Issue **12** - Sep: - Oct: 2022

Ceylon Institute of Builders
CIOB
Institute for Building Professionals
Established - 1961

SRI LANKA CONSTRUCTION TODAY

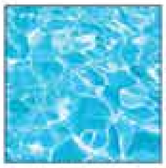
Empowering towards Sustainable Construction

"Resolving Current Issues in the Construction Industry"
On 15th November 2022 in Colombo.


DOOR STEP SERVICES


HOUSING/ APARTMENTS


PLUMBING


SWIMMING POOLS


CCTV & ELV/ BMS SYSTEM


WATER PROOFING


STEEL FABRICATION

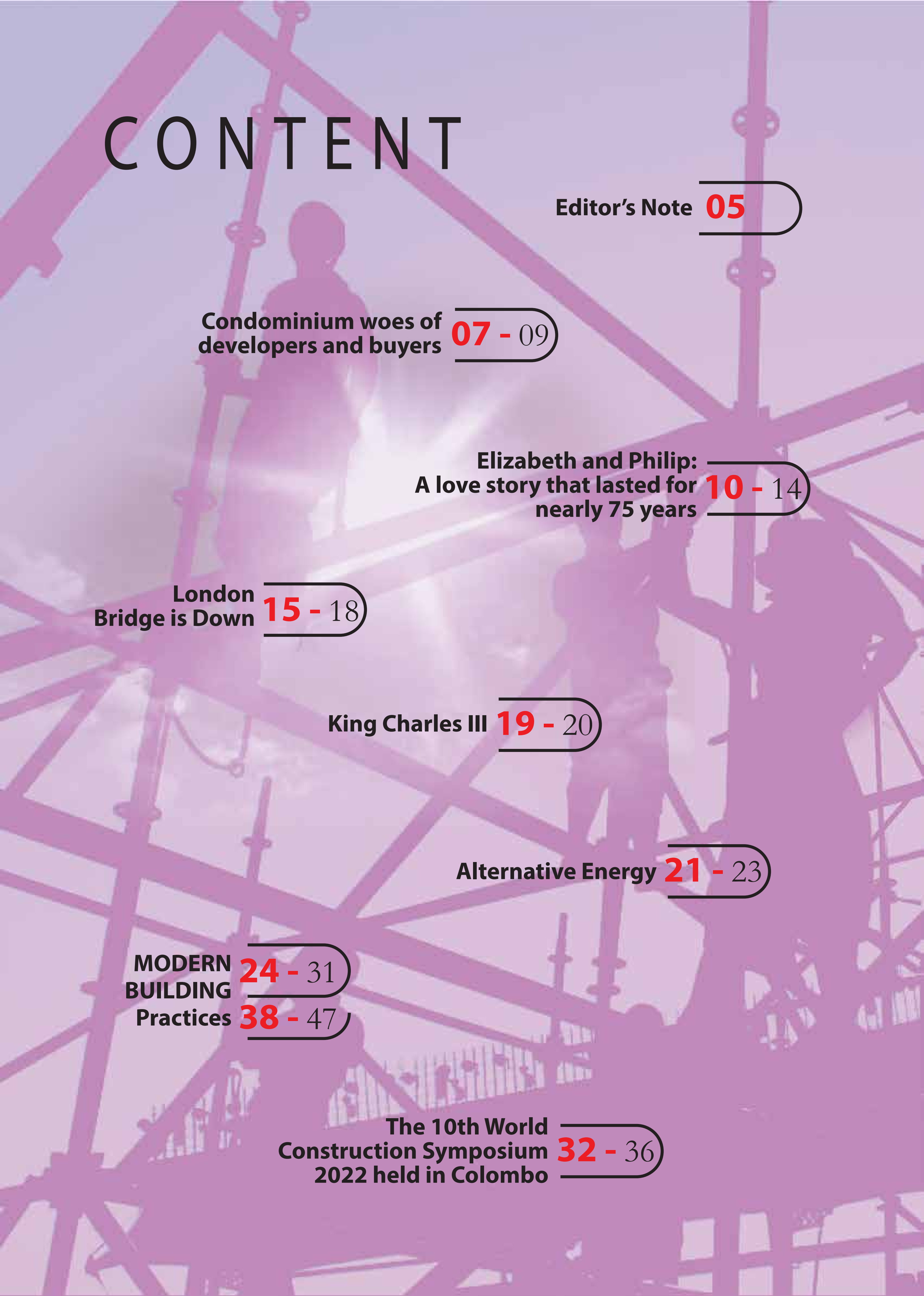

PAINTING


ELECTRICAL SERVICES


PLAYGOURNDS, LANDSCAPING & IRRIGATION


AIR CONDITIONING


CIVIL WORKS



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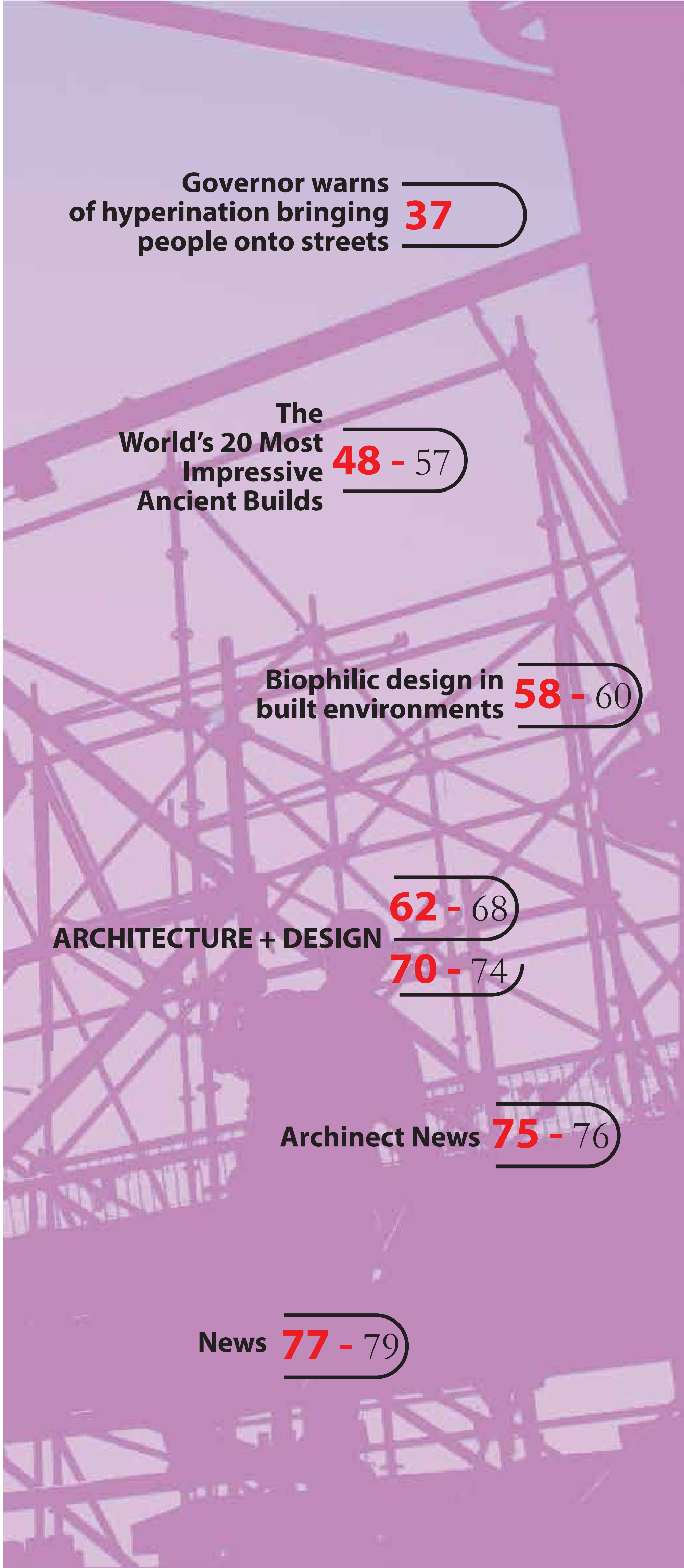

SRI LANKA
CONSTRUCTION
TODAY

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Editor's Note

Sri Lankans desperately need IMF support. The conditions the IMF places on the loan could provide desperately needed relief. The program is expected to limit public spending, including public sector wages. It also recommends fuel and electricity subsidies and increase value-added or consumption taxes which will increase prices when millions of Sri Lankan public are already struggling to make ends meet. IMF is keen on measures the government can take in passing three anti-corruption bills on judiciary, human rights and bribery commissions.

