to 0.37 and 0.43 for section A and B respectively.



•Reed Panels

The use of bundles of reeds at the base of the embankment was very effective in restricting the lateral deformation of the embankment and foundation soil, thus reducing the settlement.

•Applications of Reeds for Sewage Treatment

Courtesy Wagner Bio Cut

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Regional Courses for the Management of Heritage Buildings ICCROM

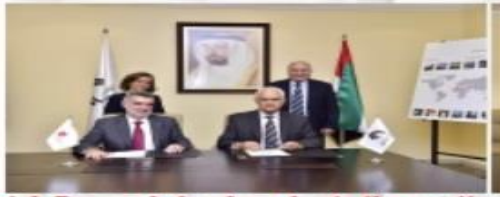
As a part of the ongoing cooperation between University of Sharjah and local institutions, Sharjah Research Academy hosted nearly 40 participants from various Arab countries, supervised by Prof. Mufid Samarai, academic advisor at Sharjah Research Academy. He also supervised the practical and scientific applications of the experiments in the laboratory.

Election of Sharjah Research Academy in the Membership of the Board of the Arab Institute of Management Operation and Maintenance

The general Assembly of the Arab Institute for Operation and Maintenance "OMAINTEC" elected Sharjah Research Academy to become a member, at the Board of Directors meeting in Beirut. This election was performed since that the Academy is the first research institute in the field of maintenance research and its applications.

Sharjah Research Academy Signs a Memorandum of Understanding with the National Portuguese Laboratory

SRA has signed a Memorandum of Understanding (MoU) with the Portuguese National Laboratory for Civil Engineering (LNEC) in order to exchange research on the feasibility of different infrastructure in warm environments. The LNEC, established in 1946, is one of the leading European scientific, academic and research institutions.



Sharjah Research Academy hosts the meeting of the Technical Committee of the Board for Saudi Standards, Metrology and Quality

SRA hosted a meeting between the Technical Committee of the Board for Saudi Standards, Metrology and Quality and the International Organization for dry Mines in Middle East.

Sharjah Research Academy Signs a Memorandum of Understanding with URUK

SRA signed an MOU for research with URUK Engineering and Contracting such that the Academy will provide various services to URUK.

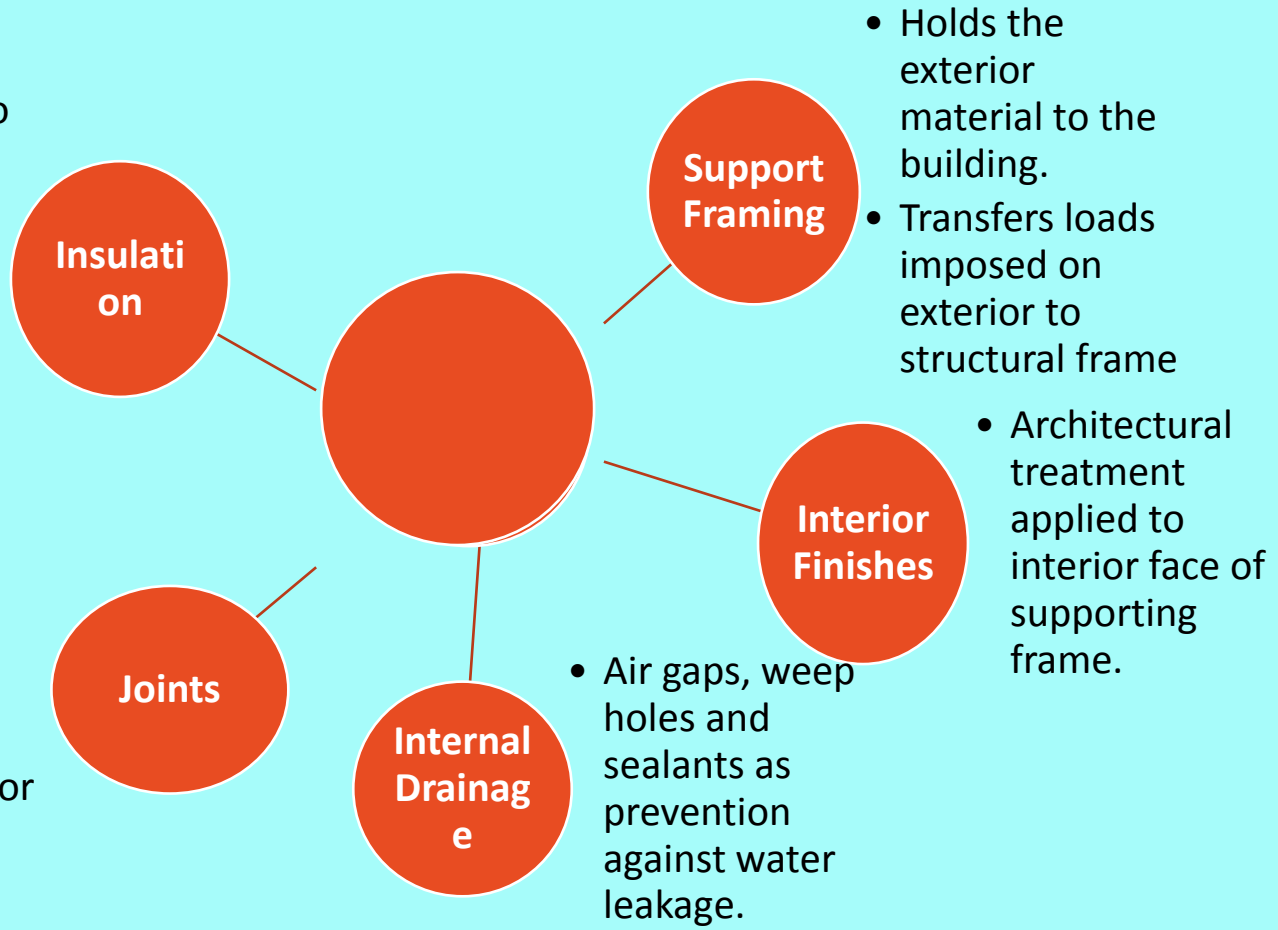
Introduction to Cladding

What is Cladding?

- Cladding is an exterior finishing system meant to protect the underlying structure (like a home) and provide an aesthetically appealing finish.
- How long it lasts depends on the type of cladding, but most cladding systems are quite durable and last up to 50 years.
- While the term cladding is widely used in Europe and Australia, these exterior finish materials are typically known as siding in North America.
- Cladding can serve both a decorative and a functional purpose.

Functional Requirements of Cladding

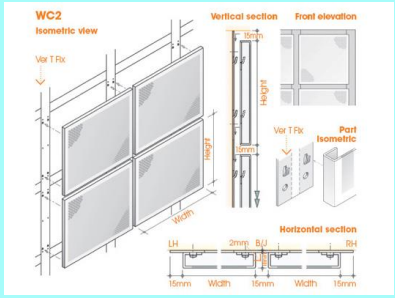
- Strength and stability
- Compatibility with Integration with vertical and horizontal frame members/elements
- Weather resistance
- Durability
- Thermal insulation
- Fire requirements
- Sound insulation
- Aesthetic

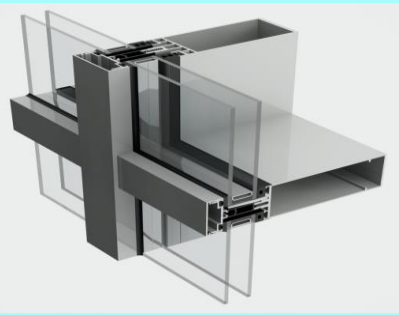


Cladding Types and Systems

Installation systems

- Attached System
- Curtain Wall System
- Infill System





Cladding Types

Interior Cladding

- TIMBER CLADDING
- PVC CLADDING
- STONE CLADDING
- BACKPAINTED GLASS CLADDING
- CERAMIC CLADDING
- WALLPAPER

Exterior Cladding

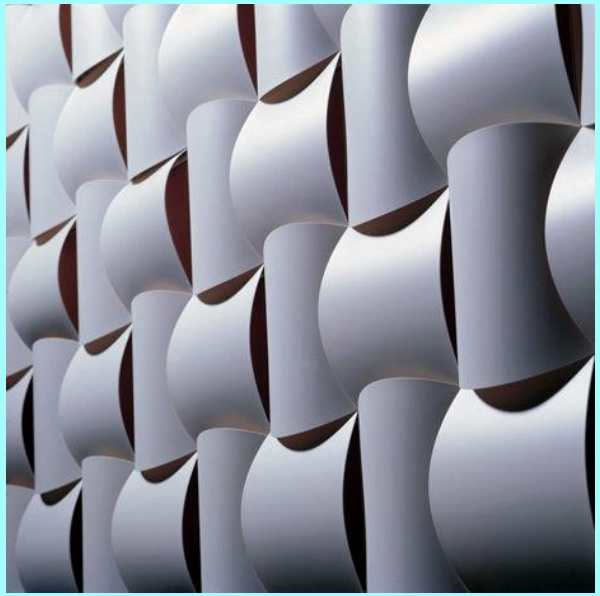
- TERRACOTTA CLADDING
- STONE CLADDING
- METAL CLADDING (ACP CLADDING)
- STICK FRAME CLADDING
- CURTAIN WALL (GLASS)
- FIBRE CEMENT CLADDING
- BRICK CLADDING

Timber Cladding

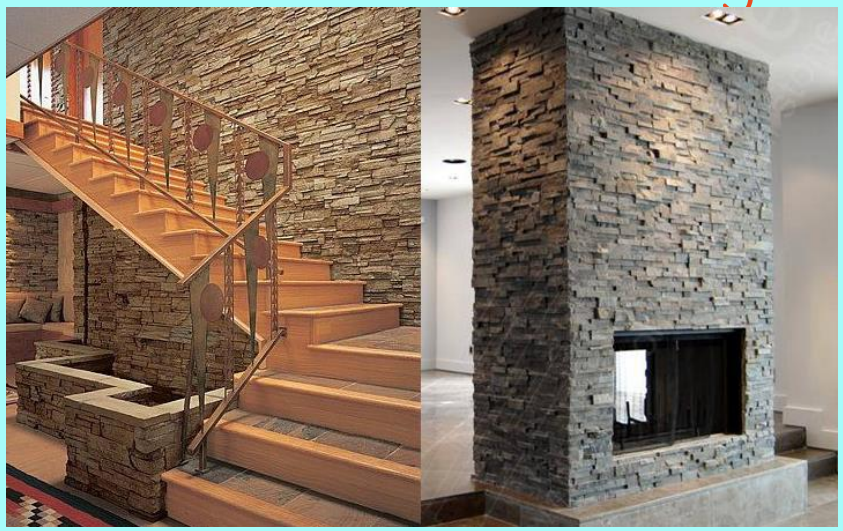
Look of elegance and warmth and can be painted any colour.

PVC Wall Cladding

Great looks, long lasting, low maintenance, provides stone, timber etc. look, moisture resistant and can be used in wet areas.



Stone Wall Cladding

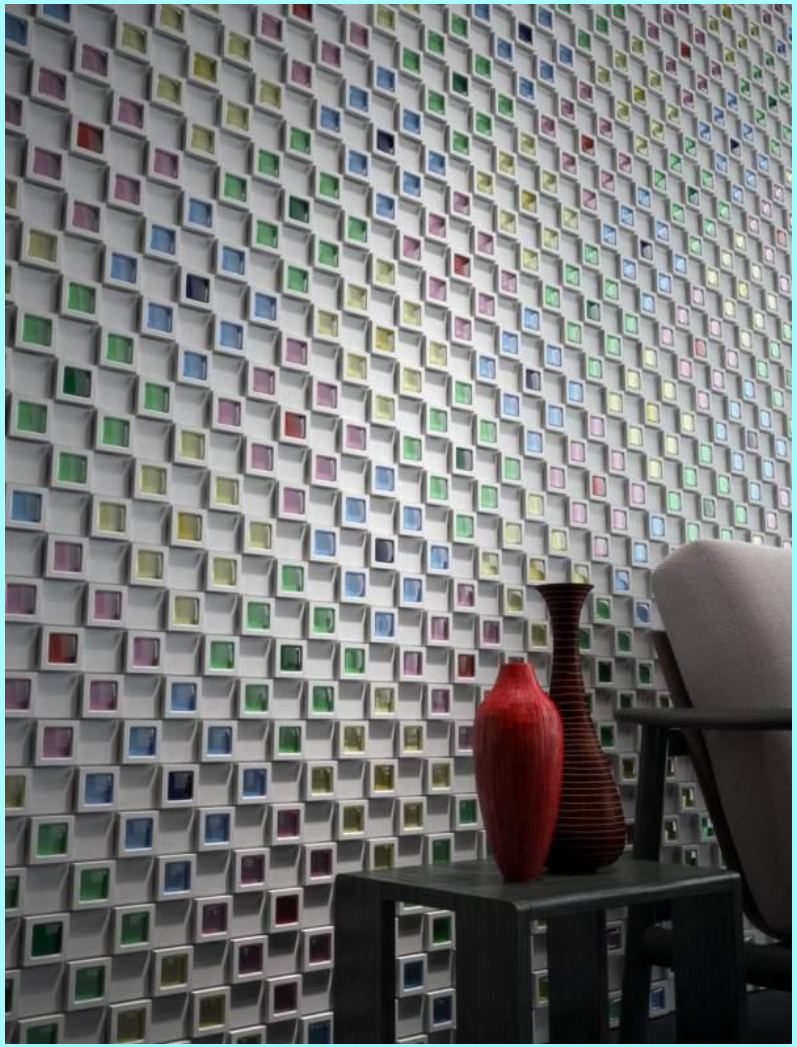


Back Painted Glass (Glass art colour spray)

Popular interior wall cladding feature in homes and commercial buildings. Provides posh, clean and sophisticated look.

Colour Spray is a uniquely formulated resin based paint system which is ideal for the back painting of glass for wall claddings in any colour imaginable.

Ceramic Cladding



•Ceramic cladding resists changes in temperature and atmospheric attack from pollution, acid rain and smog.
• Fixed to the buildings by an adhesive.
• Available in different colours and style.
• Long lasting

Wallpapers

Used for completely aesthetic purposes they are available in infinite number of patterns and designs. Due to their texture and sheen, they score over paints. They are paper, vinyl and real fabric based.

Metal Cladding

- Aluminium composite panels (ACP) & extruded aluminium are used. They are light weight, non-corrosive and recyclable in nature, have high strength-to-weight ratio and come in diverse colours and finishes.
- Copper, another type of metal cladding is used for its aesthetics alone.
- Zinc is very expensive but aesthetically eye-catching and durable.

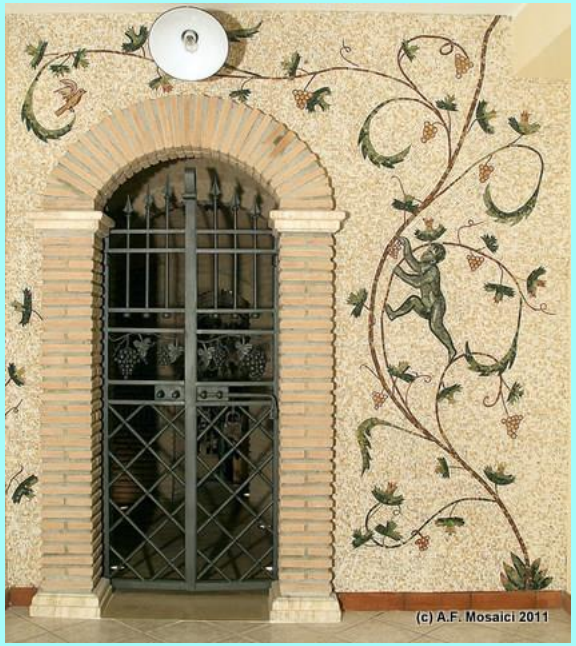
Terracotta Cladding

Natural clay based tiles factory extruded and kiln dried to provide a durable cladding product. Colour is created by adding specific dyes, custom shapes also possible.

Curtain Wall Cladding (Glass)

Mosaic Cladding

- Small tiles plastered onto the wall surface for aesthetic appeal.
- Has no insulation property.
- Available in variety of colours.



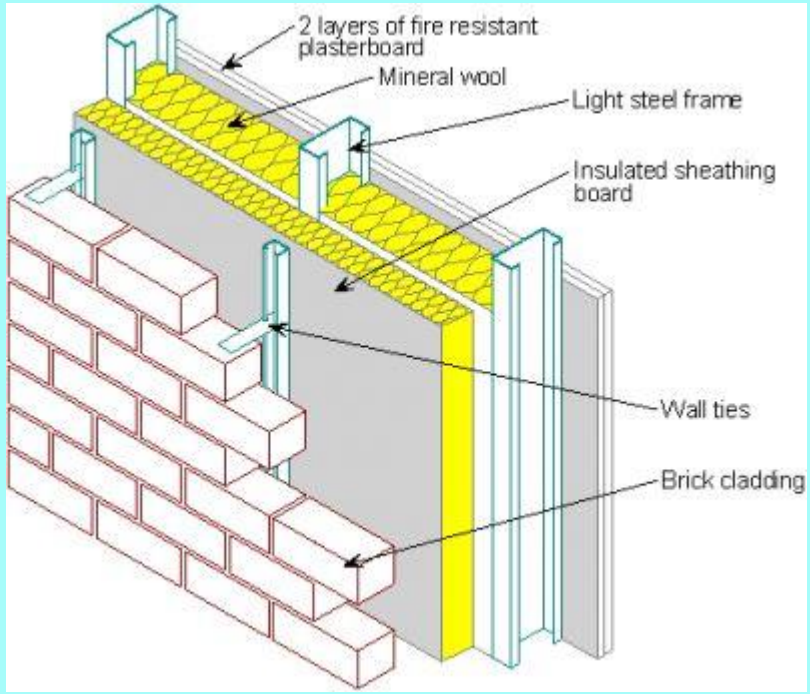
Green-wall

- With the advent of green buildings, the trend of green walls have come into place. It can be installed both in the interiors and the exterior.

Window Capping

Application of aluminum or vinyl sheeting ,cut and formed with a brake to fit over the exterior, wood trim of a building is called window capping. The aluminum is intended to make aging trim with peeling paint look better, reduce future paint maintenance, and provide a weather-proof layer to control the infiltration of water.

