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
Sharjah Research Academy
Sharjah Research Academy

Regional Courses for the Management of Heritage Buildings

Utilization of Reeds for Low-cost Housing

Economy research has been carried out in the marches of Iraq to study palm trees, reeds, and reeds as building materials for heritage housing. The implementation of this technology in one of the villages in Iraq shows that it is possible to produce building elements with sustainable strength and durability at a low cost using locally available material. The embankment and islands using reed reinforcement proved to be very efficient.

**Walls:**
The typical dike is built from reeds clustered, which consists of long and thin bundles making continuous volume and bordering and then bundles at points. The solution involves reeds that are placed on the bottom of the beam with some gaps to allow the air to pass through during the summer and allow growth and water with reeds.

**Tidal Embankment:**
A full scale fully instrumented tidal embankment was set up in the area. A 1.5 m high, 4 km long, and 5 m wide test embankment in a harbor, was completed in 1998. The test embankment included preliminary corrosion tests, laboratory, and theoretical studies. The results showed that the embankment construction and maintenance using reed reinforcement proved to be very efficient.

**Reeds Panels:**
The use of clusters of reeds at the base of the embankments was very effective in increasing the lateral deformation of the embankment foundation with the reeds acting as a stabilizer.

**Applications of Reeds for Sewage Treatment:**

Sharjah Research Academy

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 of Operation and Maintenance "AIOM" elected Sharjah Research Academy to become a member of the Board of Directors meeting in Dubai. This election was performed after the Academy was the first research institutes in the Arab League of research institutes and its applications.

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

DSMA has signed a Memorandum of Understanding (MoU) with the Portuguese National Laboratory for Civil Engineering (LNEC) in order to exchange research on the availability of different infrastructure in maintenance. The LNEC, established in 1961, is one of the leading Portuguese research institutes.

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

The meeting was held to discuss the technical committees' responsibility for building standards, metrology, and quality and the International Organization for Social Security in Middle East.

Sharjah Research Academy Signs a Memorandum of Understanding with URUK

DSMA signed an MoU 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**

**Support Framing**
- Holds the exterior material to the building.
- Transfers loads imposed on exterior to structural frame.

**Interior Finishes**
- Architectural treatment applied to interior face of supporting frame.

**Internal Drainage**
- Air gaps, weep holes and sealants as prevention against water leakage.

**Joints**
- Ease of construction between panelised systems.
- Compensate for movement.

**Insulation**
- Sandwiched into panels or added in the form of batts, blankets, rigid boards or fills.
- Example: Gypsum Board

**Framing**
- Holds the exterior material to the building.
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

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 (ACP 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

<table>
<thead>
<tr>
<th>TEST</th>
<th>TEST METHOD</th>
<th>CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fire Resistance</td>
<td>ASTM E 119</td>
<td>No effect on the fire resistance of a rated wall assembly</td>
</tr>
<tr>
<td>Ignitability</td>
<td>NFPA 268</td>
<td>No ignition at 12.5 kw/m² at 20 minutes</td>
</tr>
</tbody>
</table>
| 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

<table>
<thead>
<tr>
<th>Test</th>
<th>Test Method</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface Burning Characteristics</td>
<td>ASTM E 84</td>
<td>All components shall have a: Flame Spread ≤ 25, Smoke Developed ≤ 450</td>
</tr>
</tbody>
</table>
Fire and Life Safety Codes and Testing
Horizontal separation shall be measured at a 90-degree angle to the exterior wall.

<table>
<thead>
<tr>
<th>OCCUPANCY</th>
<th>0 to 1.5</th>
<th>More than 1.5 to 3</th>
<th>More than 3 to 9</th>
<th>More than 9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assembly, educational, day care, health care, ambulatory health care, detention and correctional, residential, residential board and care, business, industrial, and low hazard storage</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Mercantile and industrial and storage occupancies with ordinary hazards</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Industrial and storage occupancies with high hazards</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

- **Fire Rating for Exterior Walls (hr)**

- 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)

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

Non-Combustible Construction Types I, II, III, or IV?  
(Per Commercial Building Code, IBC)
NFPA 285 Wall Assembly: Exterior Insulation