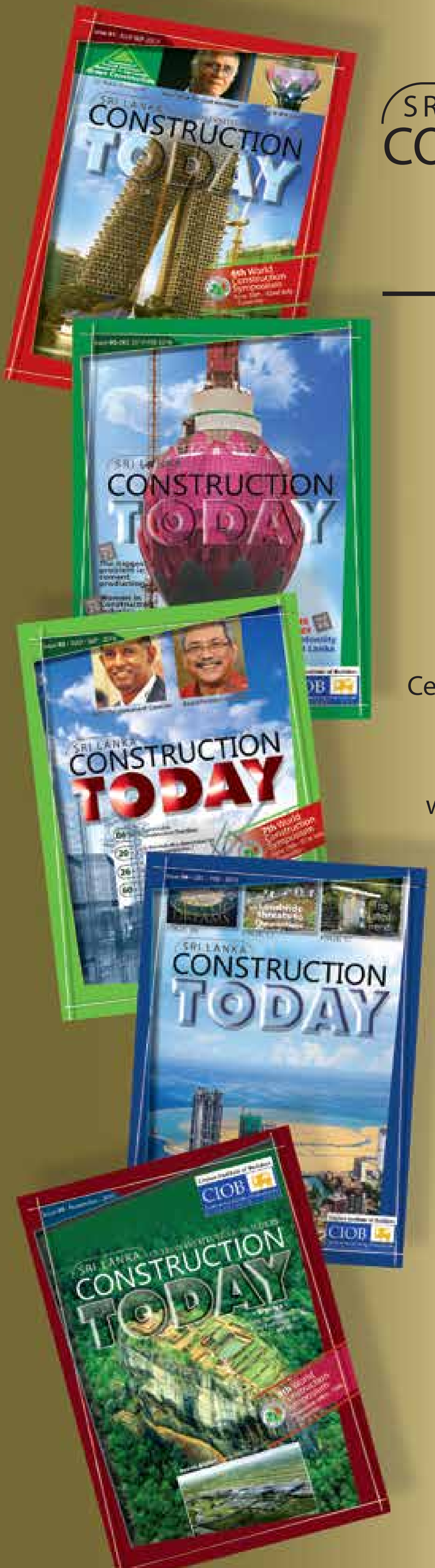
According to Human Rights Watch, the economic crisis is driving Sri Lankan people into poverty, jeopardizing their right to health, education and adequate standard of living. Their advice to the Government is to work with relevant financial institutions and partners to establish a new social protection system and obtain debt relief, adopt measures to ensure fair taxation and address corruption at the highest levels of government.

The United Nations estimation reveals that 5.7 million people in Sri Lanka need humanitarian assistance as 22 percent of the population has become food insecure. They do not have consistent access to adequate nutritious food. International financial institutions and governments involved in debt restructuring need to protect these human beings in a situation of economic crisis. All of them have an international legal obligation under the United Nations Guiding Principles on Business and Human Rights to address adverse human rights impacts.

According to experts, Sri Lanka's deepening economic crisis highlight the need for the government to give priority to the rights of the people. They recommend that the government together with IMF and other foreign creditors should act urgently to reverse the tide that is taking millions of people in to the deep sea of poverty through the economic crisis.

As a badly hit industry construction sector is very anxious on the move of the government. In the current scenario, it is essential for the government to work with relevant international financial institutions and countries to obtain debt relief and adopt fair taxation with a proper social protection system without putting people from frying pan to fire.

Being the 4th largest sector in the economy, the manpower utilized in the industry in various categories consists of a massive number of people. Reviving the industry would therefore extremely necessary to come out of the severe economic crisis engulfed in the Island nation.



SRI LANKA
CONSTRUCTION
TODAY

Ceylon Institute of Builders
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“Resolving Current Issues In the Construction Industry”

Ceylon Institute of Builders & ‘Construction Today’ Magazine has organized a special seminar to address the Present Construction Crisis of the country with the participation of stake holders, representatives of Financial Institutions, Diplomats, Parliament members & other relevant authorities.

On 15th November 2022, 4.30pm to 6.30pm,
At Sri Lanka Foundation Institute, Colombo.

Participation Fee
Rs. 3,000/- members, Rs. 3,500/- non members
Prior registration is essential.

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Condominium woes of developers and buyers

By Sugeeeswara Senadhira

The condominium market is facing a crisis due to construction cost hike in recent months. While some of the major companies try to absorb a substantial share of the price hike, some developers attempt to pass on the entire increase to unsuspecting buyers. Although it is reasonable to demand that some of the buyers, - especially those who are employed overseas and those who are commercial buyers who purchase flats for resale and as an investment- should pay at least a part of the cost increase, those who purchase flats as a place of residence should be exempted from any additional charges.

Many commercial dealers and foreign employed Sri Lankans decided to invest in condominiums to take advantage of the upswing in the condominium market in Sri Lanka before the Covid pandemic and the economic recession.

The Condominium Management Authority (CMA) stated that the absolute rate of growth of condominiums during the past decade is 34%, while it has increased by an unprecedented 64% in 2017 alone, compared to 2016. This was applicable to all three types of condominiums, i.e. super-luxury, luxury, and semi-luxury.

The signal given in 2017 was of a boom in the construction industry. According to the certifications issued by Condominiums authority, it was considered the expectant boom would find a popular solution to the growing housing demand in Sri Lanka, owing to land scarcity, high land prices, and high population density in urban areas.

By 2016, the demand outstrips supply and many investors and traders move in to make quick money. However with increase number of flats available in the market the demand started do drop. In the near future there will be about 5,000 apartments in the market.

However, the developers faced severe construction issues with the economic downturn and price hike since the last quarter of 2021. The Home Land, a giant among developers urged the buyers to understand the current crisis and cooperate with them by sharing the price hike.

In a letter to buyers who signed contracts with Home Land, the company warned them not to be misled by false information spread by some persons with hidden motives and agendas.

It is a fact that such negative comments on social media platforms about a housing project will result in drastic devaluation of the property value, discredit the brand name of the project and depreciate the value of the condominium.

One such false news circulated in the said forum was the existence of a legal case against Home Lands being handled by an industry-leading legal firm regarding one of our landmark projects – Treasure Trove Residencies in Borella. The Home Land pointed out that this project was successfully completed and handed over to all the homeowners 3 years ago and there were no issues as mentioned. The circulated information via the unsolicited social group was aimed to mislead the customers.

The condominiums developed by premier reputed companies experienced a significant property value appreciation due to the quality standards and the novel living concept of the projects. Some of them have witnessed a value appreciation of over 300% in just 03 years.

This value is expected to appreciate further. Most developers sought to increase the prices though initially they had assured to contacted buyers that any cost hike would be borne by the company.