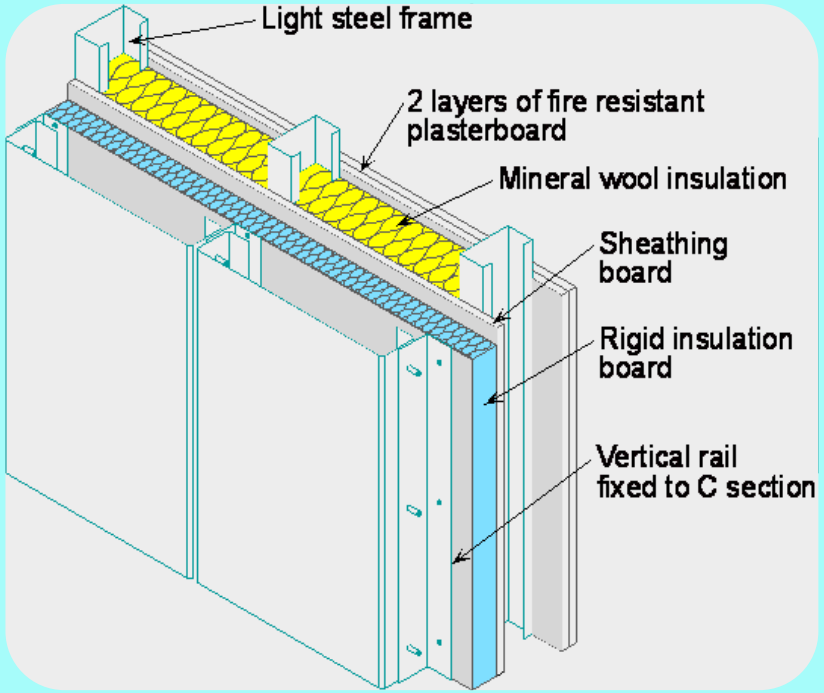
Brick Cladding



Aluminum Composite Panels:

- ACPs are thin sandwich-type panels made from two sheets of aluminium bound to a core of insulating material. A common use for ACPs is as external claddings on multi-level buildings as they are relatively lightweight and sturdy, while the aluminium sheets can be painted any colour.
- ACPs are combustible (i.e. capable of catching fire). Other examples of combustible external cladding systems include exterior insulation finish systems, structural insulation finish systems, high pressure laminates and weather-resistive barriers

Rain Screen Cladding

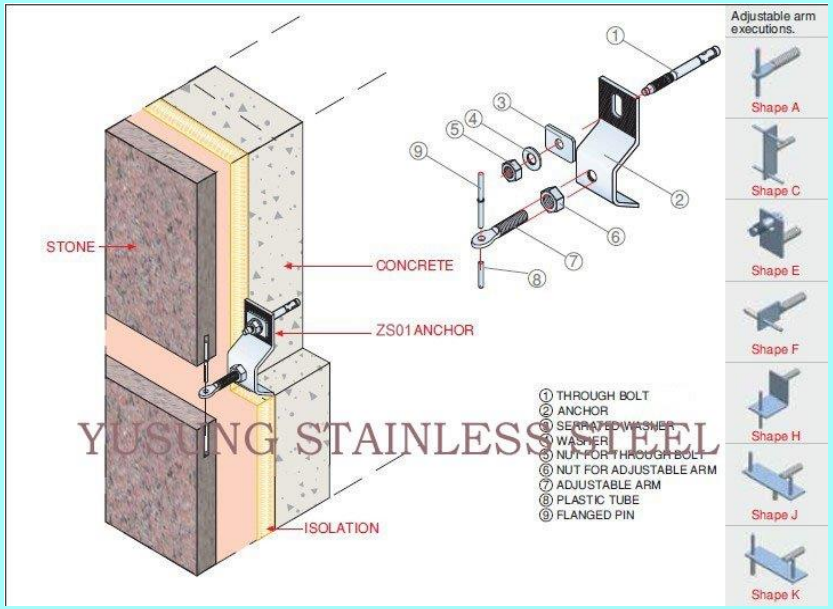


Metallic rain-screen cladding attached to light steel infill walls

Use of composite (sandwich)panels to support tiles.

Methods of Cladding

- **Direct Adhered –** This is one of the most common methods. It is thinner, less expensive and doesn't require any onsite drilling
- **Spot Bonding –** similar to the direct adhered but epoxy is only applied to about 10% of the area resulting in gaps or pockets of air between the stone and the wall reduces the chances of water staining.
- **Mechanical Bonding -** This method involves fixed or embedded anchors or ties being used to attach the stone to the surface



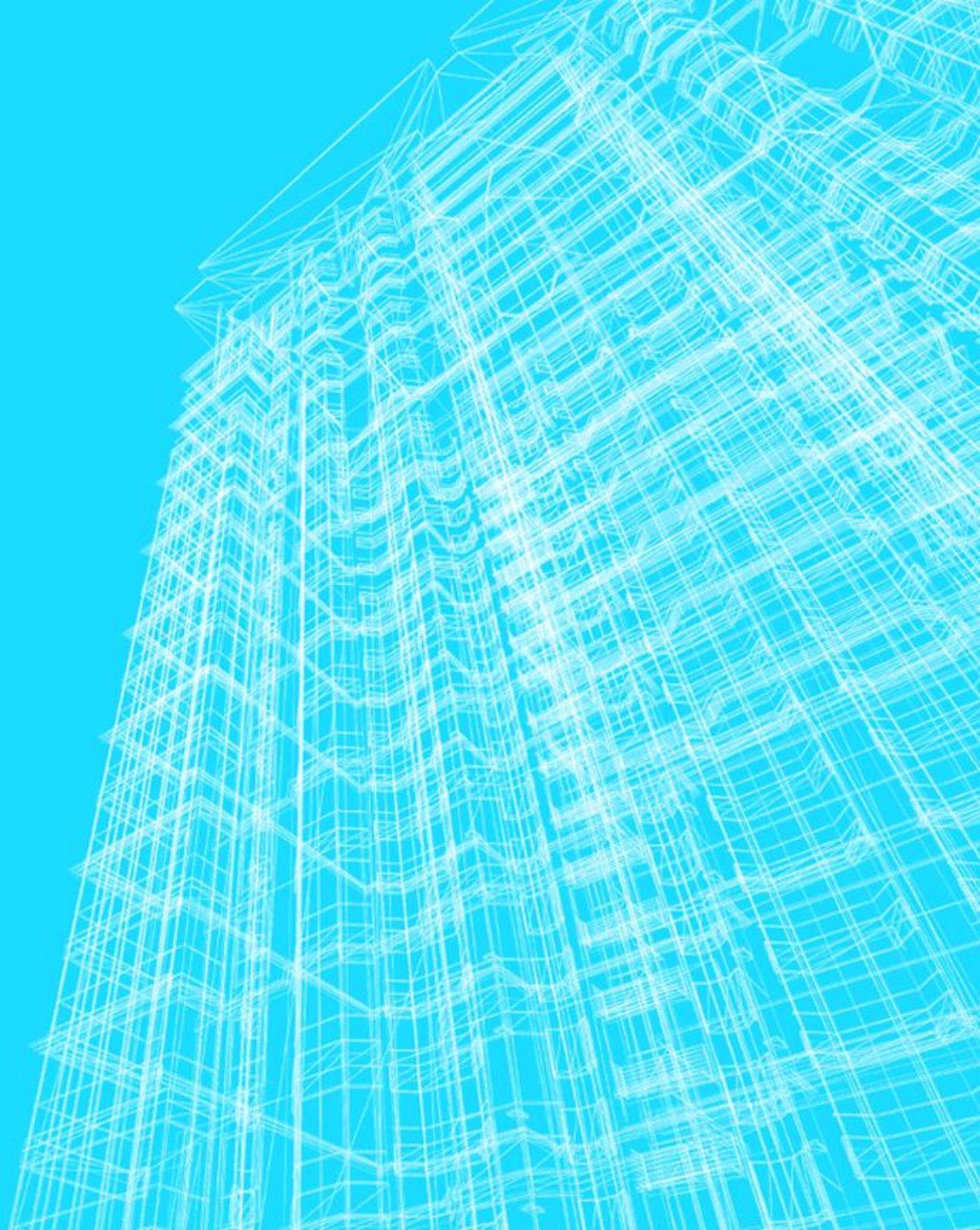
Advantages

- Low Maintenance
- Can be easily cleaned
- Protection from weather elements
- Noise, heat control
- Light weight
- Aesthetic appeal

Disadvantages

- Initial installation is costlier than normal paint.
- Needs timely maintenance.
- If not installed properly, the units tend to fall off.
- Installation time is huge depending on the surface of the building

Fire-rated Cladding



Fire-rated Cladding

- The Gulf region is home to one of the highest number of high-rise buildings in the world.
- The recent fires incidents have brought the fire safety issue and the deployment of fire-rated cladding materials in modern buildings to the fore.
- The incidents have also shifted focus to aluminum cladding that covers most high-rise towers' walls.
- The incidents have also raised a number of issues, such as:

  1. The awareness about building safety or lack of it.
  2. Regulations on building materials or the lack of it.
  3. The absence of a unified building code, not to mention the frequent use of substandard materials.

Fire-rated Cladding

- Cladding is a protective or insulating layer fixed to the outside of a building. It serves a dual purpose of improving the appearance of the building and helping guard against the elements.
- One would assume that all these color-coated cladding materials are fire resistant. However, the use of fire-rated materials, or lack of it, is the key issue that came out as a result of the recent fire incidents. Unfortunately, most of these are not fire-rated materials.
- Certified fire-rated metal composites are safe if used as a proper system and are in use all over the world. The problem here lies in awareness and legislations to enforce the use of the right materials.

Fire-rated Cladding

- The perception of high-cost implications is perhaps the biggest factor in deterring architects and developers from choosing certified fire-rated facades.
- An awareness campaign is needed to educate the stakeholders that the cost implication is not as perceived and in effect is just around 10 percent and worth it, considering the high risks involved.
- Full fire-rated system specifications including Rockwool insulation will contribute towards energy savings. This will have a direct cost savings impact reducing air conditioning tonnages and utility bills and perhaps will pay for itself.

Fire-rated Cladding

External fire spread

- External composite cladding panels are made of thin outer metal skins of steel or aluminum with cores of insulating material, which historically have included combustible materials such as expanded polystyrene (EPS) or polyurethane (PUR). The recent Dubai fires involved polyethylene (LDPE) cores with aluminum facings.

Fire-rated Cladding

External fire spread

- Polymeric core materials such as EPS and PUR contribute to fire spread and, in well-developed fires, combustible cores burn with savage intensity.
- Composite panels can delaminate suddenly, exposing the combustible core which then intensifies and spreads the fire.
- Aluminum has a much lower melting temperature than steel and hence aluminum facings will fail earlier.
- Delaminated panels can fall off the building, raining down hot metal and burning foam insulation, with risk of injury and secondary fires. We can see this happening in various photographs of the recent fires in Dubai and Ajman.

Fire-rated Cladding

External fire spread

- UK Building Research Establishment's (BRE) report entitled Fire Performance of External Thermal Insulation for Walls of Multi-Story Buildings (2013) explains the mechanisms of fire spread:

1. Initiation of the fire event: From a fire occurring inside the building or by an external fire in close proximity.
2. Fire breakout: An internal fire may develop to flashover, it is likely to break out through a window opening or doorway. Flames will typically extend 2m above the top of the opening, regardless of the cladding type.

Fire-rated Cladding

Composite Panels

- Composite panels have had various alternative core materials, and in order of decreasing probability of fire propagation include:
  - ✓ Polystyrene (EPS).
  - ✓ Polyurethane (PUR).
  - ✓ Polyisocyanurate (PIR).
  - ✓ Phenolic.
  - ✓ Mineral fiber.

Fire-rated Cladding

Composite Panels

- In the UK, influence from insurers and technical development within the composite panel industry has led to cores of polymer-cored external cladding panels changing from PUR to PIR to phenolic foam, progressively decreasing the fire hazard. In the Gulf, composite panels became widely used for the same reasons as in the UK. The manufacture of the composite panels in many countries included combustible thermoplastic cores.

Fire-rated Cladding

Exterior Cladding Fires

- In 2012, external cladding fires occurred at:
  1. Al Baker Tower and Al Tayer Tower, Sharjah
  2. Saif Belhasa Building and Tamweel Tower, Dubai.

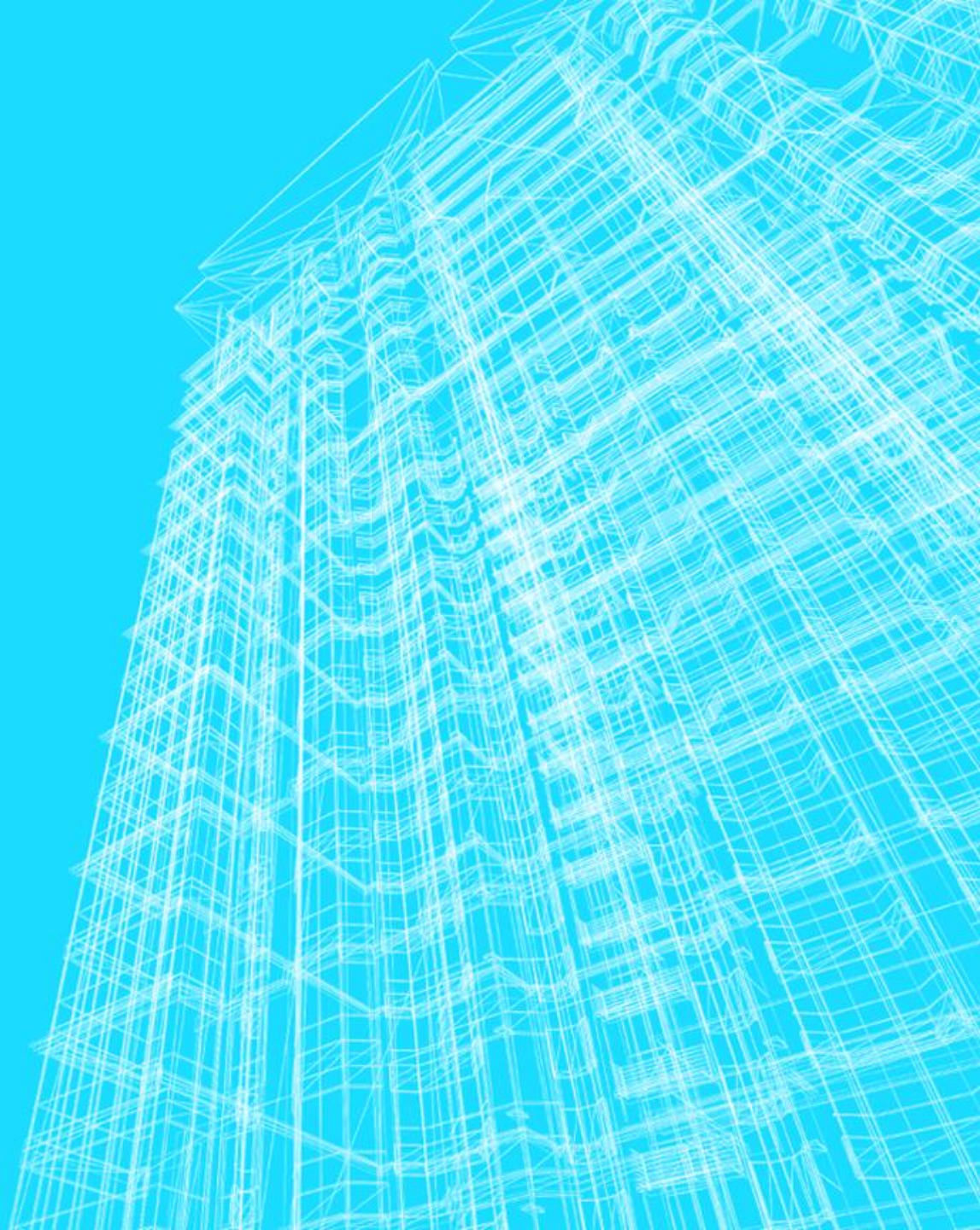
Revisions were published to the UAE Civil Defence Fire Code in 2012, which significantly reduced the risk of similar fires in new buildings.

Fire-rated Cladding

Exterior Cladding Fires

- There has been speculation about possible late alarm (and sprinkler) activation in the Tamweel, Torch and The Address fires, but the likely reason is that smoke did not reach the smoke detectors, and heat did not reach the sprinkler heads, until the external fires had become sufficiently developed to break into the interior of the buildings.
- The cladding on The Address is described by Alumco, the supplier/installer, as: "Aluminum plastic composite panels compounded with top and bottom layers of aluminum sheet, anti-toxic polyethylene core material."

Fire Performance of Cladding



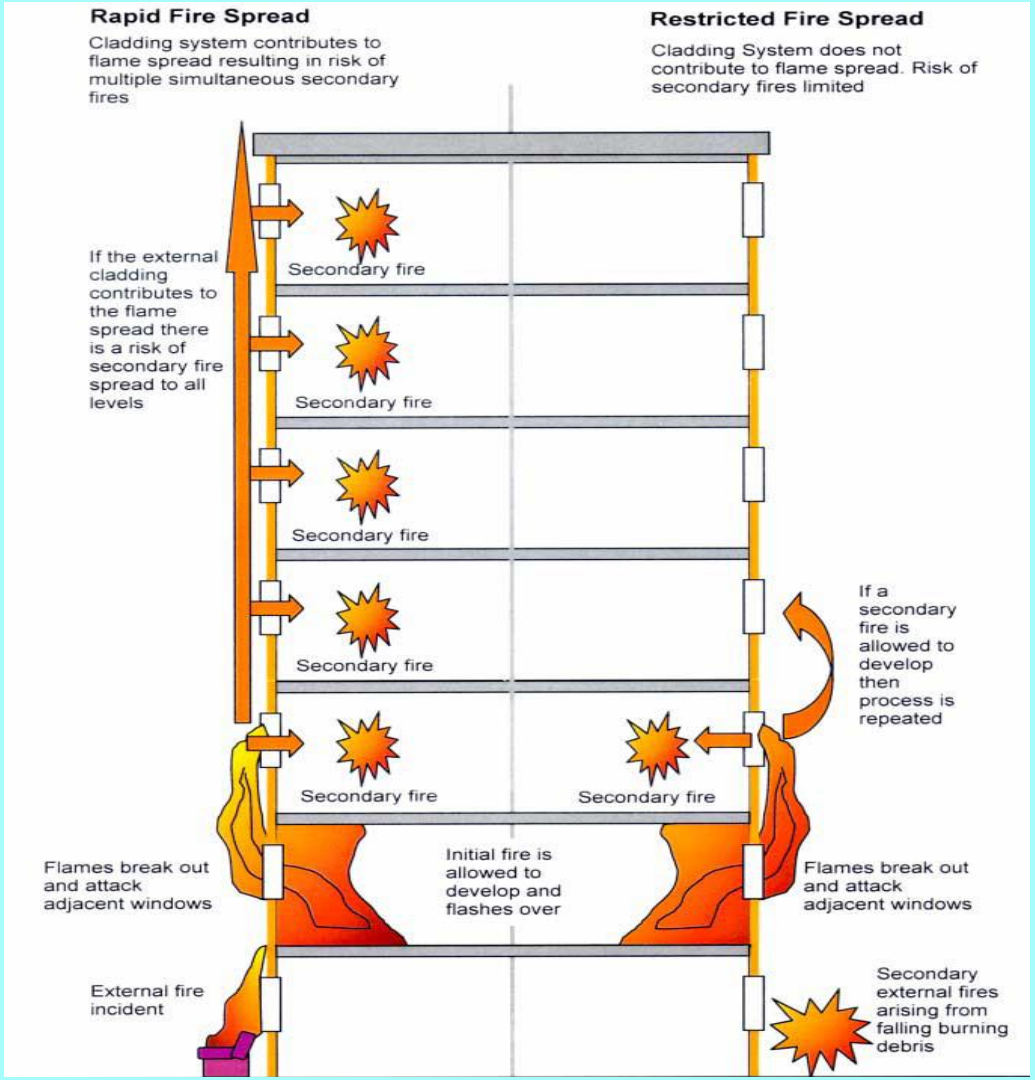
Fire Spread in Building Envelopes

Fires involving multi-storey buildings

- are a risk to life
- property loss
- disruption to commercial business or
- domestic life if dwellings are involved.