Air & Water Barriers – §1403.5

Combustible Claddings
- EIFS - § 1408.2
- MCM - § 1407.10
- FRP - § 2612.5
- HPL - § 1409.10

Foam Plastic Insulation – § 2603.5.5
Wall Assembly: Exterior Cladding

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

Air & Water Barriers – §1403.5

Combustible Claddings
- EIFS - § 1408.2
- MCM - § 1407.10
- FRP - § 2612.5
- HPL - § 1409.10

Foam Plastic Insulation – § 2603.5.5
Variations in Wall Assemblies

\[ T(\text{°C}) = 750(1 - e^{-0.49/\sqrt{t}}) + 22\sqrt{t} + 20 \]

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Temperature °F (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>1000 (538)</td>
</tr>
<tr>
<td>10</td>
<td>1300 (704)</td>
</tr>
<tr>
<td>30</td>
<td>1550 (843)</td>
</tr>
<tr>
<td>60</td>
<td>1700 (927)</td>
</tr>
<tr>
<td>120</td>
<td>1850 (1010)</td>
</tr>
<tr>
<td>240</td>
<td>2000 (1093)</td>
</tr>
</tbody>
</table>

ASTM E119 Time-Temperature Curve

Standard fire-resistance test evaluation criteria
ASTM E1354 Cone Calorimeter Test
Sustainability and Life-Cycle
The reason for recent changes in the construction industry is the increasing attention being given to sustainable design.
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)

- Extraction
- Creation
- Maintenance
- Disposal
- Environmental impacts
Environmental Profiles 2008 Impact categories

<table>
<thead>
<tr>
<th>Environmental Issue</th>
<th>Weighting (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate Change</td>
<td>21.6</td>
</tr>
<tr>
<td>Water extraction</td>
<td>11.7</td>
</tr>
<tr>
<td>Mineral resource depletion</td>
<td>9.8</td>
</tr>
<tr>
<td>Stratospheric ozone depletion</td>
<td>9.1</td>
</tr>
<tr>
<td>Human toxicity</td>
<td>8.6</td>
</tr>
<tr>
<td>Ecotoxicity to water</td>
<td>8.6</td>
</tr>
<tr>
<td>Nuclear waste</td>
<td>8.2</td>
</tr>
<tr>
<td>Ecotoxicity to land</td>
<td>8.0</td>
</tr>
<tr>
<td>Waste disposal</td>
<td>7.7</td>
</tr>
<tr>
<td>Fossil fuel depletion</td>
<td>3.3</td>
</tr>
<tr>
<td>Eutrophication</td>
<td>3.0</td>
</tr>
<tr>
<td>Photochemical ozone creation</td>
<td>0.20</td>
</tr>
<tr>
<td>Acidification</td>
<td>0.05</td>
</tr>
</tbody>
</table>
How are Cladding & Facades assessed within BREEAM and The Code?

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

<table>
<thead>
<tr>
<th>Elements assessed</th>
<th>Non Domestic schemes</th>
<th>Domestic</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>BREEAM</td>
<td></td>
</tr>
<tr>
<td>Bespoke</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Offices (design)</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Offices (fit out)</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Retail (design)</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Retail (fit out)</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>NEAT (NHS)</td>
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<td>Y</td>
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<tr>
<td>Healthcare</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Prisons</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Schools</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Courts</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Industrial</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Further Education</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>EcoHomes (2008)</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Multi-Residential</td>
<td></td>
<td>Y</td>
</tr>
<tr>
<td>Code For Sustainable Homes</td>
<td></td>
<td>Y</td>
</tr>
</tbody>
</table>

- Upper Floors: Y
- Ground Floors: Y
- External walls: Y
- Roofs: Y
- Floor Finishes: Y
- Windows: Y
- Internal walls/partitions: Y
- Hard landscaping: Y
- Boundary protection: 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
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

- PAST
- PRESENT
- FUTURE

Initiation Period
Propagation
Repair Cycles
End of Service Life

Deterioration

Time
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 aluminum skins
Aluminum Composite Panels: Reuse and Recycling

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

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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