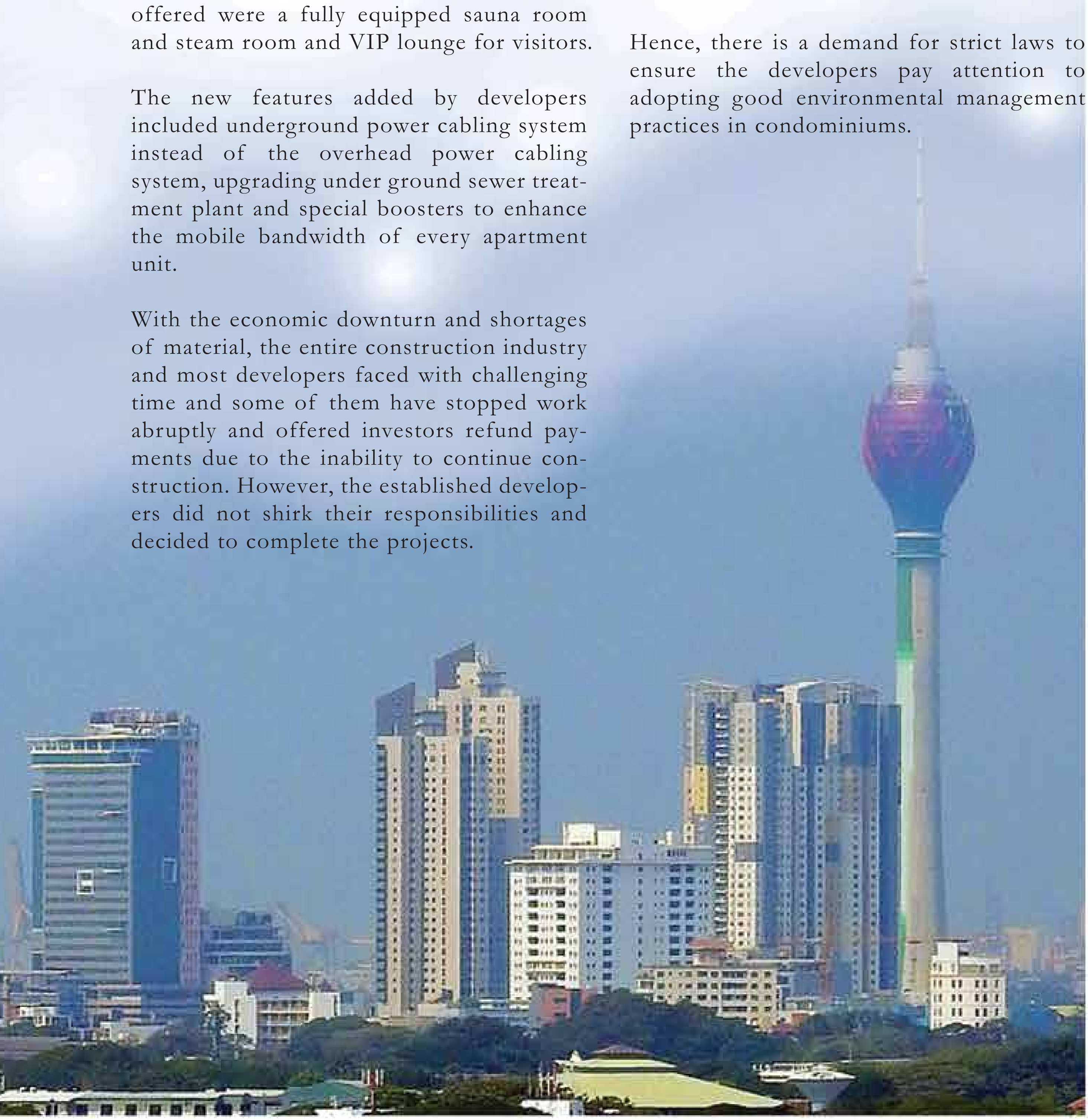
Some premier developers, while hiking the installments offered more facilities to offset the increase in payments. In view of the current electricity cuts due to power crisis, they offered full backup generator to all the project units. Other additional facilities offered were a fully equipped sauna room and steam room and VIP lounge for visitors.

The new features added by developers included underground power cabling system instead of the overhead power cabling system, upgrading under ground sewer treatment plant and special boosters to enhance the mobile bandwidth of every apartment unit.

With the economic downturn and shortages of material, the entire construction industry and most developers faced with challenging time and some of them have stopped work abruptly and offered investors refund payments due to the inability to continue construction. However, the established developers did not shirk their responsibilities and decided to complete the projects.

Some projects faced environmental issues with the upward trend in both the number of condominiums and housing units. The total number of condominiums built in Colombo during the past decade is 727, and constitutes a total of 12,643 units. With that there is an alarming increase in the number of complaints of alleged environmental malpractices; these include sound pollution, insufficient space to dispose garbage, improper mechanisms of waste disposal, and using drinking water to wash vehicles.

Hence, there is a demand for strict laws to ensure the developers pay attention to adopting good environmental management practices in condominiums.



Elizabeth and Philip: A love story that lasted for nearly 75 years

By Leigh Tonkin

The official wedding picture of Princess Elizabeth and her new husband the Duke of Edinburgh, after their return to Buckingham Palace in November, 1947.

It was a love affair that spanned 73 years, the longest of any British monarch.

And in many ways, the love of Queen Elizabeth and her life partner Prince Philip - who died aged 99 - rewrote the rulebook, with an ardent partnership, enduring bond and strong work ethic.

While the public displays from some of her forebears were somewhat mixed - including beheadings and the invention of divorce - the Queen and her consort presented a united front and weren't afraid to declare it.

Not long after their wedding, Queen Elizabeth put it simply in a letter to her parents: "We behave as though we had belonged to each other for years."

At a lunch to celebrate their silver anniversary in 1972, the Queen made what the New York Times declared "a very mild joke".

"When the bishop was asked what he thought about sin," she said, "he replied with simple conviction that he was against it. If I am asked today what I think about family life after 25 years of marriage, I can answer with equal simplicity and conviction. I am for it."

Just as well, considering there was nearly another 50 years to come.

The beginning

Princess Elizabeth and Philip Mountbatten at their engagement. (Supplied: The Royal Family)

The couple first met in 1934, at the wedding of Prince Philip's cousin, Princess Marina of Greece and Denmark, and Queen Elizabeth's uncle, Prince George, Duke of Kent - the Queen was 8, and Philip was 13.

They met again in 1939 - when the Queen was 13 - at the Royal Naval College in Dartmouth and became friends. The Queen became smitten and they began exchanging letters.

Their engagement was announced on July 8, 1947. It wasn't all smooth sailing though - Philip was foreign born, with little financial standing and his family had connections with German noblemen with Nazi links.

Before they married, Philip renounced his Greek and Danish titles and converted to the Church of England.

He, too, showed his devotion in early letters, according to this one to Princess Elizabeth quoted in Philip Eade's book, Young Prince Philip: His Turbulent Early Life:

"To have been spared in the war and seen victory, to have been given the chance to rest and to re-adjust myself, to have fallen in love completely and unreservedly, makes all one's personal and even the world's troubles seem small and petty."

They married on November 20, 1947, at Westminster Abbey, in front of around 2,000 guests in a ceremony broadcast to 200 million radio listeners around the world.

In her speech for their golden wedding anniversary in 1997, the Queen set the scene for the start of their union.

"Britain had just endured six years of war, emerging battered but victorious. Prince Philip had served in the Royal Navy in the Far East, while I was grappling, in the ATS, with the complexities of the combustion engine and learning to drive an ambulance with care," she said.

It was a far cry from the high ceremony and pretence of royal life to come, but the couple took to their royal duties, visiting the far-flung lands of the Commonwealth.

The couple were in Kenya, on their way to a tour in Australia and New Zealand, in February 1952 when they received word that George VI has died - in fact, Philip broke the news to his wife.

After, of course, she was crowned Elizabeth II, their relationship changed.

Never a 'normal' couple

The Duke of Edinburgh, Queen Elizabeth II and a baby Prince Charles in 1949.
(Supplied: Royal Family)

They were never like a "normal" couple by the standards of the 1950s. Prince Philip was always a step behind his wife in public, though in private they had more equal footing, to a degree.

The Queen didn't take her husband's name. At one stage it seemed like the royal house would take Prince Philip's name - Mountbatten - but others preferred the continuation of the House of Windsor, which the Queen took up.

The Duke complained: "I am the only man in the country not allowed to give his name to his own children."

But in 1960, after the death of the Queen's grandmother and the resignation of then prime minister Winston Churchill, the surname Mountbatten-Windsor was adopted for the couple's male descendants who don't receive a royal title.

Prince Charles was born in November 1948 and Princess Anne in 1950, followed by Prince Andrew (1960) and Prince Edward (1964) after her coronation.

In a 2011 BBC interview for his 90th birthday, Prince Philip explained the difficulty of finding his place in the early years.

"The problem was to recognise what the niche was and to try and grow into it and that was by trial and error... There was no precedent. If I asked somebody, 'What do you expect me to do?' they all looked blank. They had no idea, nobody had much idea."

Philip was Elizabeth's 'strength'

Queen Elizabeth and Prince Philip at Balmoral for their silver wedding anniversary.

Despite the formal nature of their public presence, aides and insiders have said a shared sense of humour was an integral part of the royal couple's bond.

Their down-to-earth sensibility and support for each was the bedrock of a relationship that was professional as well as personal and loving.

The Queen was fond of pointing out her husband's inability to take a compliment.

In 1997, in a speech to mark their golden anniversary, she showed the role he played behind the scenes.

"Yesterday I listened as Prince Philip spoke at the Guildhall, and I then proposed our host's health. Today the roles are reversed," she said.

"All too often, I fear, Prince Philip has had to listen to me speaking. Frequently we have discussed my intended speech beforehand and, as you will imagine, his views have been expressed in a forthright manner.

"He is someone who doesn't take easily to compliments but he has, quite simply, been my strength and stay all these years, and I, and his whole family, and this and many other countries, owe him a debt greater than he would ever claim, or we shall ever know."

And again in 2012, at her Diamond Jubilee:

"Prince Philip is, I believe, well known for declining compliments of any kind. But throughout he has been a constant strength and guide."

For his part, Prince Philip claimed to lerance as an abiding guide.

"I think the main lesson that we have learnt is that tolerance is the one essential ingredient of any happy marriage. It may not be quite so important when things are going well, but it is absolutely vital when the going gets difficult,"

he said.

The Queen is now a changed monarch, without her faithful shadow and life partner two steps behind.