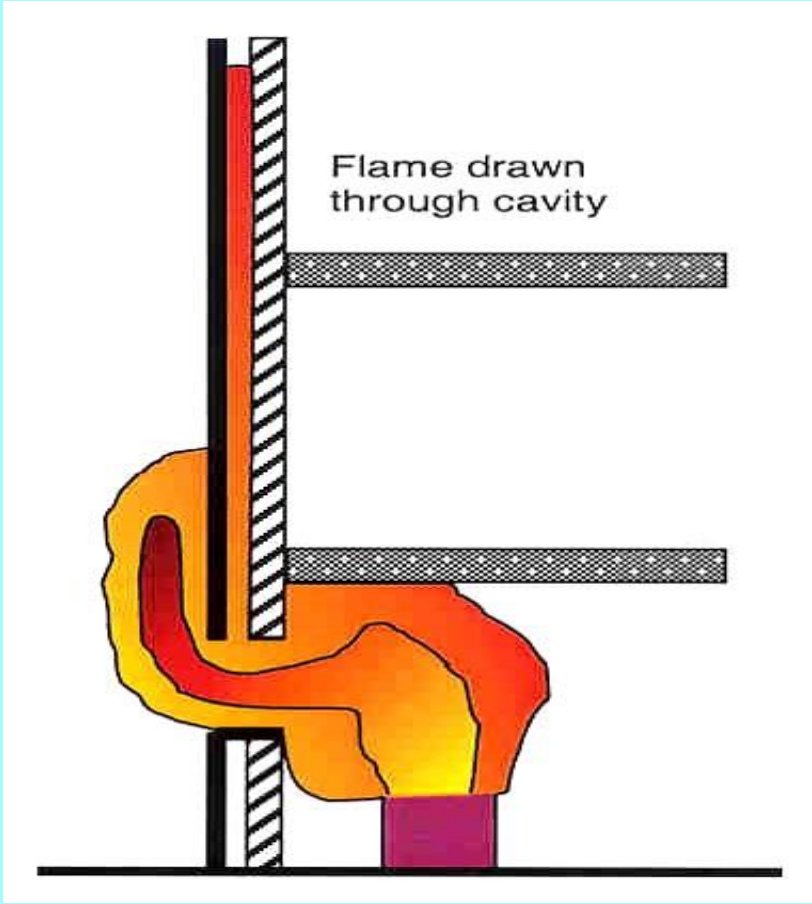
Mechanisms of Fire Spread

- Fires allowed to develop may flash over and break out through windows.
- Flames spread up over or through the cladding.
- Flames can extend over 2m above window opening. Regardless of cladding materials.
- If fire re-enters building secondary fires may then develop



Mechanisms of External Fire Spread

- Combustible materials
- Cavities either
  - Part of system.
  - Created by delamination.
- Flames in cavities can extend 5 to 10 times original length regardless of materials present.



Fire Performance of Different Cladding Systems

Aluminum Composite Panels: Fire performance

- The degree of combustibility of ACPs ranges from:
  - products that are readily combustible (ACPs with cores that are 100% polyethylene, or PE, which melts at relatively low temperatures and is highly flammable), to
  - products with a core of mineral fibre and some PE, which are less combustible, to
  - products with a core of almost all mineral fibre plus a small amount of PE to bind this fibre to the aluminium, which have limited combustibility.

EIFS:
Fire performance - System

TEST	TEST METHOD	CRITERIA
Fire Resistance	ASTM E 119	No effect on the fire resistance of a rated wall assembly
Ignitability	NFPA 268	No ignition at 12.5 kw/m^2 at 20 minutes
Intermediate Multi-Story Fire Test	NFPA 285 (UBC 26-9)	1. Resist flame propagation over the exterior surface 2. Resist vertical spread of flame within combustible core/component of panel from one story to the next 3. Resist vertical spread of flame over the interior surface from one story to the next 4. Resist lateral spread of flame from the compartment of fire origin to adjacent spaces

EIFS:
Fire performance - Components

TEST	TEST METHOD	CRITERIA
Surface Burning Characteristics	ASTM E 84	All components shall have a: Flame Spread ≤ 25 Smoke Developed ≤ 450

Fire and Life Safety Codes and Testing

Fire and Safety Codes: UAE

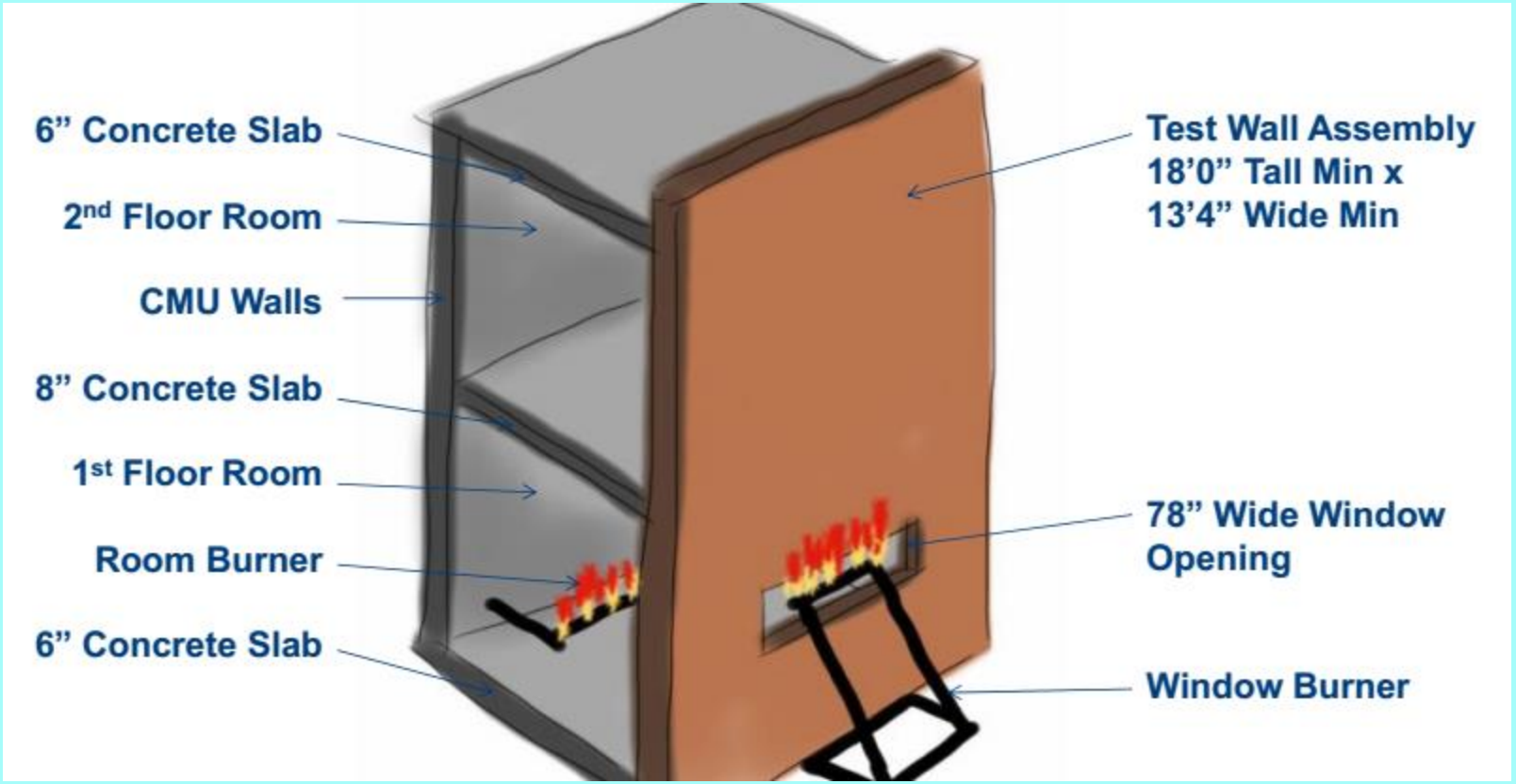
OCCUPANCY	Horizontal separation (m)			
	0 to 1.5	More than 1.5 to 3	More than 3 to 9	More than 9
Assembly, educational, day care, health care, ambulatory health care, detention and correctional, residential, residential board and care, business, industrial, and low hazard storage	1	1	0	0
Mercantile and industrial and storage occupancies with ordinary hazards	2	1	0	0
Industrial and storage occupancies with high hazards	3	2	1	0

Horizontal separation shall be measured at a 90-degree angle to the exterior wall.

- Fire Rating for Exterior Walls (hr)

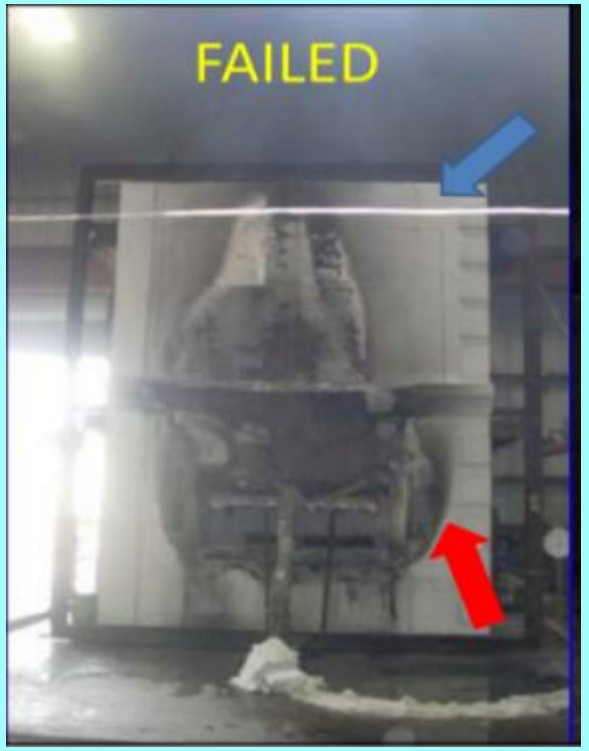
NFPA 285: Standard Fire Test Method for Evaluation of Fire Propagation Characteristics of Exterior Non-load-Bearing Wall Assemblies Containing Combustible Components

- NFPA 285 Fire Test - Components



NFPA 285: Purpose (Pass/Fail Criteria)

- Application: To Evaluate Flame Propagation Characteristics specified in the following:
  resist flame propagation over the exterior face of the wall assembly
  resist vertical flame propagation within the combustible core
  resist vertical flame propagation over the interior surface of the wall assembly from one story to the next
  resist lateral flame propagation from the compartment of fire origin to adjacent compartments



NFPA 285: Code Application

- Construction Types (IBC ch 5, 6)

- Each Type has an “A” and a “B” sub-category
- “A” has increased fire protection requirements

NFPA Code Application

- Maximum Building Height (IBC Table 503)

Maximum Building Height (IBC Table 503)

Including 1-story sprinkler system increase





	Type V Combustible	Type IV Heavy Timber	Type III Non-Combustible Exterior	Type II Non-Combustible Components	Type I Fire-Rated Structure
Assembly***	3	4	4	4	Unlimited
Education	2	4	4	4	Unlimited
Business	4	6	6	6	Unlimited
Factory/Ind	4	6	5	6	Unlimited
High Hazard	4	6	6	6	Unlimited
Institutional	3	5	5	5	Unlimited
Mercantile	4	5	5	5	Unlimited
Residential	4	5	5	5	Unlimited
Storage	5	6	5	6	Unlimited
Utility	3	5	4	5	Unlimited

IBC Fire Related Tests and Reports

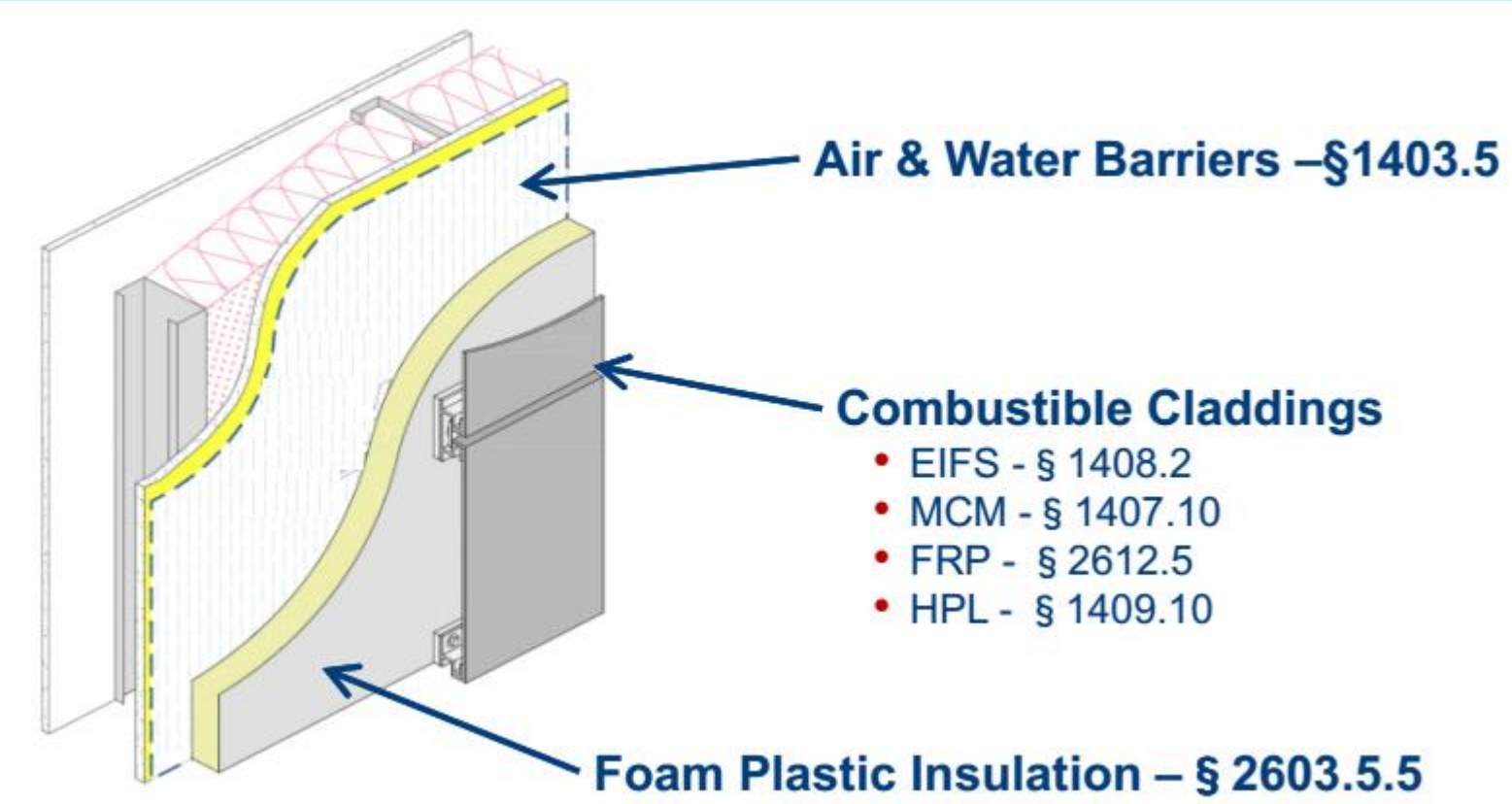
- Product Properties
  ASTM E84 Surface Burning Characteristics
  ASTM E1354 Cone Calorimeter Test
  ASTM E136 Combustible Materials
  ICC ES Reports (compliance aid, not a test method)
  Assembly Properties
  ASTM E 119 or UL 263 Fire Rated Walls
  NFPA 268 Radiant Ignitibility of Assemblies
  NFPA 285 Walls With Combustible Components

IBC NFPA 285 Testing - Material Triggers

- Foam Plastic Insulation (Ch. 26)
  - Applies to Type I – IV construction (~1988)
  - Applies to buildings of any height
  - Combustible Exterior Cladding (Ch. 14)
  - EIFS - (~2000 IBC)
  - MCMs - (~2003 IBC)
  - FRPs - (~2009 IBC)
  - HPLs - (~2012 IBC)

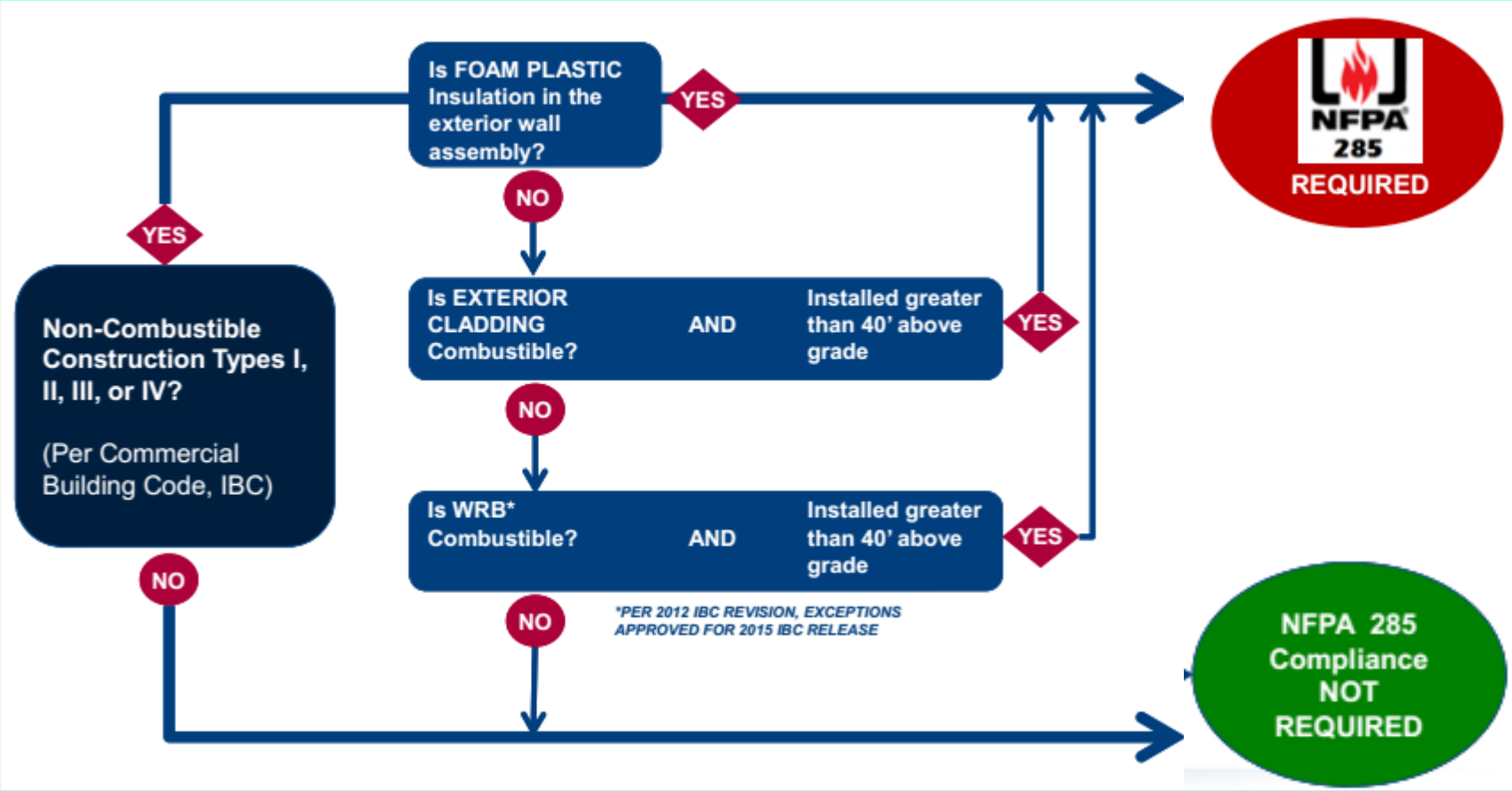
  Water-Resistive Barriers (Ch. 14)
  - Applies to Type I, II, III, IV buildings over 40 ft - (2012 IBC)
  - Applies to combustible WRB's - (2012 IBC)

IBC Combustible Component Requirements

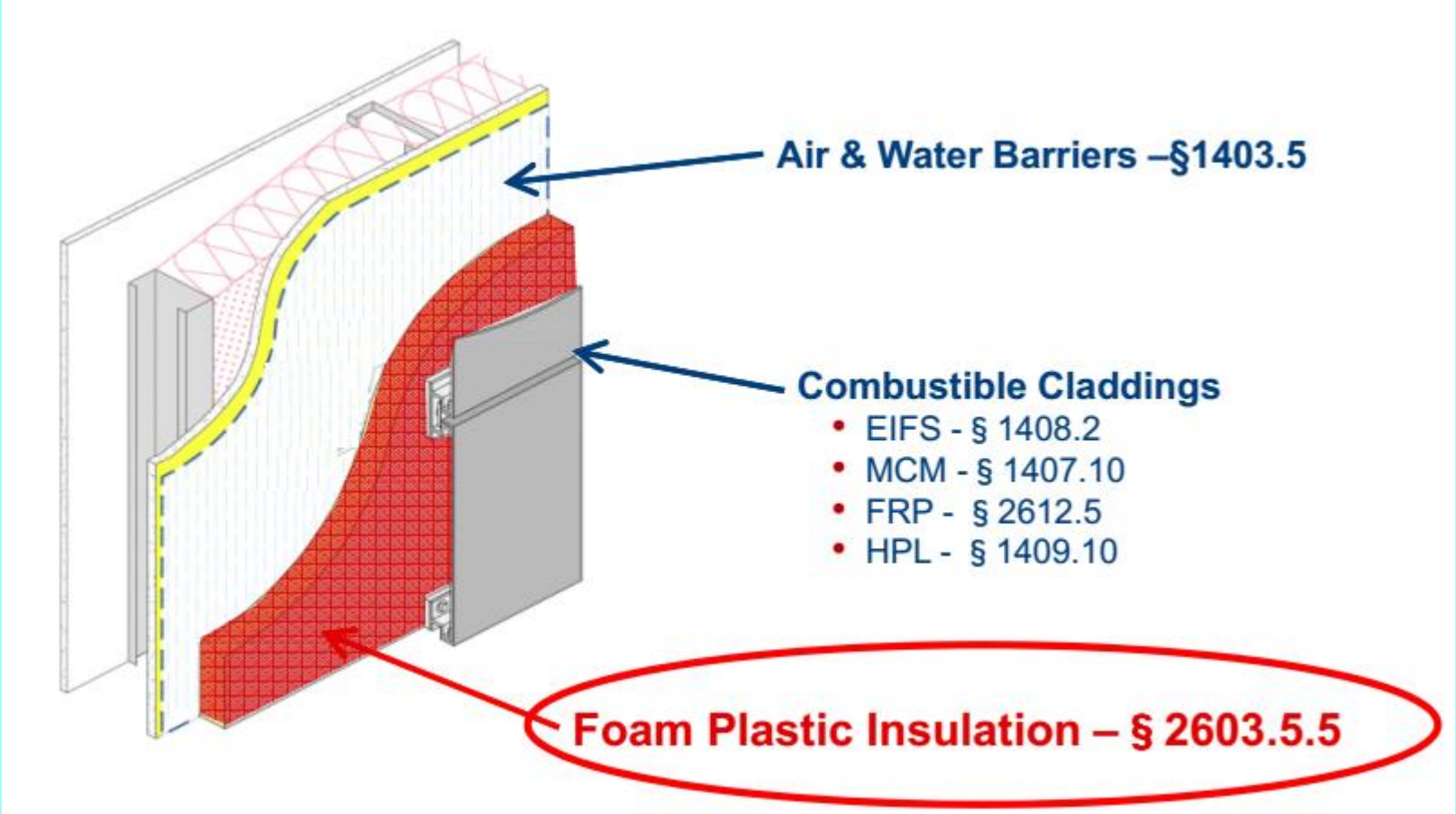


- Exterior Insulation Finishing Systems (EIFS)
- Metal Composite Materials (MCMs)
- Fiber Reinforced Plastics (FRPs)
- High Pressure Laminates (HPLs)

IBC NFPA 285 Testing Requirements



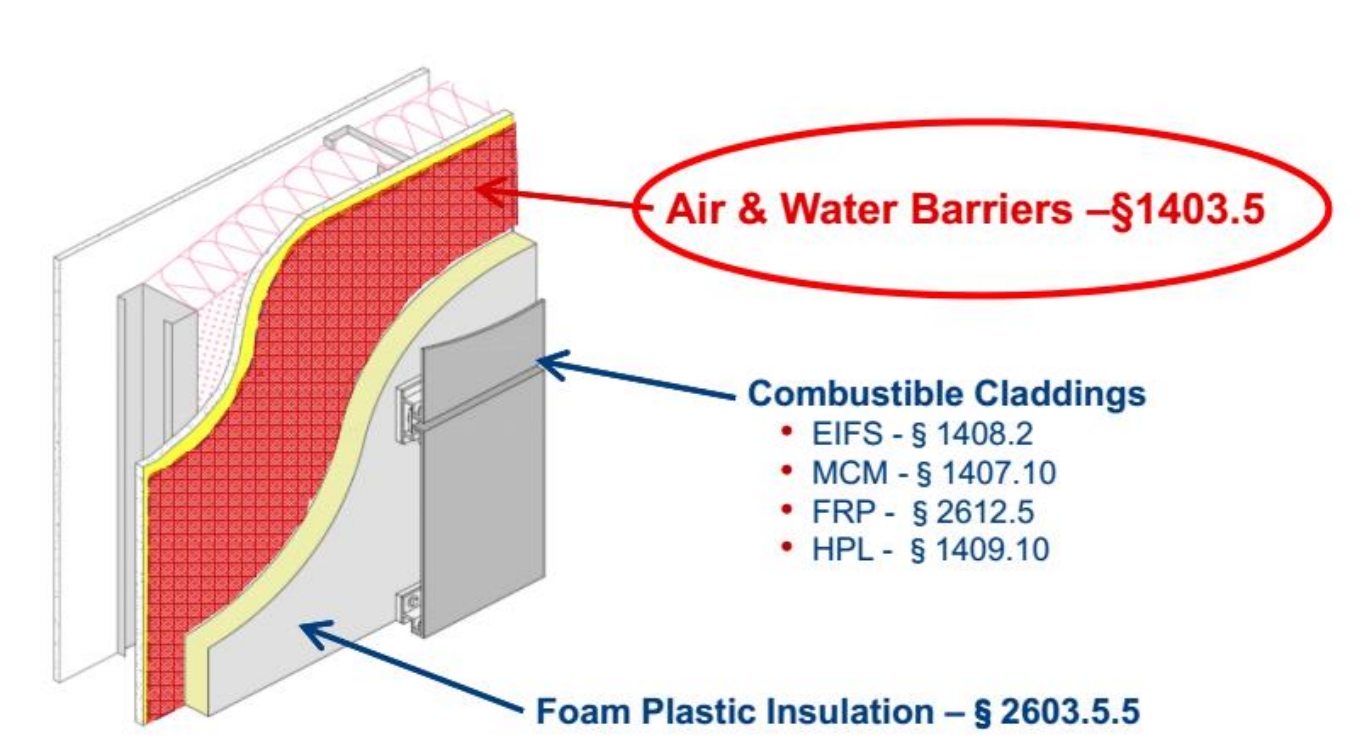
NFPA 285 Wall Assembly: Exterior Insulation



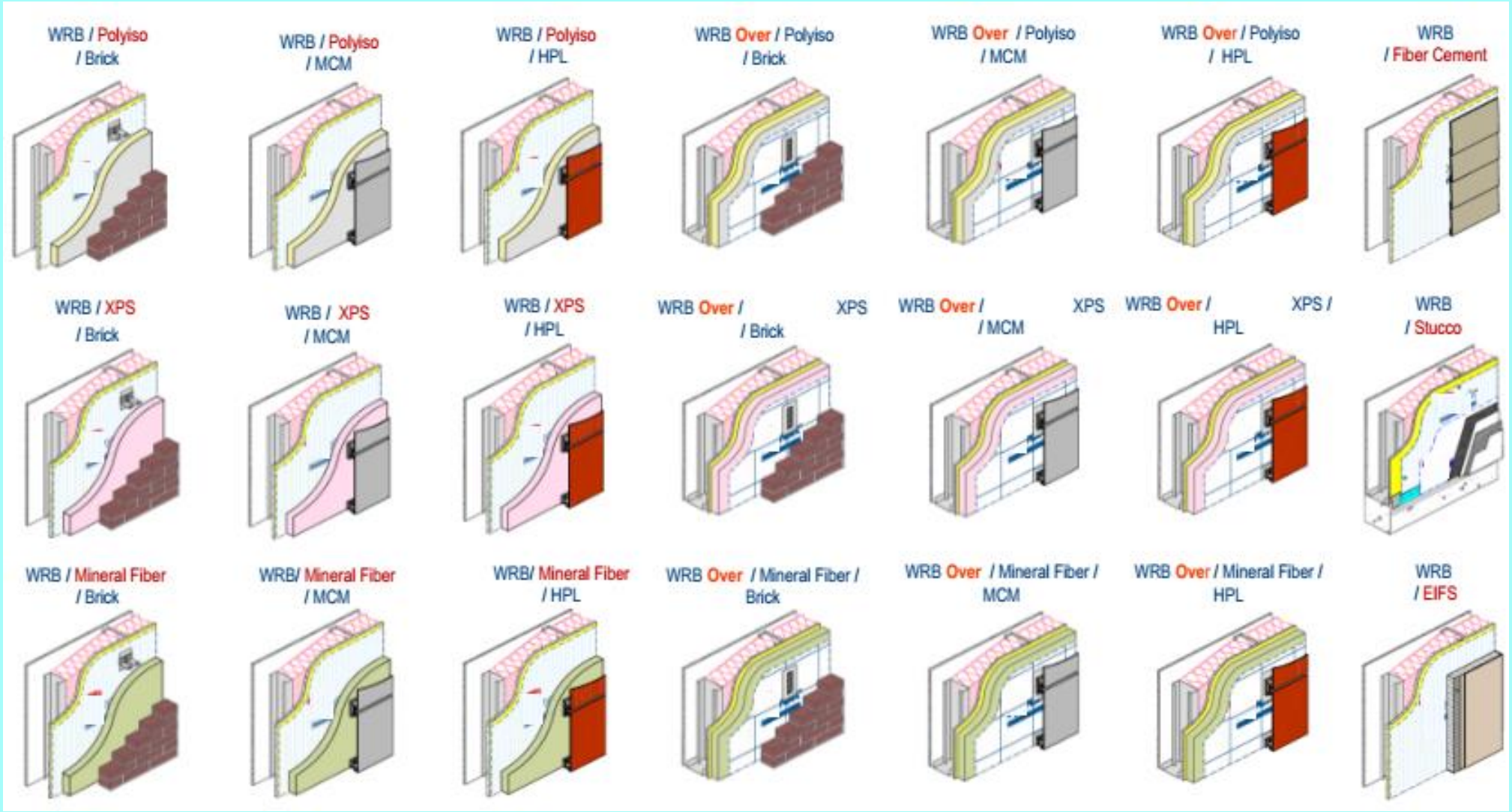
Wall Assembly: Exterio FRPs

- Fiber Reinforced Plastics (FRPs)
  - Foam cores comply with “Foam Plastic” Req’s
  - Installations less than 40’ above grade
  - Limited to 10% area when separation <10’
  - Flame Spread Index ≤200 (ASTM E84)
  - Fireblocking Required

NFPA 285 Wall Assembly: Air & Water Barrier



Variations in Wall Assemblies



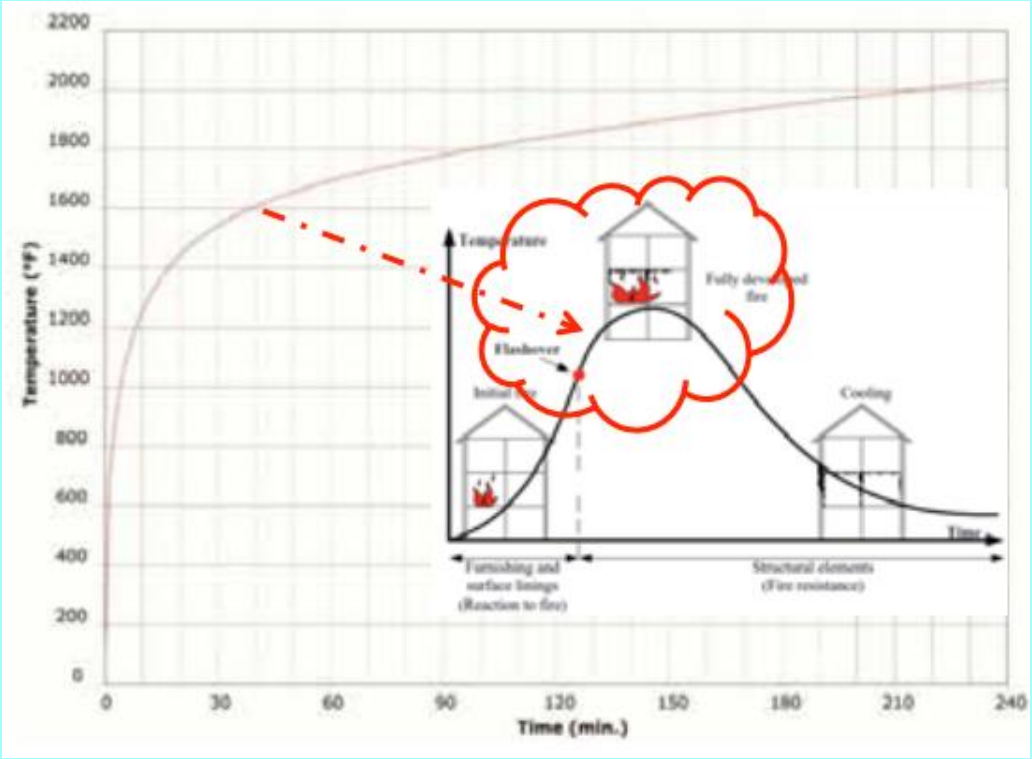
ASTM E119: Standard Test Methods for Fire Tests of Building Construction and Materials

$$T(°C) \cong 750(1 - e^{-0.49\sqrt{t}}) + 22\sqrt{t} + 20$$

Time (min)	Temperature °F (°C)
5	1000 (538)
10	1300 (704)
30	1550 (843)
60	1700 (927)
120	1850 (1010)
240	2000 (1093)

ASTM E119 Time-Temperature Curve

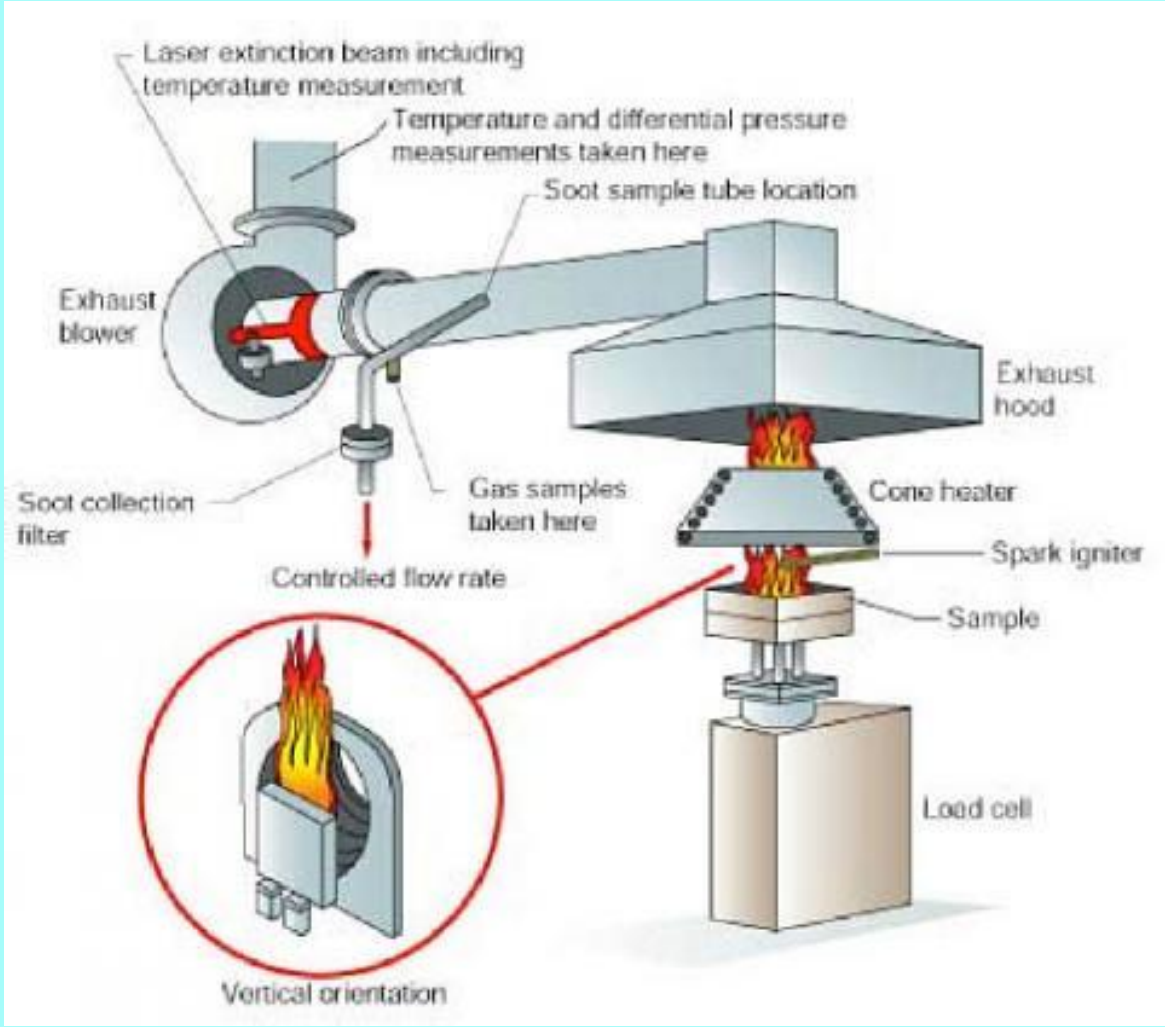
ASTM E119: Standard Test Methods for Fire Tests of Building Construction and Materials