London Bridge is Down

Queen Elizabeth II

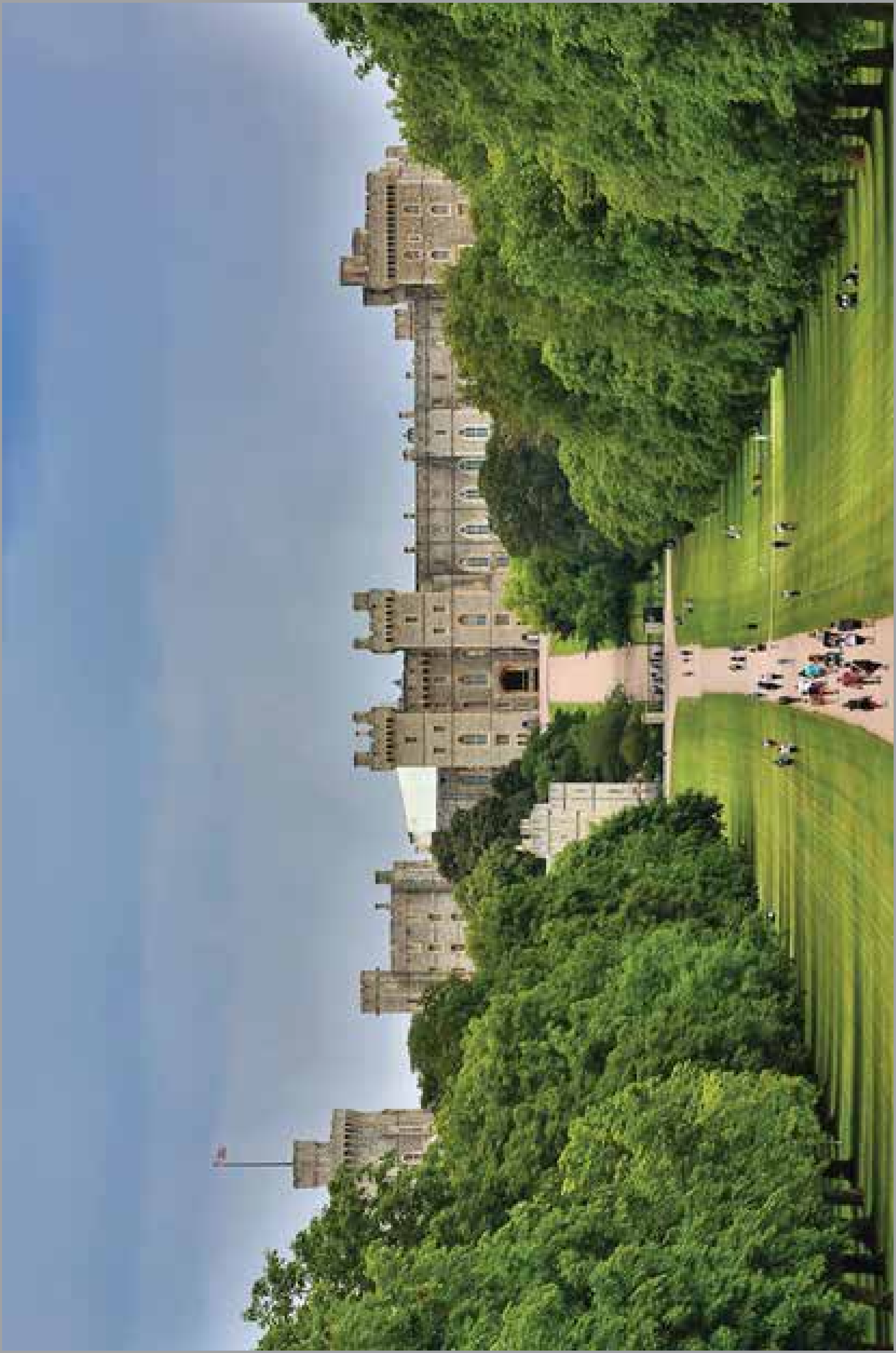
21 April 1926 to
8 September 2022
(aged 96)

Operation London Bridge (also known by its code phrase London Bridge is Down) is the name of a funeral plan for Queen Elizabeth II. The plan includes the announcement of her death, the period of official mourning, and the details of her state funeral.

Queen Elizabeth II

The Queen Elizabeth II and the sister Princess Margaret.

The Buckingham Palace, London.



The Windsor Castle in London

King Charles III

At the moment the Queen died, the throne passed immediately and without ceremony to the heir, Charles, the former Prince of Wales.

What will he be called?

He will be known as King Charles III.

That was the first decision of the new king's reign. He could have chosen from any of his four names - Charles Philip Arthur George.

He is not the only one who faces a change of title. Prince William and his wife Catherine are now titled Duke and Duchess of Cornwall and Cambridge, and the king has conferred on them the title of Prince and Princess of Wales.

There is also a new title for Charles' wife, Camilla, who becomes the Queen Consort - consort is the term used for the spouse of the monarch.

The coronation

The symbolic high point of the accession will be the coronation, when Charles is formally crowned. Because of the preparation needed, the coronation is not likely to happen very soon after Charles's accession - Queen Elizabeth succeeded to the throne in February 1952, but was not crowned until June 1953.

For the past 900 years the coronation has been held in Westminster Abbey - William the Conqueror was the first monarch to be crowned there, and Charles will be the 40th.

Head of the Commonwealth

Charles has become head of the Commonwealth, an association of 56 independent countries and 2.4 billion people. For 14 of these countries, as well as the UK, the King is head of state.

These countries, known as the Commonwealth realms, are: Australia, Antigua and Barbuda, the Bahamas, Belize, Canada, Grenada, Jamaica, Papua New Guinea, St Christopher and Nevis, St Lucia, St Vincent and the Grenadines, New Zealand, Solomon Islands, Tuvalu.

King Charles III with and Camilla the Queen Consort.

Alternative Energy ….. Advantages and Challenges with Solar PV

In addition to several advantages to solar photovoltaic system, there are challenges associated with this technology.

Advantages

- Since there are large amount of energy simply coming from sun's rays, scarcity is not a concern at all. This can be a solution to the scarcity of other energy sources, especially sources originating from fossil fuels.
- Solar radiation does not emit any type of pollution so therefore it lacks any CO2 emissions.
- Solar radiation energy is available anywhere so regardless of location, solar energy can be generated anywhere in a decentralized way (such as rooftop panels). This would also mean that the losses occurring due to the transmission of energy is being reduced.
- Implementing solar PV technology can be modular so the size of PV system can be increased when the need for electricity increases.

Challenges

- The cost of solar PV is usually a cost effective way to supply large quantities of electricity needed. However, producing electricity is more electricity. Although the cost of solar PV electricity has been significantly decreasing, further decreasing is still necessary in order for this technology to be affordable to everyone.
- Solar PV has challenges regarding the uncertainty of how much of sun's rays it would receive, as weather can change from time to time. This would prove difficulty in determining how much energy to store for future use. Sunlight is clearly unavailable during night hours while there is still demand for electricity. In addition, peak radiation availability may not match with the demand for peak electricity. A mechanism for effective energy storage and efficient recovery is needed for this reason.
- Location can be an issue. The availability of solar radiation can vary depending on location. Some places, such as the Southwest, there are significantly more solar radiation than other location, such as the Northeast. This would mean that solar energy generation is dependent on certain locations where the systems would need to be installed.

Courtesy : Amos Han & Joe Donatoni

Advantages and Challenges with Wind Power

Wind energy offers many advantages, which explains why it's one of the fastest-growing energy sources in the world. Research efforts are aimed at addressing the challenges to greater use of wind energy. Read on to learn more about the benefits of wind power and some of the challenges it is working to overcome.

Advantages

- Wind power is cost-effective. Land-based utility-scale wind is one of the lowest-priced energy sources available today, costing 1–2 cents per kilowatt-hour after the production tax credit. Because the electricity from wind farms is sold at a fixed price over a long period of time (e.g. 20+ years) and its fuel is free, wind energy mitigates the price uncertainty that fuel costs add to traditional sources of energy.
- Wind creates jobs. The U.S. wind sector employs more than 100,000 workers, and wind turbine technician is one of the fastest growing American jobs. According to the Wind Vision Report, wind has the potential to support more than 600,000 jobs in manufacturing, installation, maintenance, and supporting services by 2050.

Courtesy : Wind Energy Technologies Office

- Wind enables U.S. industry growth and U.S. competitiveness. New wind projects account for annual investments of over $10 billion in the U.S. economy. The United States has a vast domestic resources and a highly-skilled workforce, and can compete globally in the clean energy economy.

- It's a clean fuel source. Wind energy doesn't pollute the air like power plants that rely on combustion of fossil fuels, such as coal or natural gas, which emit particulate matter, nitrogen oxides, and sulfur dioxide—causing human health problems and economic damages. Wind turbines don't produce atmospheric emissions that cause acid rain, smog, or greenhouse gases.

- Wind is a domestic source of energy. The nation's wind supply is abundant and inexhaustible. Over the past 10 years, U.S. wind power capacity has grown 15% per year, and wind is now the largest source of renewable power in the United States.

- It's sustainable. Wind is actually a form of solar energy. Winds are caused by the heating of the atmosphere by the sun, the rotation of the Earth, and the Earth's surface irregularities. For as long as the sun shines and the wind blows, the energy produced can be harnessed to send power across the grid.

- Wind turbines can be built on existing farms or ranches. This greatly benefits the economy in rural areas, where most of the best wind sites are found. Farmers and ranchers can continue to work the land because the wind turbines use only a fraction of the land. Wind power plant owners make rent payments to the farmer or rancher for the use of the land, providing landowners with additional income.

Challenges

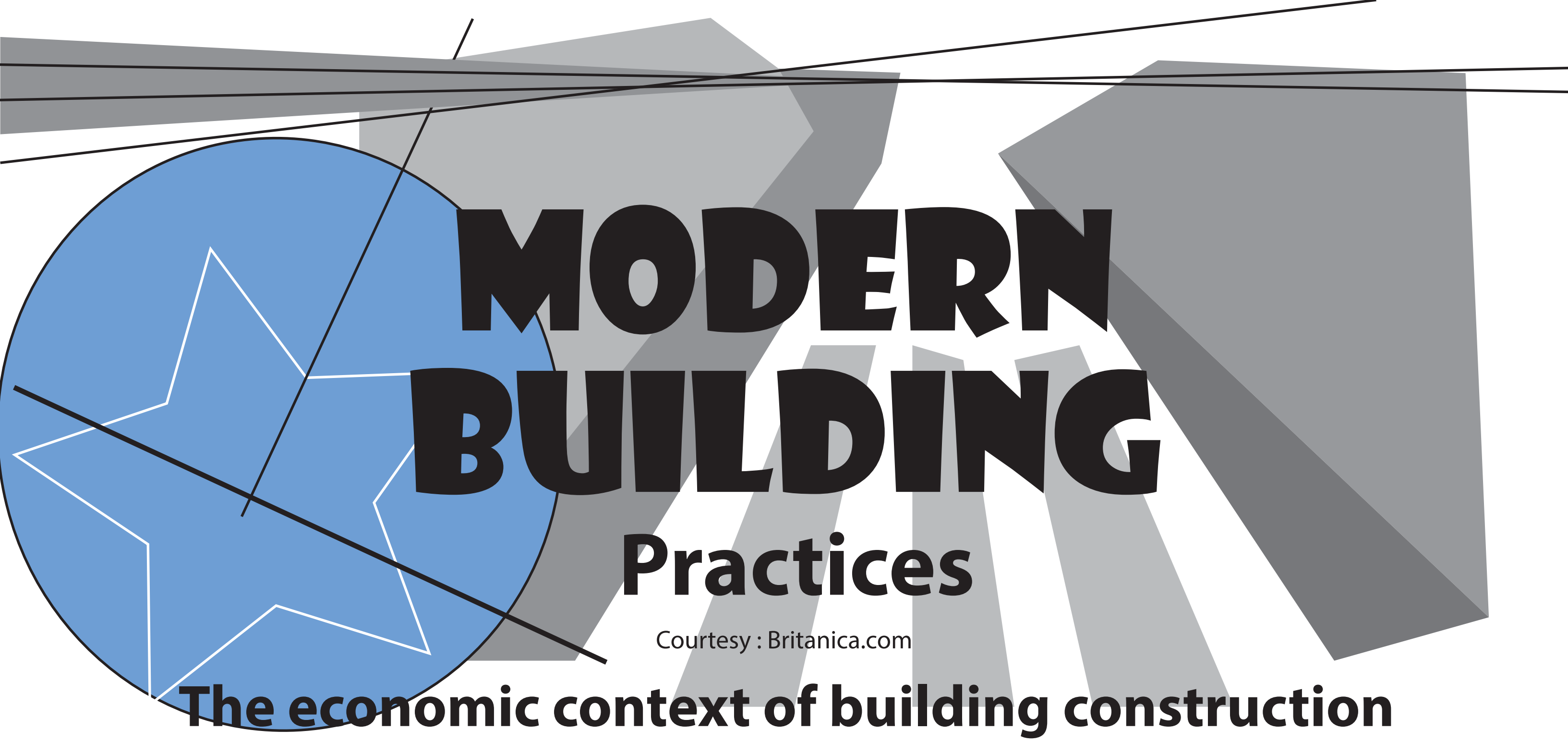
- Wind power must still compete with conventional generation sources on a cost basis. Even though the cost of wind power has decreased dramatically in the past several decades, wind projects must be able to compete economically with the lowest-cost source of electricity, and some locations may not be windy enough to be cost competitive.

- Good land-based wind sites are often located in remote locations, far from cities where the electricity is needed. Transmission lines must be built to bring the electricity from the wind farm to the city. However, building just a few already-proposed transmission lines could significantly reduce the costs of expanding wind energy.

- Wind resource development might not be the most profitable use of the land. Land suitable for wind-turbine installation must compete with alternative uses for the land, which might be more highly valued than electricity generation.

- Turbines might cause noise and aesthetic pollution. Although wind power plants have relatively little impact on the environment compared to conventional power plants, concern exists over the noise produced by the turbine blades and visual impacts to the landscape.

- Wind plants can impact local wildlife. Birds have been killed by flying into spinning turbine blades. Most of these problems have been resolved or greatly reduced through technology development or by properly siting wind plants. Bats have also been killed by turbine blades, and research is ongoing to develop and improve solutions to reduce the impact of wind turbines on these species. Like all energy sources, wind projects can alter the habitat on which they are built, which may alter the suitability of that habitat for certain species.



MODERN BUILDING

Practices

Courtesy : Britanica.com

The economic context of building construction

Buildings, like all economic products, command a range of unit prices based on their cost of production and their value to the consumer. In aggregate, the total annual value of building construction in the various national economies is substantial. In 1987 in the United States, for example, it was about 10 percent of the gross domestic product, a proportion that is roughly applicable for the world economy as a whole. In spite of these large aggregate values, the unit cost of buildings is quite low when compared to other products. In the United States in 1987, new building cost ranged from about $0.50 to $2.50 per pound. The lowest costs are for simple pre-engineered metal buildings, and the highest represent functionally complex buildings with any mechanical and electrical services, such as hospitals and laboratories. These unit costs are at the low end of the scale of manufactures, ranking with inexpensive foodstuffs, and are lower than those of most other familiar consumer products. This scale of cost is a rough index of the value or utility of the commodity to society. Food, although essential, is relatively easy to produce; aircraft, at the high end of the scale, perform a desirable function but do so with complex and expensive mechanisms that command much higher unit prices which reflect not only the materials and labour required to produce them but also substantial capital and research investments. Buildings fall nearer to food in value; they are ubiquitous and essential, yet the services consumers expect them to provide can be supplied with relatively unsophisticated technology and inexpensive materials. Thus there has been a tendency for building construction to remain in the realm of low technology, for there has been relatively little incentive to invest in research given consumer expectations.

Within this general economic context, there are a number of specific parameters that affect the cost of buildings. First are government building codes, which are enacted to protect public health and safety; these take the form of both prescriptive and performance requirements. Structural requirements include description of the loads buildings must support, beginning with the constant everyday loads of building contentsimposed by gravity and extending to the less frequent but more extreme loadings of wind and earthquake forces. These are specified on a statistical basis, usually the maximum expected to occur with a 100-year frequency. Safety factors for materials are specified to allow for accidental overloading and lapses of quality control. Economic considerations are also reflected; for example, buildings must perform well under normal gravity loads, but no code requires a building to resist direct exposure to the wind and low-pressure effects of a tornado, for its cost would be prohibitive.

Planning and zoning requirements provide for height and floor area limitations and building setbacks from lot lines to ensure adequate light and air to adjoining properties. Zoning regulations also establish requirements for permitted building usages, parking spaces, and landscaping and even set standards for the visual appearance of buildings. Another example is requirements for building atmosphere conditions; these include minimum (but not maximum) temperatures and rates of air change to dilute odors and provide an adequate oxygen supply. Life-safety requirements include adequate stairways for emergency exits, emergency lighting, smoke detection and control systems, and fire-resistant building materials. Sanitation requirements include adequate numbers of plumbing fixtures and proper pipe sizes. Electrical requirements include wire sizes, construction requirements for safety, and location of outlets. Beyond the government standards there are market standards, which reflect user expectations for buildings. One example is elevator systems; elevators are not required by building codes, but in the United States, for example, the number of elevators in office buildings is calculated based on a maximum waiting period of 30 seconds. Cooling of building atmospheres is also not required by code but is provided in climates and building types where the marketplace has shown it to be cost-effective.