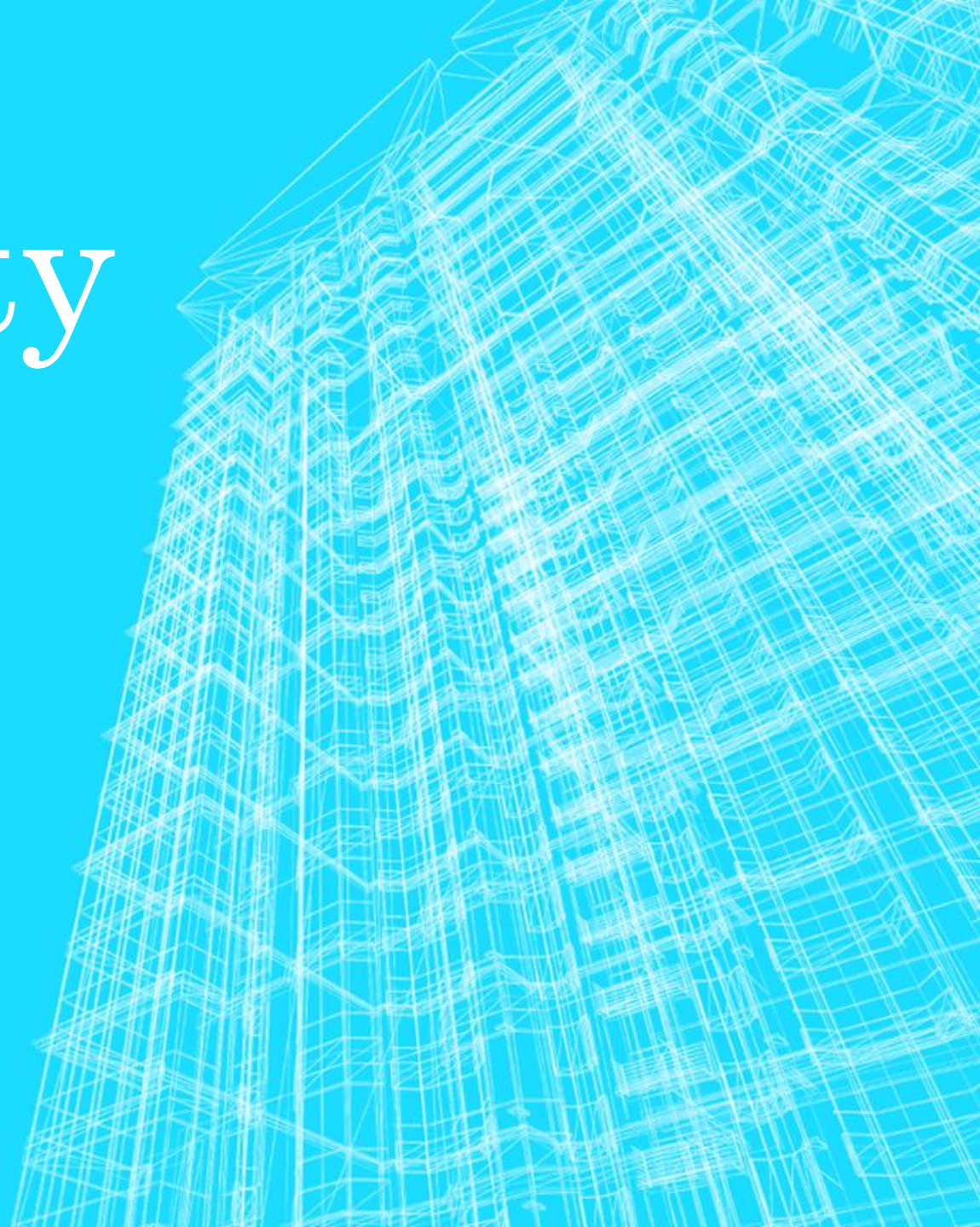
	Structural Function	Separating Function	
	Mechanical Resistance (R)	Integrity (E)	Insulation (I)
Partition / door		✓	✓
Load-bearing Wall	✓	✓	✓
Floor / Ceiling	✓	✓	✓
Beam	✓		
Column	✓		
Fire-Resistant Glazing		✓	

Standard fire-resistance test evaluation criteria

ASTM E1354 Cone Calorimeter Test

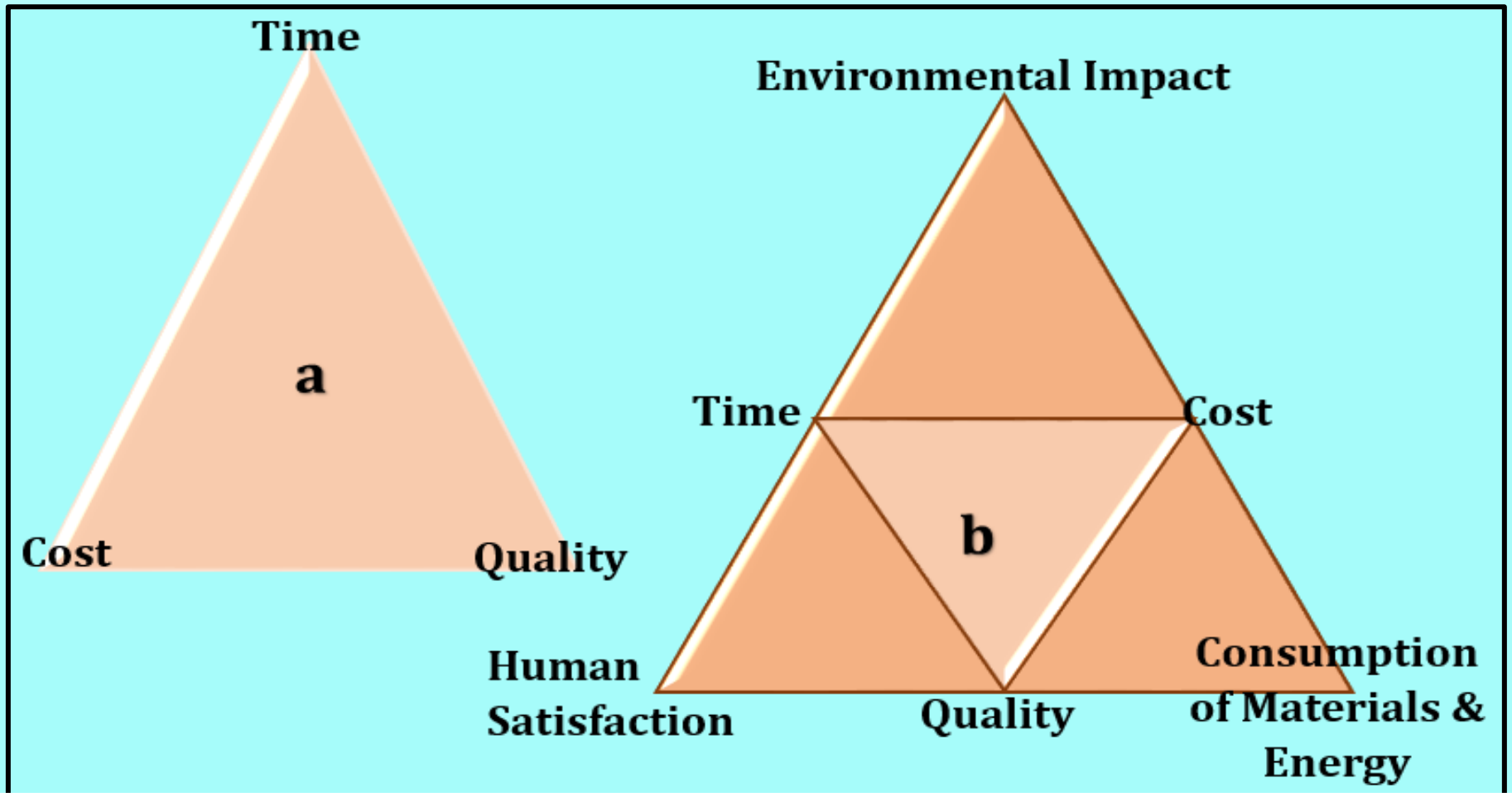


Sustainability and Life-Cycle



Construction Practices

The reason for recent changes in the construction industry is the increasing attention being given to sustainable design.



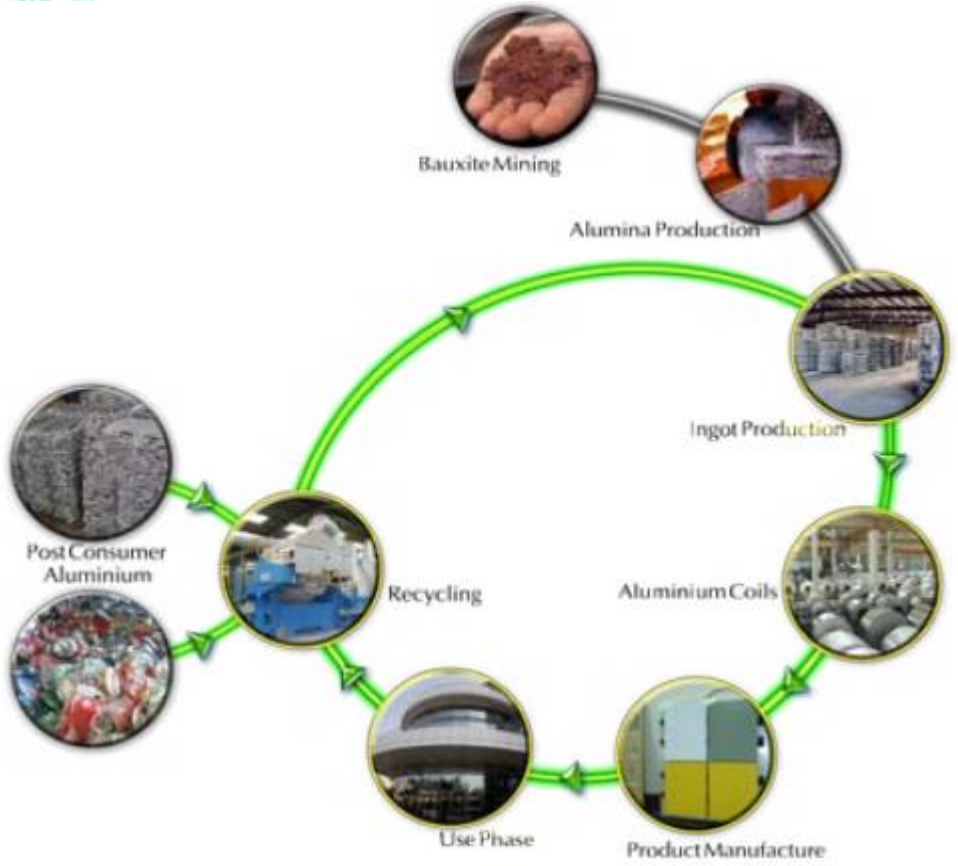
Construction practices (a) old phenomena (b) New phenomena

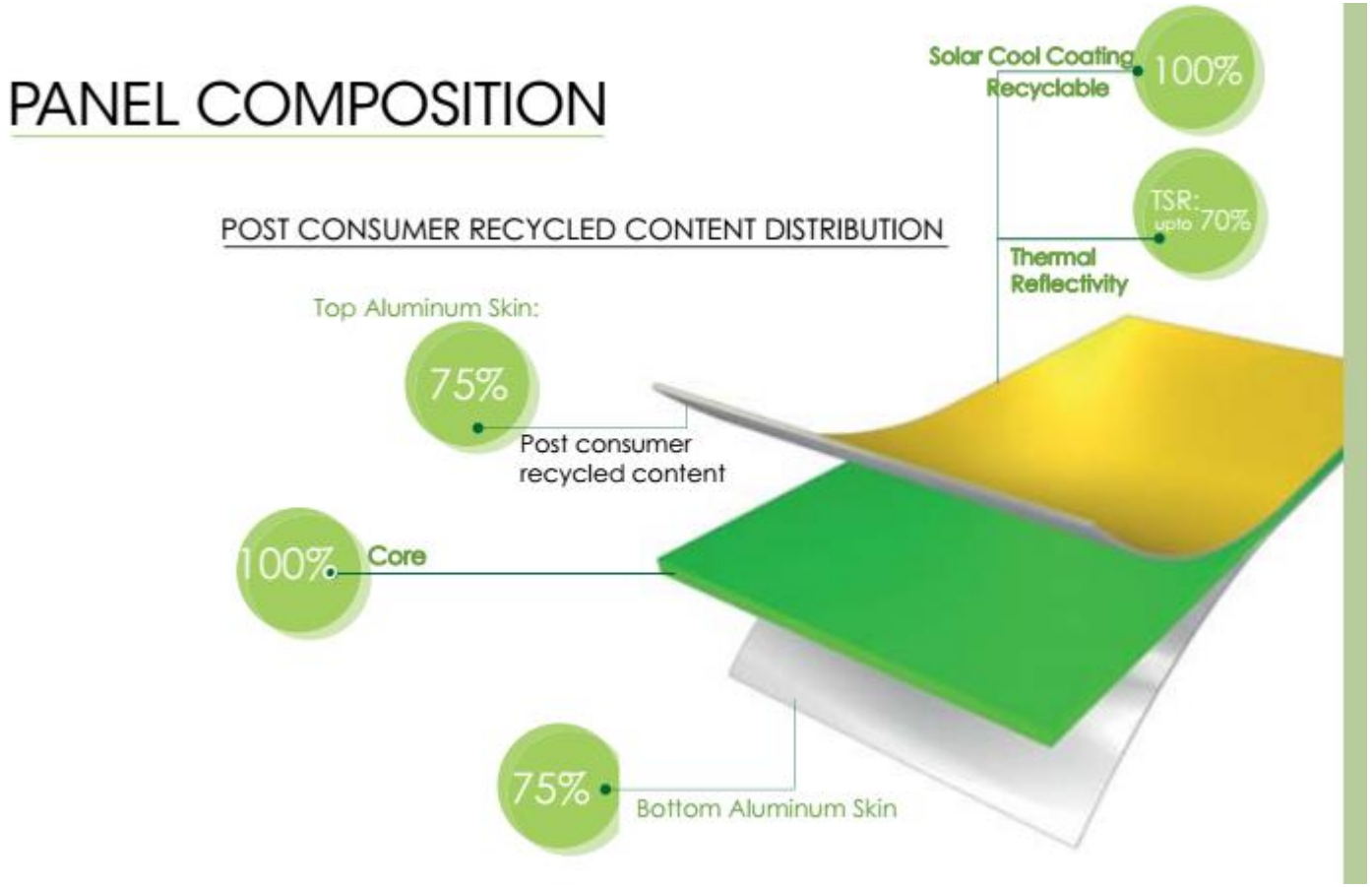
Sustainability

- "…meeting the needs of the present generation without compromising the ability of future generations to meet their needs."
- **Sustainable Design & Construction Actions**
  - Energy efficient buildings
  - Re-use existing structures
  - Efficient land use
  - Use of renewable products / materials
  - Protect soil and water resources
  - Reduce / eliminate pollution
- **Sustainability - addressed on a Life Cycle basis**

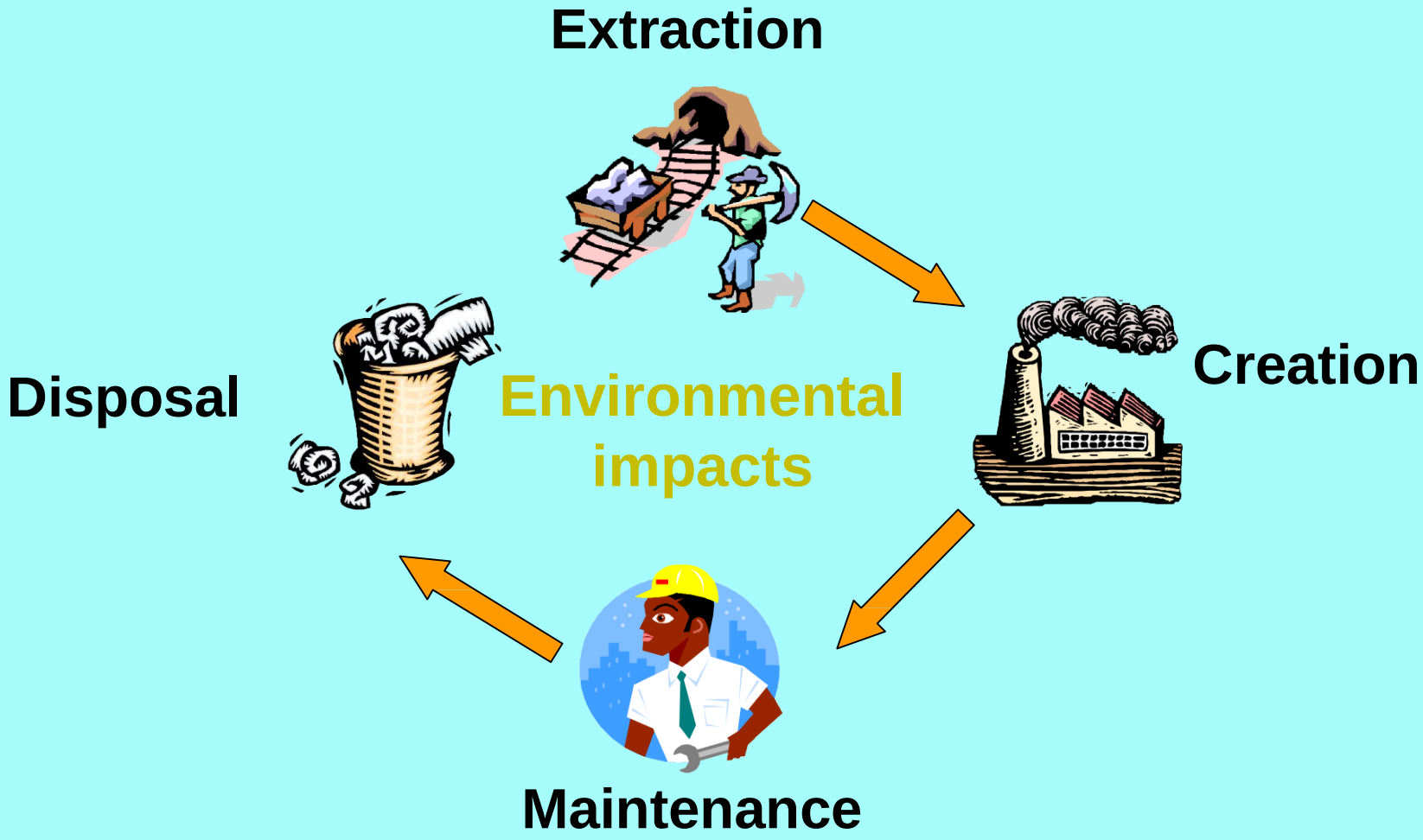
Aluminum Composite Panels: Sustainability

- Product Cycle





Life Cycle Assessment (LCA)



Environmental Profiles 2008 Impact categories

Environmental Issue	Weighting (%)
Climate Change	21.6
Water extraction	11.7
Mineral resource depletion	9.8
Stratospheric ozone depletion	9.1
Human toxicity	8.6
Ecotoxicity to water	8.6
Nuclear waste	8.2
Ecotoxicity to land	8.0
Waste disposal	7.7
Fossil fuel depletion	3.3
Eutrophication	3.0
Photochemical ozone creation	0.20
Acidification	0.05

How are Cladding & Facades assessed within BREEAM and The Code?