Building systems and components are perceived as having two dimensions of value. One is the purely functional dimension: the structure is expected to resist loads, the roof must keep out rain. The other is the aesthetic or psychic dimension: stone is perceived as more durable than wood; an elevator system with a waiting time of 30 seconds is preferable to one with a waiting time of two minutes. For these perceived differences many users are willing to pay more. When symbolic buildings such as temples, cathedrals, and palaces play an important role in society, the aesthetic dimension is important in valuing buildings; for example, the Parthenon of Athens or Chartres Cathedral commanded a level of investment in their economies that might be roughly compared to the U.S. Apollo space program. But in most buildings the functional dimension of value is dominant.

Because of its relatively low level of technology, wide geographic distribution, highly variable demand, and wide variety of building products, the building industry in industrialized countries is subdivided into many small enterprises. This lack of centralization tends to discourage research and keeps building components sturdy and simple, following well-tried formulas. Within this diversity there are a number of fairly well-defined markets based on building types; these include low-rise residential buildings, low-rise commercial, institutional, and industrial buildings, high-rise buildings, and long-span buildings.

A somewhat similar pattern is found in eastern Europe, although the building industry there is more centralized. There is also a much smaller low-rise residential market, with most new housing being provided in high-rise buildings. In developing countries the major market is for low-rise residential buildings to house rapidly growing populations. Much of the construction is undertaken by local craftsmen using simple building products. Local timber is widely used, and masonry materials still include the ancient mud brick. More sophisticated long-span and high-rise technologies are found only in major cities.

Building design and construction

Design programming

The design of a building begins with its future user or owner, who has in mind a perceived need for the structure, as well as a specific site and a general idea of its projected cost. The user, or client, brings these facts to a team of design professionals composed of architects and engineers, who can develop from them a set of construction documents that define the proposed building exactly and from which it can be constructed.

Building design professionals include those licensed by the state—such as architects and structural, mechanical, and electrical engineers—who must formally certify that the building they design will conform to all governmental codes and regulations. Architects are the primary design professionals; they orchestrate and direct the work of engineers, as well as many other consultants in such specialized areas as lighting, acoustics, and vertical transportation.

The design professionals draw upon a number of sources in preparing their design. The most fundamental of these is building science, which has been gradually built up over the past 300 years. This includes the parts of physical theory that relate to building, such as the elastic theory of structures and theories of light, electricity, and fluid flow. There is a large compendium of information on the specific properties of building materials that can be applied in mathematical models to reliably project building performance. There is also a large body of data on criteria for human comfort in such matters as thermal environment, lighting levels, and sound levels that influence building design.

In addition to general knowledge of building science, the design team collects specific data related to the proposed building site. These include topographic and boundary surveys, investigations of subsoil conditions for foundation and water-exclusion design, and climate data and other local elements.

Concurrently with the collection of the site data, the design team works with the client to better define the often vague notions of building function into more precise and concrete terms. These definitions are summarized in a building space program, which gives a detailed written description of each required space in terms of floor area, equipment, and functional performance criteria. This document forms an agreement between the client and the design team as to expected building size and performance.

Design development

The process by which building science, site data, and the building space program are used by the design team is the art of building design. It is a complex process involving the selection of standard building systems, and their adaptation and integration, to produce a building that meets the client's needs within the limitations of government regulations and market standards. These systems have become divided into a number of clear sectors by the building type for which they are intended. The design process involves the selection of systems for foundations, structure, atmosphere, enclosure, space division, electrical distribution, water supply and drainage, and other building functions. These systems are made from a limited range of manufactured components but permit a wide range of variation in the final product. Once the systems and components have been selected, the design team prepares a set of contract documents, consisting of a written text and conventionalized drawings, to describe completely the desired building configuration in terms of the specified building systems and their expected performance. When the contract documents have been completed, the final costs of the building can usually be accurately estimated and the construction process can begin.

Construction

Construction of a building is usually executed by a specialized construction team; it is normally separate from the design team, although some large organizations may combine both functions. The construction team is headed by a coordinating organization, often called a general contractor, which takes the primary responsibility for executing the building and signs a contract to do so with the building user. The cost of the contract is usually an agreed lump sum, although cost-plus-fee contracts are sometimes used on large projects for which construction begins before the contract documents are complete and the building scope is not fully defined. The general contractor may do some of the actual work on the building in addition to its coordinating role; the remainder of the work is done by a group of specialty subcontractors who are under contract to the general contractor. Each subcontractor provides and installs one or more of the building systems—e.g., the structural or electrical system. The subcontractors in turn buy the system components from the manufacturers. During the construction process the design team continues to act as the owner's representative, making sure that the executed building conforms to the contract documents and that the systems and components meet the specified standards of quality and performance.

Low-rise residential buildings

Low-rise residential buildings include the smallest buildings produced in large quantities. Single-family detached houses, for example, are in the walk-up range of one to three stories and ypically meet their users' needs with about 90 to 180 square metres (about 1,000 to 2,000 square feet) of enclosed floor space. Other examples include the urban row house and walk-up apartment buildings. Typically these forms have relatively low unit costs because of the limited purchasing power of their owners. The demand for this type of housing has a wide geographic distribution, and therefore most are built by small local contractors using relatively few large machines (mostly for earth moving) and large amounts of manual labour at the building site. The demand for these buildings can have large local variations from year to year, and small builders can absorb these economic swings better than large organizations. The building systems developed for this market reflect its emphasis on manual labour and its low unit costs. A proportion of single-family detached houses are "factory-built"; that is, large pieces of the building are prefabricated and then transported to the site, where considerable additional work is required to complete the finished product.

Foundations

All foundations must transmit the building loads to a stable stratum of earth. There are two criteria for stability: first, the soil under the foundations should be able to receive the imposed load without more than about 2.5 centimetres (one inch) of settlement and, second, the settlement should be uniform under the entire building. It is also important that the bottom of the foundation be below the maximum winter frost level. Wet soil expands as it freezes, and repeated freeze–thaw cycles can move the building up and down, leading to possible displacement and damage. Maximum frost depth varies with climate and topography. It can be as deep as 1.5 metres (five feet) in cold continental climates and is zero in tropical and some subtropical areas. The foundation systems for low-rise residential buildings are suitable for their light loads; nearly all are supported on spread footings, which are of two types—continuous footings that support walls and isolated pad footings that support concentrated loads. The footings themselves are usually made of concrete poured directly on undisturbed soil to a minimum depth of about 30 centimetres (12 inches). If typical continuous concrete footings are used, they usually support a foundation wall that acts either as a retaining wall to form a basement or as a frost wall with earth on both sides. Foundation walls can be built of reinforced concrete or masonry, particularly concrete block. Concrete blocks are of a standard size larger than bricks and are hollow, forming a grid of vertical planes. They are the least expensive form of masonry—using cheap but strong material—and their large size economizes on the labour required to lay them. Their appearance and weathering properties are inferior to those of fired masonry, but they are satisfactory for foundation walls. In some places timber foundation walls and spread footings are used. Excavation for foundations is the most highly mechanized operation in this building type; it is done almost entirely with bulldozers and backhoes.

Structural systems
Timber frames

In these small buildings the ancient materials of timber and masonry are still predominant in the structural systems. In North America, which has abundant softwood forests, light timber frames descended from the 19th-century balloon frame are widely used. These present-day "platform" frames are made of standard-dimension timbers, usually two or four centimetres (0.75 or 1.5 inch) thick, which are joined together by machine-made nails and other metal fasteners using hand tools. The first step is to construct a floor, which rests on the foundation wall. A heavy timber sill is attached to the wall with anchor bolts, and on top of it are nailed the floor joists, typically 4 × 28 centimetres (1.5 × 11.25 inches) and spaced 40 centimetres (16 inches) apart. The span of the floor joists is usually about 3.6 metres (12 feet), which is the common maximum length of available timbers. The floor may need intermediate supports in the form of interior foundation walls or, if there is a basement, intermediate beams of wood or steel supported by the foundation walls and columns. For longer spans, floor trusses can be made, with members joined by nail grids or nailed plywood gussets or with wood chords and diagonal metal web members. On top of the joists is nailed plywood subflooring, which forms the deck and gives lateral stability to the floor plane.

The exterior bearing walls are made of 4 × 9-centimetre (1.5 × 3.5-inch; "2 × 4") timber verticals, or studs, spaced 40 or 60 centimetres (16 or 24 inches) apart, which rest on a horizontal timber, or plate, nailed to the floor platform and support a double plate at the top. The walls are sheathed on the outside with panels of plywood or particleboard to provide a surface to attach the exterior cladding and for lateral stability against wind. Plywood and particleboard are fabricated in panels of standard sizes. Plywood is made of thin layers of wood, rotary-cut from logs and glued together with the wood grain running perpendicularly in adjoining layers. Particleboard consists of fine wood chips mixed together in an adhesive matrix and allowed to harden under pressure. On top of the wall plate is placed either a second floor or the roof.

Since most of the roofing materials used in these buildings are not fully watertight, the roofs must have sloped surfaces to rapidly drain off rainwater. Sloped forms are created by two methods. The traditional method uses joists similar to those of floor construction to span between exterior walls. Rafters are nailed to the ends of each joist and the rafters meet at a central ridge member, forming a triangular attic space. Where no attic space is needed, it has proved more economical to span the roof with triangular trusses with interior web members. These roof trusses are usually made of narrow timbers joined by nails, glue, or metal connectors, and they are often prefabricated in a workshop. Plywood or particleboard sheathing is then nailed to the roof surfaces to receive the roofing and to provide lateral stability, making the entire frame into a rigid box.

Light timber frames are quite flammable, but small one- or two-story buildings are easy to evacuate in case of a fire, and building codes permit the use of these frames with such features as fire-resistant gypsum board on the interiors and fire-stops (short wooden members) between the studs. Timber structures are attacked by certain species of insects—such as termites and carpenter ants—as well as certain fungi, particularly in warm, moist climates. Wood can be chemically treated to discourage these attacks; other precautions include raising the timber above the ground and keeping it dry.

Masonry walls

Structural masonry walls are also used in this building type, primarily in multistory buildings, where they offer greater load-bearing capacity and fire resistance. Brick and concrete block are the major materials, brick being favoured for exterior surfaces because of its appearance and durability. Solid brick walls are rarely used, due to the higher labour and material costs; composite walls of brick and block or block alone are common. Cavity walls are used in colder climates; in these, two wythes (vertical layers) of masonry are built on either side of a layer of rigid insulation. The wythes are joined together by steel reinforcement that runs through the insulation and is laid in the horizontal masonry joints at intervals. Cavity walls have a heat-flow rate that is 50 percent of that of a solid wall. Timber floor and roof construction, similar to balloon framing, is used with masonry construction; and there is also some use of precast prestressed hollow concrete panels, which are fireproof and can span up to nine metres (30 feet).

Enclosure systems

Enclosure systems for this building type are varied. For roofs, traditional wood shingles or, more commonly, felt asphalt shingles are used, as are semicylindrical clay tiles and standing-seam metal roofs. Rainwater from roofs is usually caught in metal gutters and directed to exterior downspouts that discharge onto splash blocks or into underground drains connected to storm sewers.

The wall surfaces of low-rise residential buildings are clad with a range of different materials. Traditional wood elements such as shingles and horizontal shiplap, or clapboard siding, are used on light timber frames as are vertical tongue-and-groove siding and boards and battens. Aluminum and vinyl sidings have been adapted from these wooden forms. Brick and stone veneer are also applied over timber and anchored to it with metal fasteners. Cement plaster, or stucco, is another traditional material used to enclose both timber and masonry structures, and its semiliquid application allows great plasticity of form. A more recent development is a very thin synthetic resin stucco applied directly to the surface of rigid plastic foam insulation.

Insulation, which slows the rate of heat transfer through the enclosure, is usually applied at all exterior building surfaces that are exposed to air. There are two major types of insulation, rigid and nonrigid. Rigid insulations are primarily plastic foams (the dead air in the foam cells is the true insulator), which vary in thickness from 2.5 to five centimetres (one to two inches). They include styrofoam, used primarily below grade behind frost walls due to its low fire resistance; urethane foam; isocyanurate foam, which has the best fire resistance; and foam glass. Nonrigid insulations are usually made of fibre—glass fibre being the most common—often with a foil-backed paper on one side. Fibre insulations are made in thicknesses up to 23 centimetres (9.25 inches). The effectiveness of an insulation material is measured in terms of its heat-transfer rate, or U-value, often expressed as the number of BTUs passing through a given unit of insulating material each hour at an expressed temperature differential across the material. Low U-values indicate good insulating properties of the material. U-value is an inverse function of thickness, so that there is a limit to the cost-effectiveness of increasing the amount of insulation on a surface. Rigid insulation panels are applied to vertical wall sheathing and the surfacing material is fastened through the insulation, or it is applied to horizontal roof decks. Glass fibre is usually applied in the spaces between wall studs and between roof joists or the bottom chords of roof trusses.

Most low-rise residential buildings have a limited number of transparent openings in their exteriors, because of the traditional requirements of interior privacy and the relatively higher cost of windows compared to opaque walls. The traditional wooden frames of domestic windows are often clad in extruded vinyl or aluminum cladding, and frames made entirely of extruded aluminum are common. Residential windows are a major means of ventilation, and there are a variety of operating actions for their movable sections: sliding or double-hung windows are still the major form, but hinged types—including casement, hopper, and awning forms—are also used. Sliding glass panel doors are also used, particularly in warmer regions. Glazing is still largely of clear glass. Double glazing, with two panes bonded to a metal tubular separator that contains a desiccant, is cost-effective in northern climates, but triple glazing is used commonly only in regions above about 55° to 60° latitude. A recent development is heat-mirror glass, in which a low-emissivity coating enhances the relative opacity of the glass to infrared radiation and slows the rate of internal heat loss in winter.

Interior finishes

Interior finishes and space-division systems define the living spaces within residential buildings with a range of both natural and synthetic materials. The most widely used wall finish is gypsum board, a prefabricated form of traditional wet plaster. Wet gypsum plaster is cast between paper facings to form large panels that are nailed to light timber or metal frameworks. The joints between the panels are filled with a hard-setting resin compound, giving a smooth seamless surface that has considerable fire resistance. Gypsum board forms the substrate to which a number of other materials, including thin wood-veneered plywood and vinyl fabrics, can be applied with adhesives. In wet areas such as kitchens and bathrooms, water-resistant gypsum board is used, sometimes with the addition of adhesive-applied ceramic tile.

Doors in residential buildings are usually of the hollow-core type, with thin veneers of wood glued over a honeycomb paper core and solid wood edge strips; door frames are typically made of machined timber shapes. Plastic laminates bonded to particleboard are extensively used for built-in cabinets and countertops. The most common floor finish is carpeting, most of which is now made of synthetic fibres, displacing the traditional wool and cotton. It can be easily maintained, and its soft visual and tactile texture, as well as its sound-absorbing qualities, make it attractive for residential use. Hardwoods - primarily oak, birch, and maple - are also used for floors, both in the traditional narrow planks nailed to plywood decks and as prefabricated parquet elements, which are applied with adhesives. In wet or hard-use areas vinyl-composition tiles or ceramic tiles are used.

Plumbing

Domestic water-supply systems for low-rise residential buildings have two sources, either municipal water-distribution systems or, where these are not available, wells that are drilled to underground aquifers which are free of contamination. Water is drawn from the wells with small submersible electric pumps, which are lowered through the well casing to the intake. Underground exterior water-supply pipes are usually cast-iron with threaded connections to contain the pressures applied to the fluid, which is typically sufficient to raise it four stories.

Within the building, copper tubing with soldered connections is used for distribution because of its corrosion resistance and ease of fabrication; in some areas plastic pipe is also used. The domestic water supply is divided into cold and hot systems, the cold water being piped directly to the fixtures. The hot-water system first draws the supply through a hot-water heating tank, which raises its temperature to about 60 °C (140 °F) using electric resistance or gas heat. Domestic water heaters that use solar radiation to heat water in coils exposed to the sun on a glass-covered black metal plate (flat-plate solar collectors) are found in areas where there is ample sunshine and relatively high energy costs. The hot water is then distributed from the heater to the fixtures in a recirculating loop pipe system, in which gravity and temperature differentials maintain a constant temperature in period of low demand.

The primary residential use of water is in the bathroom, which typically includes a bathtub of cast iron or pressed steel with a ceramic porcelain coating (although fibre-glass-reinforced resin is also used), a ceramic lavatory, and a ceramic tank-type water closet. The bath and lavatory are supplied with hot and cold water through faucets with lever or screw-type valve controls. The valve of the water closet supply is also lever-operated and relies on the gravity power of the water in the tank for its flushing action. Shower baths are also common, often incorporated into bathtub recesses or in a separate compartment finished with ceramic tile. In some countries a bidet is included.