- Points available within the materials specification credit
  - **External walls**

Elements assessed	Non Domestic schemes												Domestic		
	BREEAM														
	Bespoke	Offices (design)	Offices (fit out)	Retail (design)	Retail (fit out)	NEAT (NHS)	Healthcare	Prisons	Schools	Courts	Industrial	Further Education	EcoHomes (2006)	Multi-Residential	Code For Sustainable Homes
Upper Floors	Y	Y		Y		Y	Y	Y	Y	Y		Y	Y	Y	Y
Ground Floors													Y		Y
External walls	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Roofs	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Floor Finishes	Y		Y		Y	Y	Y		Y	Y		Y		Y	
Windows	Y	Y		Y		Y	Y		Y	Y		Y	Y	Y	Y
Internal walls/partitions	Y		Y		Y	Y	Y		Y	Y		Y	Y	Y	Y
Hard landscaping	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	
Boundary protection	Y	Y		Y		Y	Y	Y	Y	Y	Y	Y	Y	Y	

Green Guide performance for external cladding finishes

- Cladding on framed construction
  - **Steel or timber framed performs well (A and A+)**
  - **Claddings include**
    - ***Copper***
    - ***Canadian cedar***
    - ***Clay tiles***
    - ***Concrete tiles***
    - ***Polymeric render***
    - ***Pre-treated softwood***
    - ***PVC weatherboarding***
    - ***UK Natural slate***
    - ***Glass reinforced Plastic (GRP)***
  - **Sheathing material is important**
    - ***Plywood sheathing has a higher impact than OSB***

Green Guide performance for external cladding finishes

- Cladding on loadbearing masonry
  - ***Autoclaved fibre cement, Fibre cement sheet, Concrete tiles, Cement rendered blockwork***
  - ***Canadian Western Red cedar, treated softwood***
  - ***Clay tiles, Terracotta***
  - ***Coated steel composite profiled panels / single sheet, copper sheet***
  - ***Imported granite / marble, limestone, sandstone, natural UK slate***
  - ***PVC weatherboarding***

  - **Timber and PVC weatherboarding specifications perform well (A+)**
  - **Coated steel composite panels perform well (A)**
  - **Imported stones and sandstone specifications perform less well (B)**
  - **Slate rainscreen cladding performs poorly (E)**
    - ***High mineral resource extraction & ozone depletion***

Green Guide performance for external cladding finishes

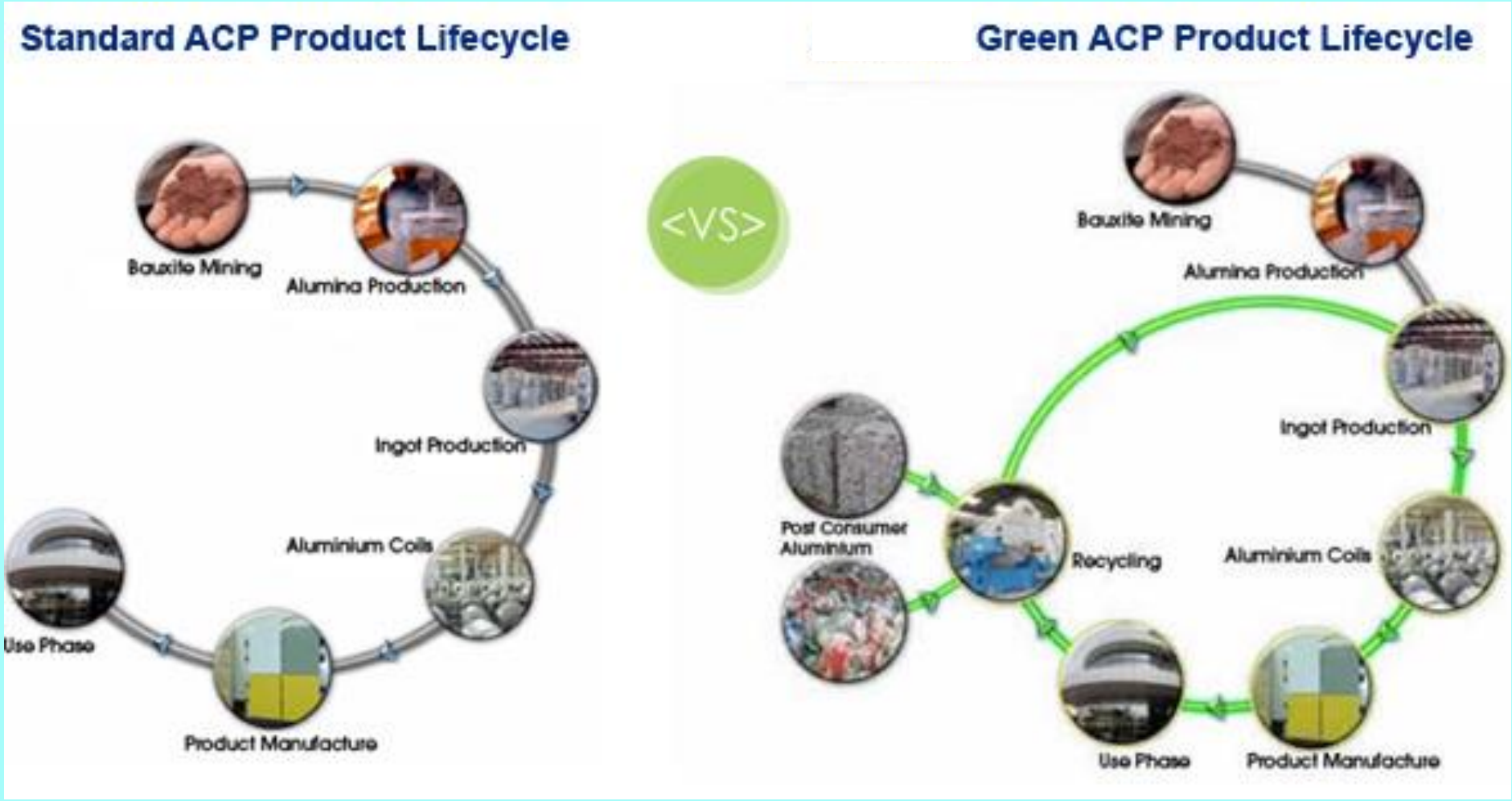
- Rainscreen claddings
  - **On various different frames & infills**
    - ***Precast concrete panels with stone facing specifications performs poorly***
      - **High climate change impacts**
    - ***Autoclaved fibre cement sheet and coated aluminium / steel profiled sheet perform well***
      - **Low climate change & mineral resource extraction**
    - ***Treated softwood performs very well***
      - **Low climate change & water extraction**
    - ***Coated steel / aluminium composite profiled insulated panels mostly all get A's***
- Curtain walling systems (aluminium, timber or precast concrete)
      - **Poor ratings with range from B - E**

Life Cycle of Different Cladding Systems

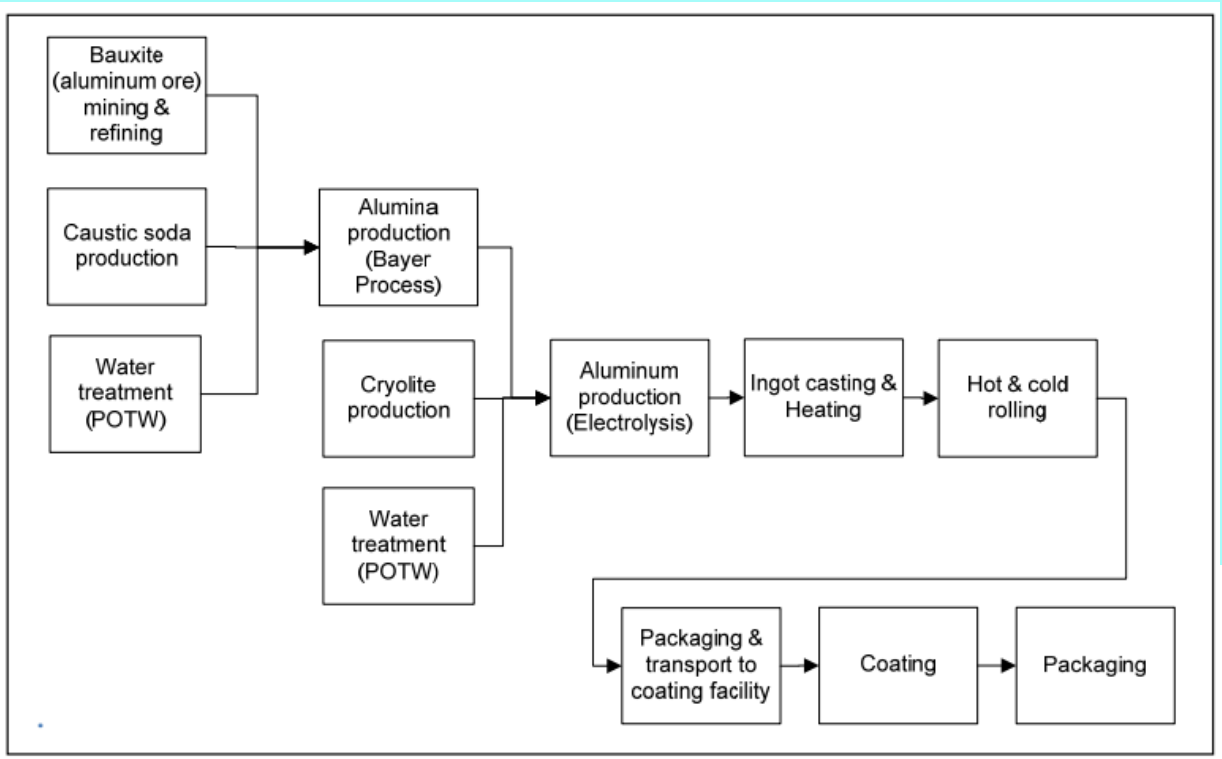
Precast Concrete Cladding

- Precast cladding is used in a variety of commercial and residential building types. It can be of custom design or one of many proprietary systems.
- Precast panels range in size from small spandrel units to entire wall units and are limited only by available transportation and erection methods. Precast cladding is commonly used as a component of non-load-bearing curtain-wall assemblies.
- It may also be used as a veneer over load-bearing concrete or masonry walls or as a substrate for other finish materials

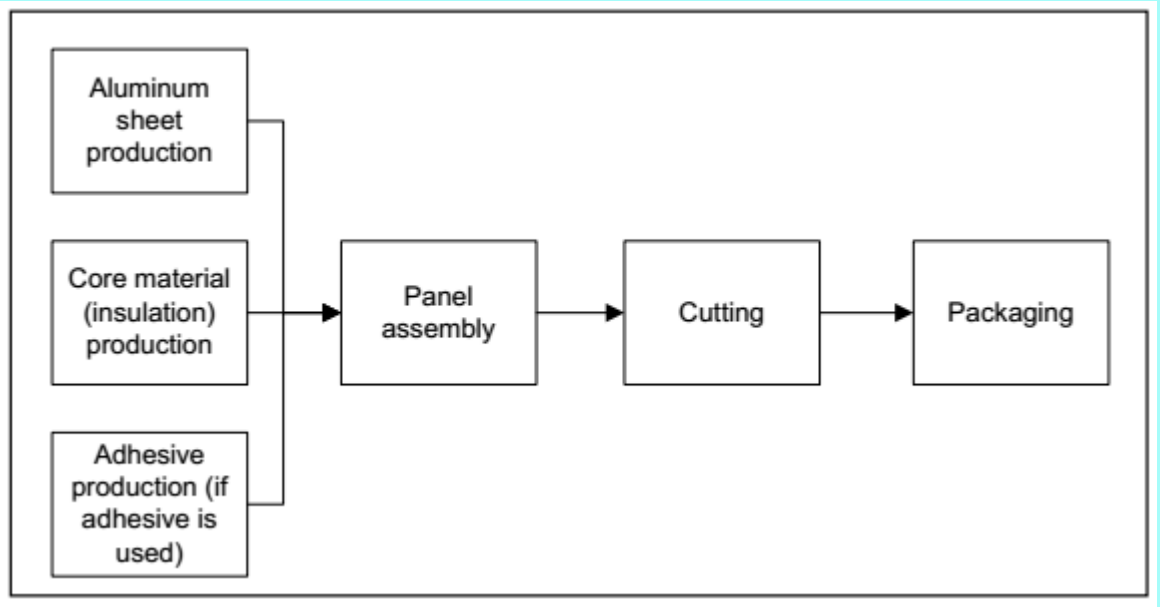
Aluminum Composite Panels: Life-Cycle and Sustainability



Aluminum Composite Panels: Life-Cycle



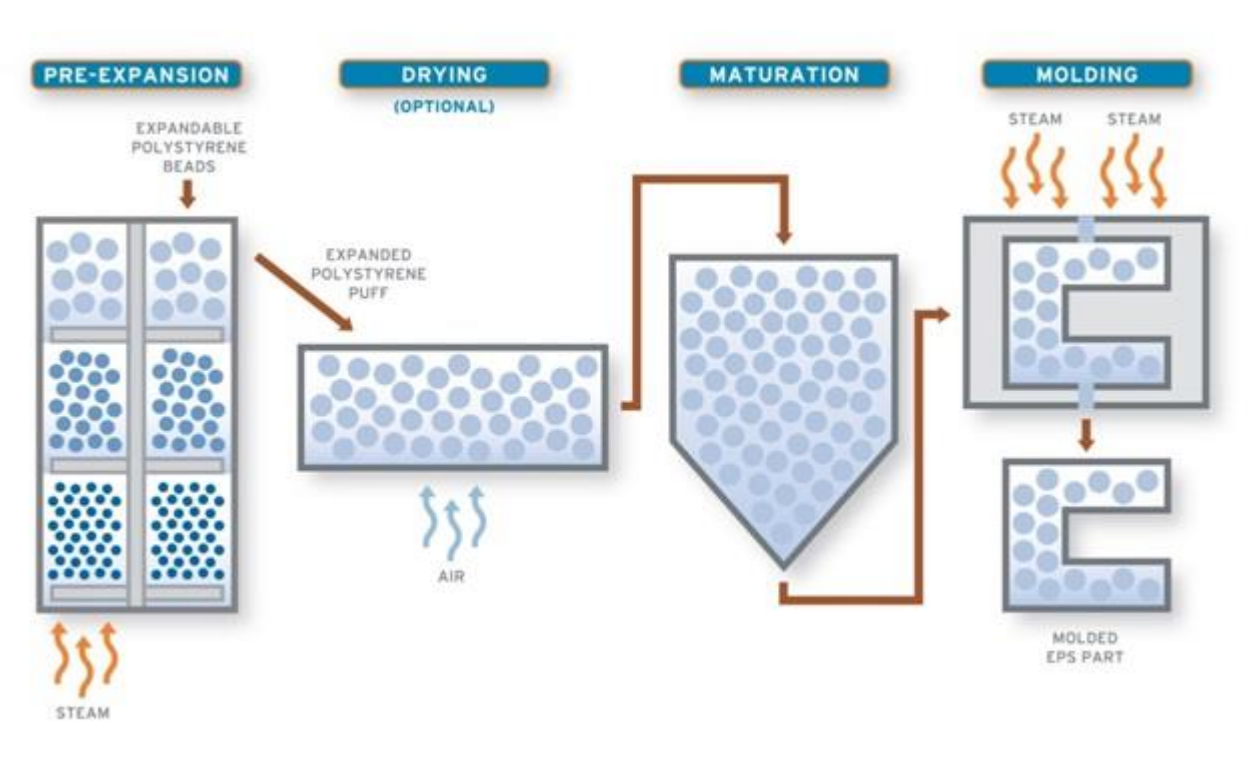
Production of aluminum sheet.



Production of aluminum composite panels.

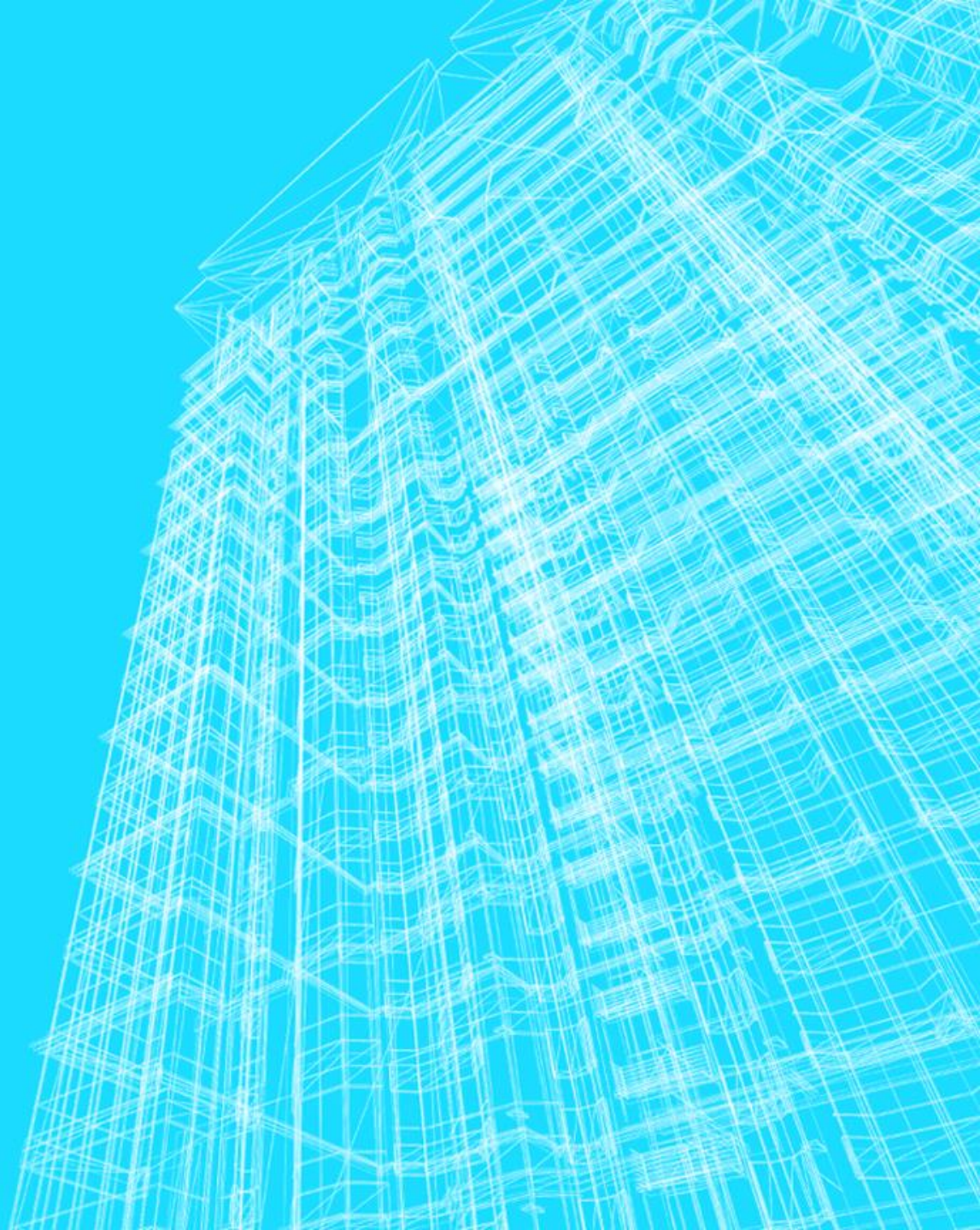
EIFS: Life-Cycle

EIFS: Life cycle



EIFS: Manufacturing

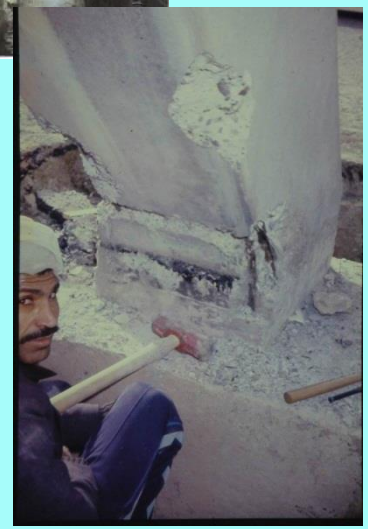
Maintenance, repair and Retrofitting



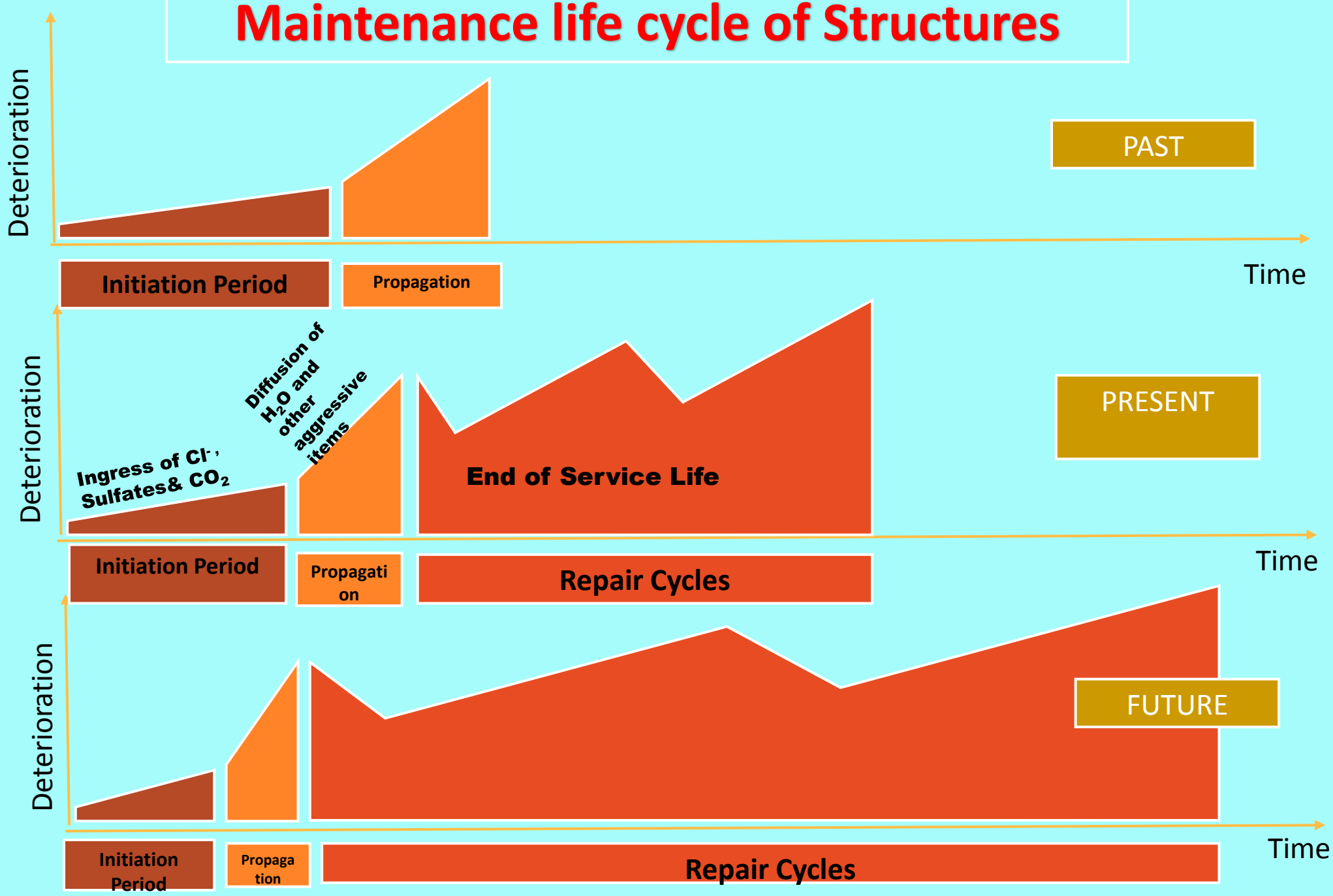
Importance Of Maintenance

Cost of Maintenance

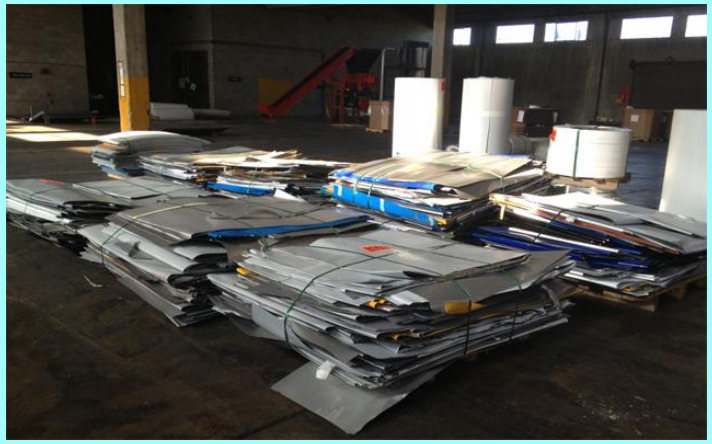
- Although accurate figures are hard to come by, it is estimated that the world spend about US $5.0 Trillion in construction which translates into a work potential of $14 billion per day on global scale .
- In the United States conservative estimates of the current cost to rehabilitate deteriorating concrete structures are in the 130 billion dollar range.
- Within Europe it has been estimated that the value of the infrastructure built environment represents around 50% of the national wealth of most countries. Around 50% of the expenditure in the construction industry in Europe is spent on repair, maintenance and remediation.



Maintenance life cycle of Structures



Aluminum Composite Panels: Reuse and Recycling

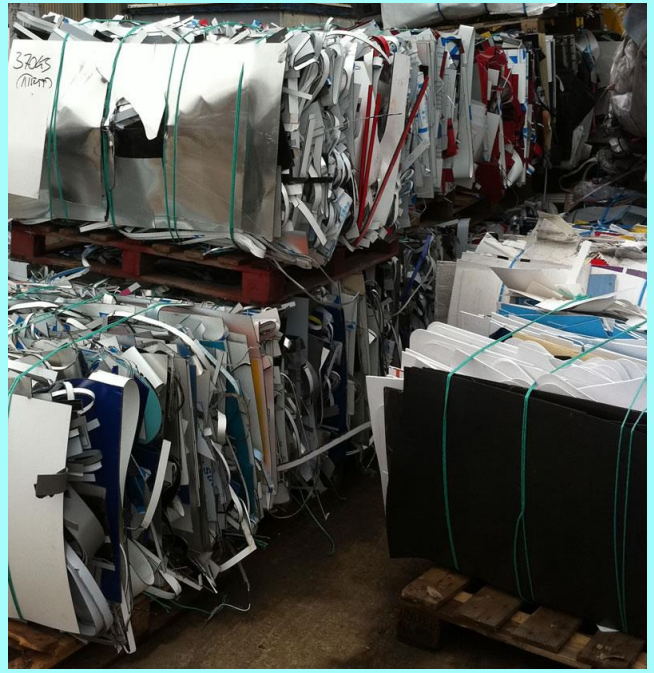


Aluminum Composite Panels - ACP or ACM - Polyethylene core of LDPE, LLDPE or Fire-retardant LDPE sandwiched between 3XXX alloy aluminim skins

Aluminum Composite Panels: Reuse and Recycling

- Fabricators Scrap - ACP or ACM scrap panel from construction projects and signage projects

Aluminum Composite Panels: Reuse and Recycling



- Various scrap smelted down into its core elements for reuse.

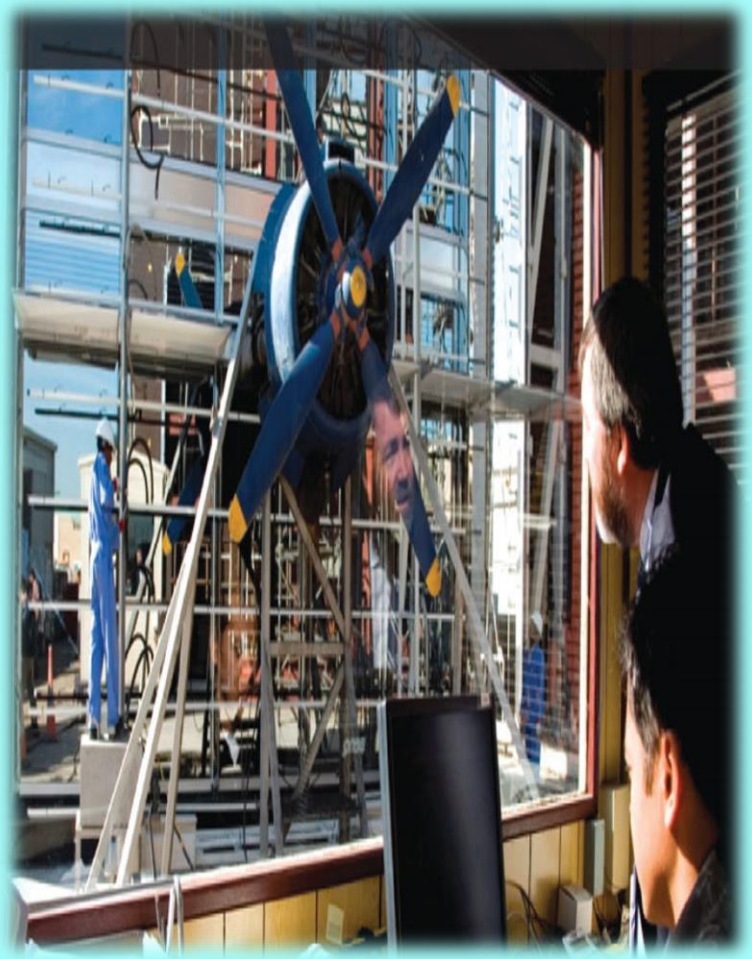
A Case Study

Cladding of Burj Khalifah

- The Burj is cladded with high-tech glass which forms as a curtain wall.
- The exterior cladding is comprised of reflective glazing with aluminum and textured stainless steel spandrel panels and stainless steel vertical tubular fins.
- If the whole cladding has to be done with high-tech glass which will cost about 100 million dollars.

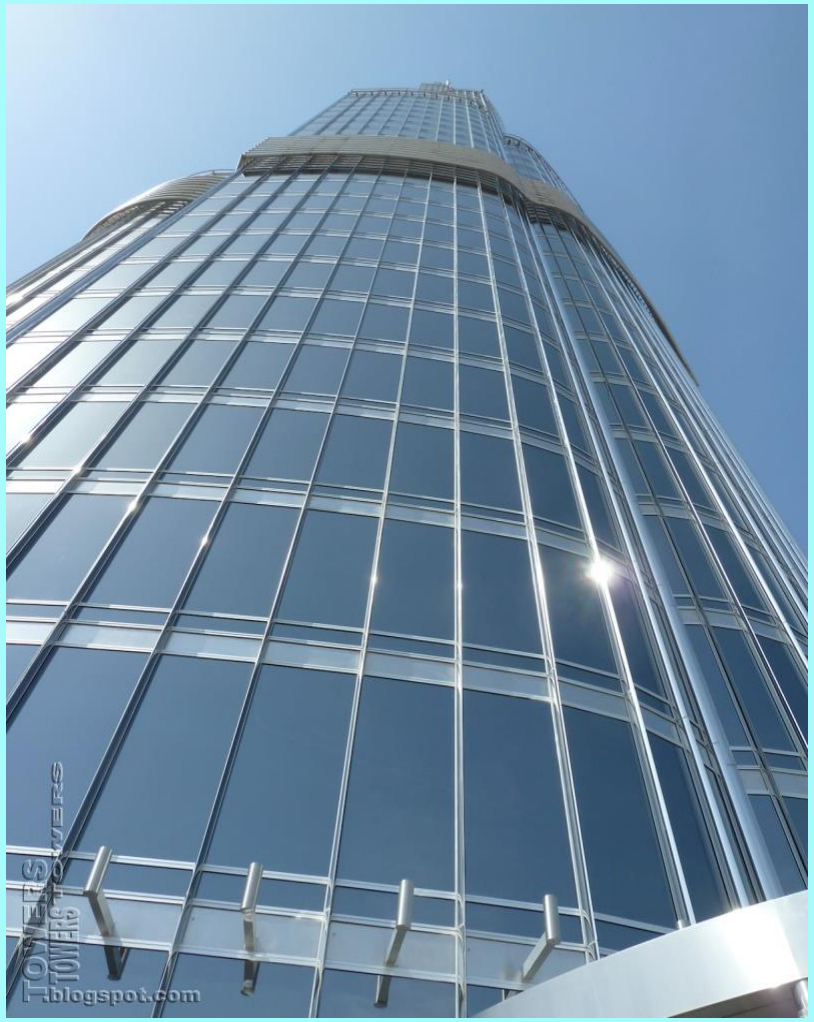
Test for the Cladding against Storm

- The cladding should withstand the heavy sand storms that with in include water and dust
- Prototypes were selected and with the help of propellers artificially created storm was allowed to hit the glass panels at a greater speed
- The glass panels withstands the storm up to 75km/hr .



Glass panel

- The outer layer of panel is coated with a thin layer of metal so that it reflects the UV radiations
- The inner layer of panel is coated with thin layer of silver so that it reflects the IR radiations.
- The exterior cladding is comprised of reflective glazing with aluminum and textured stainless steel spandrel panels and stainless steel vertical tubular fins.
- Close to 26,000 glass panels, each individually hand-cut, were used in the exterior cladding of Burj Khalifa.

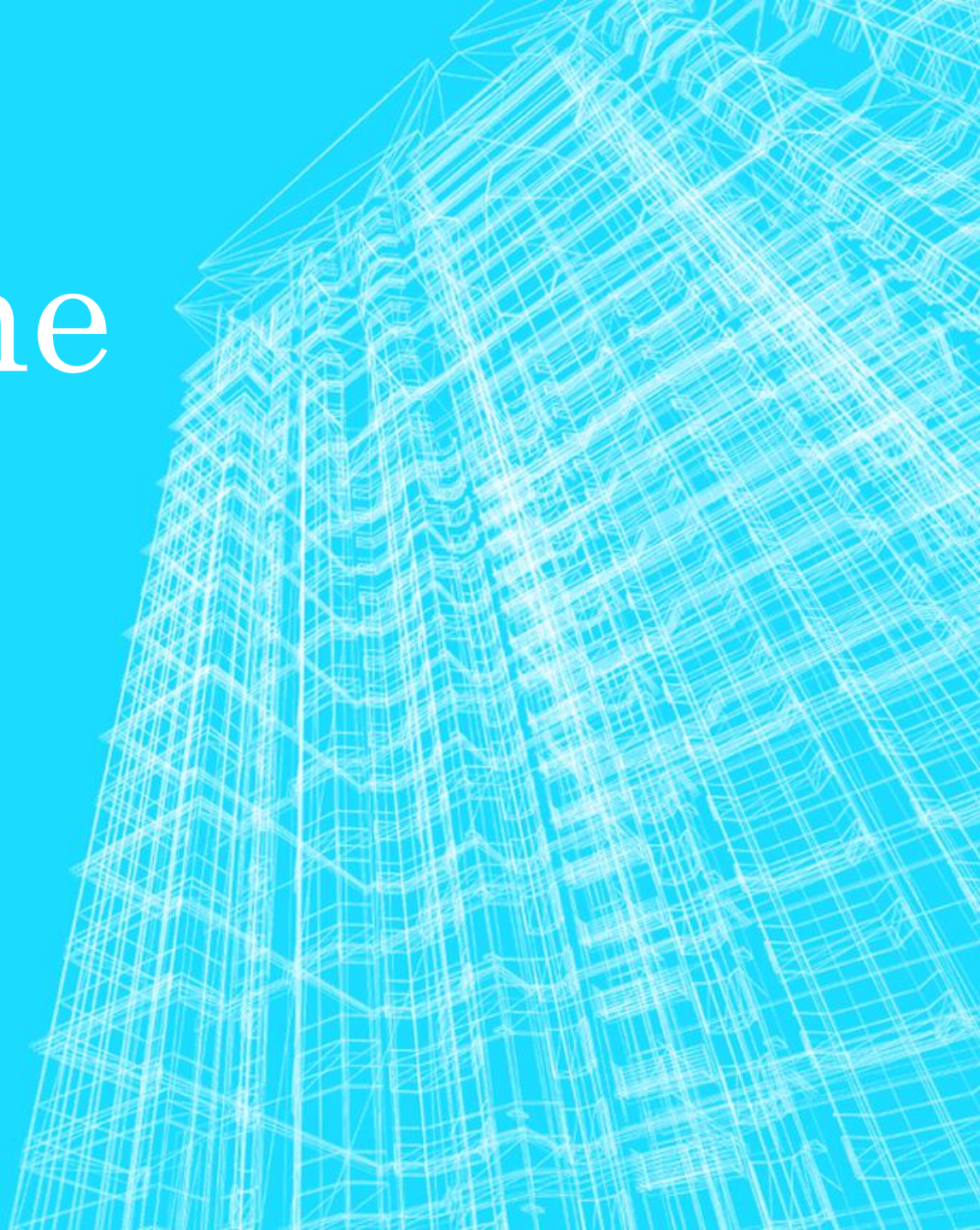


Evacuation and Fire Safety

- The Burj is naturally fire resistant as the concrete backbone is already fire resistant
- More than that the Burj consist of refuge rooms
- These refuge rooms are made of RCC and fire proof sheets that resist the heat up to 2hrs
- These refuge rooms has a special supply of air which pumps through fire resistant pipes
- There are 9 refuge rooms, one in every 30 floors.
- The Burj fire safety system mainly consist of 3 components
  - ✓ A smoke detector
  - ✓ Water sprinkler
  - ✓ High power fans

As the water is sprinkled the fire gets extinguished and the high power fans supplies fresh air by pushing the smoke out.

GFRC Is It One the Solutions



Glass Fiber Reinforced Concrete

Under construction

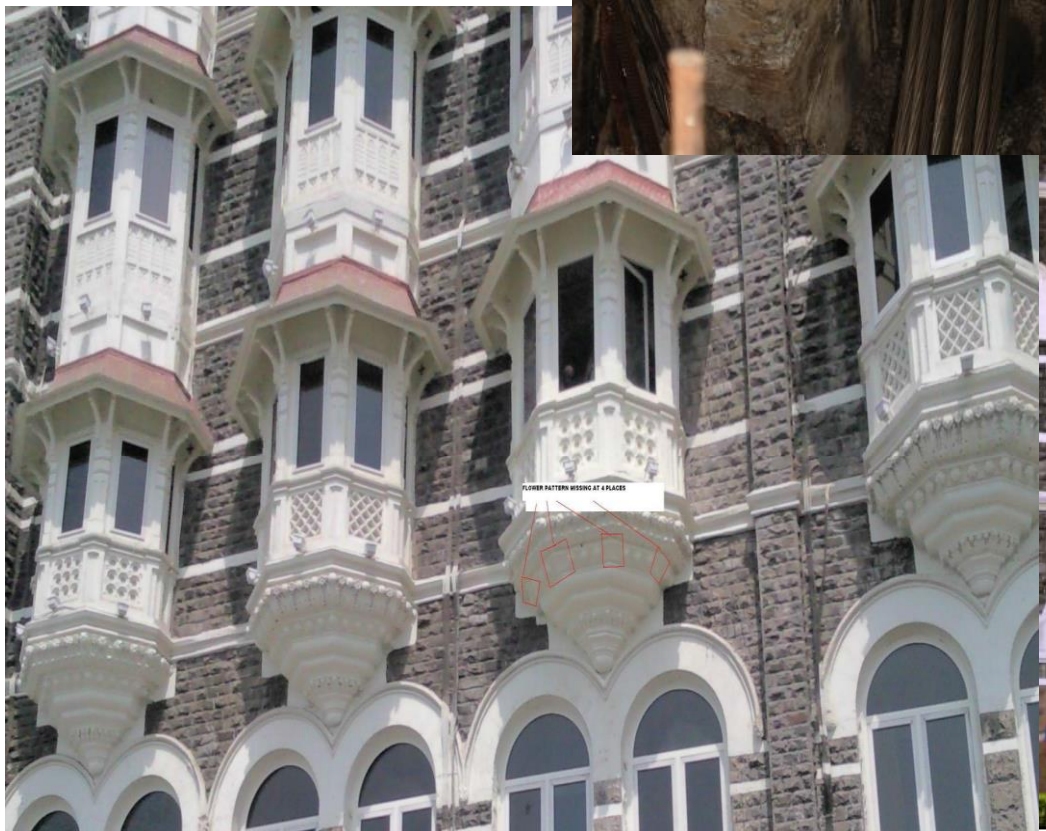
Post construction

WHAT IS GLASS FIBER CONCRETE ?

- GFRC is similar to chopped fiberglass (the kind used to form boat hulls and other complex three-dimensional shapes), although much weaker. It’s made by combining a mixture of fine sand, cement, polymer (usually an acrylic polymer), water, other admixtures and alkali-resistant (AR) glass fibers. Many mix designs are available online, but you’ll find that all share similarities in the ingredients and proportions used.

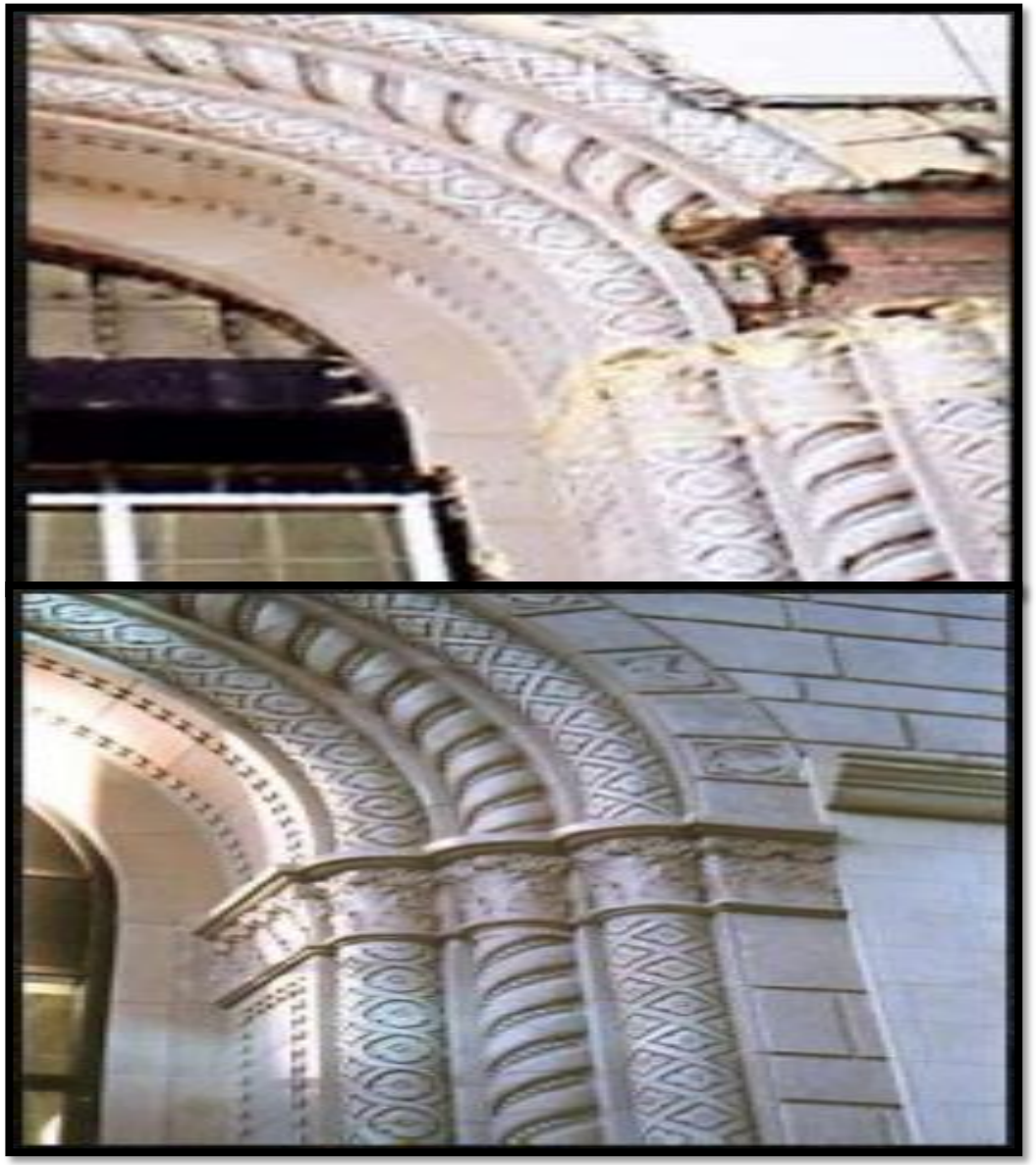
- The glass fibers used in GFRC help give this unique compound its strength. Alkali resistant fibers act as the principle tensile load carrying member while the polymer and concrete matrix binds the fibers together and helps transfer loads from one fiber to another. Without fibers GFRC would not possess its strength and would be more prone to breakage and cracking.

REPLACEMENT BALCONY BY GRC (taj hotel)



ADVANTAGES OF GFRC

- High strength can be obtained by using GFRC, being tough and resistant to cracking. It has a high ratio of strength-to-weight. Therefore, the GFRC products are durable and light. The transportation costs are reduced significantly being of less weight.
- Since GFRC is internally reinforced, other types of reinforcement are not necessary that may be complicated for complicated molds.
- Suitable consolidation of mix is achieved for GFRC that is sprayed, without any vibrations. Use of rollers or vibrations, to attain consolidation, is simple for GFRC that is poured.
- A good surface finish is obtained, without voids, since it is sprayed and such defects do not appear.
- Since the materials have a fiber coating, they are unaffected by the environmental effects, corrosion attacks, and other harmful effects.

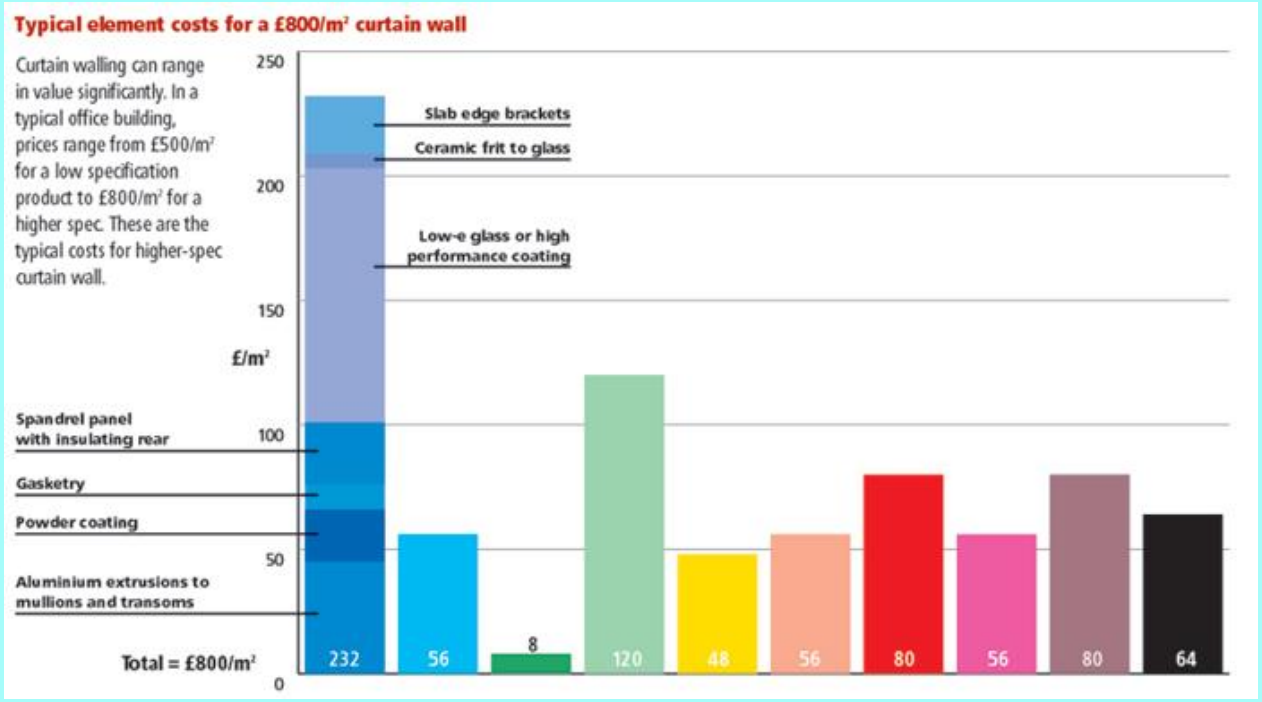


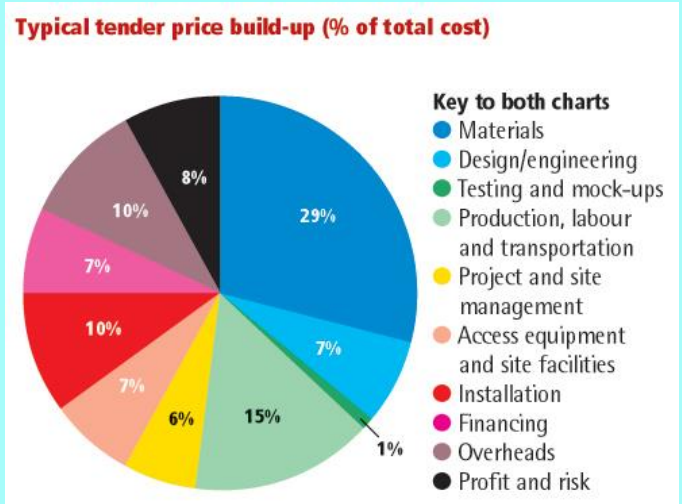
Repair Case Using GFRC

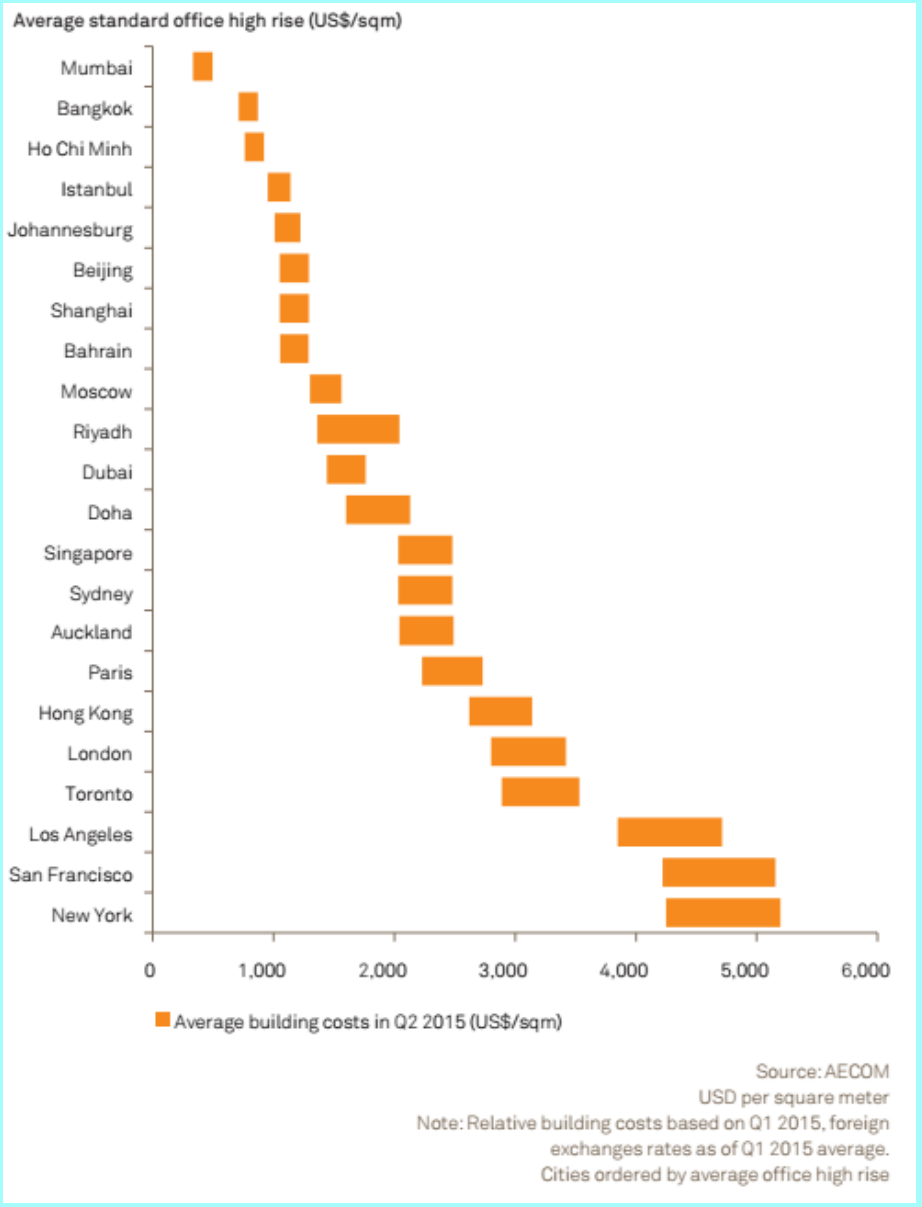
BENEFITS OF GFRC

- Improve mix cohesion, improving pump ability over long distances
- Improve freeze-thaw resistance
- Improve resistance to explosive spelling in case of a severe fire
- Improve impact resistance
- Increase resistance to plastic shrinkage during curing

Average building Costs – Commercial Offices







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http://www.icc-es.org/News/eNews/0708/EIFS.pdf

Observation

Materials + Manufacture + Transportation + Erection + Finishing

Strength + Durability + Impermeability + Pleasant Appearance + Utility + Insulation + Resistance to Fire + Resistance to Chemical Attack + Resistance to Vibration + Monitoring + MAINTAINABILITY

THANK YOU FOR YOUR ATTENTION