Other widely used plumbing fixtures include kitchen sinks, usually of cast iron or pressed steel with a ceramic porcelain coating, or of stainless steel; automatic dishwashing machines; and automatic washing machines for laundry. Kitchen sinks can be fitted with garbage disposals, which grind solid waste into a fluid slurry that is flushed out with wastewater. Where the possibility of back siphonage of wastewater into the water supply exists, a vacuum breaker must be provided at the supply to prevent this happening, but most domestic plumbing fixtures are designed to avoid this possibility.

Drainage systems to remove wastewater are made of cast-iron pipe with threaded joints or bell-and-spigot joints sealed with molten lead or with plastic pipe with solvent-welded joints. The waste pipe of every plumbing fixture is provided with a semicircular reverse curve, or trap, which remains constantly filled with water and prevents dours from the drainage system from escaping into occupied spaces. Immediately downstream from each trap is an opening to a vent pipe system, which lets air into the drainage system and protects the water seals in the traps from removal by siphonage or back pressure. When wastewater leaves the building, it is drained through a backflow-prevention valve and into underground ceramic pipes. It then flows by gravity to either a private sewage treatment plant, such as septic tank and tile field, or to the public sewer system. If the discharge level of the wastewater is below the level of the sewer, a sewage ejector pump is required to raise the wastewater to a higher level, where gravity carries it away.

Heating and cooling

Atmosphere-control systems in low-rise residential buildings use natural gas, fuel oil, or electric resistance coils as central heat sources; usually the heat generated is distributed to the occupied spaces by a fluid medium, either air or water. Electric resistance coils are also used to heat living spaces directly with radiant energy. Forced-air distribution moves the heat-bearing air through a treelike system of galvanized sheet-metal ducts of round or rectangular cross section; electric-powered fans provide a pressure differential to push the air from the heat source (or furnace) to the living spaces, where it is expelled from grills located in the walls or floors. The negative pressure side of the fan is connected to another treelike system of return air ducts that extract air from living spaces through grills and bring it back to the furnace for reheating. Fresh outside air can be introduced into the system airstream from an exterior intake, and odour-laden interior air can be expelled through a vent, providing ventilation, usually at the rate of about one complete air change per hour. To conserve energy, air-to-air heat exchangers can be used in the exhaust–intake process. The heated air is usually supplied in constant volume, and the ambient temperature is varied in response to a thermostat located in one room. Central humidity control is rarely provided in this building type.

Another common heating system is the radiant hot-water type. The heat source is applied to a small boiler, in which water is heated and from which it is circulated by an electric pump in insulated copper pipes similar to a domestic hot-water system. The pipes can be connected to cast-iron or finned tube steel radiators within the living spaces. The radiators are placed near the areas of greatest heat loss (such as windows or outside walls) where their radiant energy heats the surrounding air and creates a convection cycle within the room, producing a roughly uniform temperature within it. The hot water can also be conducted through narrow pipes placed in a continuous looping pattern to create a large radiant surface; this pattern of pipes may be cast in a concrete floor slab or placed above a ceiling to heat the adjoining living space. Temperature control in hot-water systems uses a thermostat in the living space to adjust the pumped flow rate of the water to vary the heat supplied.

Radiant electric resistance heating systems use coils in baseboard units in the rooms, which create convection cycles similar to hot-water radiators, or resistance cables in continuous looped patterns embedded in plaster ceilings. Local temperature control can be much more precise with electric heating, because it is possible to install a thermostatically controlled rheostat to vary the energy output of relatively small sections of baseboard units or cable.

A type of space heating that is increasing in use in residential buildings is passive solar radiation. On sunny winter days, south-facing windows let in substantial amounts of energy, often enough to heat the entire building. Wood-burning fireplaces with chimneys are still widely provided in residential buildings, but their use is mostly for aesthetic effect.

The cooling of atmospheres in low-rise residential buildings is often done locally with unit air conditioners, which penetrate the exterior wall of the space to be cooled; this permits the intake of fresh air when desired and the ejection of heat pumped from the space to the exterior air. Less often, forced-air heating systems have cooling coils introduced into the airstream to provide a centrally cooled interior. A compressive cooling process is used, similar to that in a domestic refrigerator. A refrigerant, which is a liquid at room temperature, is pumped through a closed system of coiled copper tubes. An electric pump maintains a low pressure in the cooling coils, and the liquid refrigerant passes through an expansion valve from a region of high pressure to the low-pressure coils. This change in pressure results in a phase change of the refrigerant; it turns from a liquid into a gas and absorbs heat in the process, just as water absorbs heat when it is boiled and converted into steam. The heat absorption of the liquid-to-gas transition cools air passing over the cooling coils. The cooled air is circulated through the building by the forced-air system. When the low-pressure gaseous refrigerant leaves the cooling coils, it goes through the pump and is pressurized. The refrigerant travels through condensing coils, which are located outside the building; there the phase change is reversed as the gas turns to a high-pressure liquid and liberates heat to the exterior air passing over the condensing coils. The liquid refrigerant returns to the expansion valve to repeat the cooling cycle. The refrigeration machine is thus a "heat pump" that moves heat out of the building to the exterior atmosphere. Heat pumps can also be run in reverse in the winter months to pump heat from the outside air into the building interior; they work best in mild climates with fairly warm winter temperatures. The use of heat pumps in cold climates poses many difficult technological problems.

Interior atmospheres are also ventilated by operating windows, as well as by unintended leakage at all types of exterior openings. Bathrooms, kitchens, and laundries generate odours and heat and often have separate exhaust systems powered by electric fans that are operated intermittently as required. Residential atmosphere quality is also protected by the smoke detector, which sounds an alarm to warn of possible danger when smoke reaches even a very low level in living spaces.

Electrical systems

Electrical systems in residential buildings are supplied from public utility power grids, starting from a step-down transformer near the building that reduces the high line voltage to a safer level. An underground or overhead cable from the transformer leads to the building, where it is connected to a meter that records the energy used by the subscriber. Immediately beyond the meter is a fused main switch to protect the building against an accidental power surge from the grid. The main service is then broken down into a number of circuits by a panelboard, each circuit having a fused switch. From the panelboard the wires of each circuit distribute the electricity to different areas of the building. The wires are usually copper, although aluminum is also used, and are covered with thermoplastic insulation. The wires must be contained in conduit, which is either metal or plastic tubing, to protect against damage and reduce the possibility of fire in the

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The 10th World Construction Symposium 2022 held in Colombo

On the theme 'Sustainability and Resilience in the Built Environment: Changed Perspectives'

Sustainability and resilience in the built environment: Changed perspectives
24-26 June 2022 - Colombo

The 10th World Construction Symposium 2022 on **"Sustainability and Resilience in the Built Environment: Changed Perspectives"** was successfully held recently. This symposium is indexed by SCOPUS since 2019. The symposium provides a special forum for researchers and practitioners in the area of sustainable construction worldwide to share their knowledge, experience and research findings.

The Ceylon Institute of Builders (CIOB) and Building Economics and Management Research Unit (BEMRU) of the Department of Building Economics, University of Moratuwa jointly organised the 10th World Construction Symposium with the following associate partners.

- Western Sydney University, Australia;
- The University of Newcastle, Australia;
- Colombo School of Construction Technology (CSCT), Sri Lanka; and
- Built Environment Project and Asset Management (BEPAM): Journal, published by Emerald Group Publishing.

Further, BEPAM Best Paper Award and BEPAM Highly Commended Paper Awards were sponsored by Built Environment Project and Asset Management (BEPAM) and CIOB Best paper Award and CEOM Highly Commended Paper Award were arranged by Ceylon Institute of Builders (CIOB).

Inauguration

This year's symposium marks the 10th milestone of this symposium series, which has been held annually since 2012. Throughout the past decade, we are happy to see WCS grow in success and gaining recognition from academics and industry participants from around the world, providing a multi-stakeholder platform for those involved in the built environment and construction industry related research and practice to come together to share their knowledge and experiences. Amidst the political and economic crisis prevailing in Sri Lanka that has critically impacted many industries including construction, this year's symposium was organized around the theme "Sustainability and resilience in the built environment: Changed perspectives". The crisis meant that this was the second year in a row that we organised this symposium as a mainly digital event.


Welcome Address
by President, CIOB
Dr. Rohan Karunaratne


Address by
Conference Chairperson
Prof. Chitra Weddikkara

Address by Head,
Department of Building
Economics,
Ch QS Suranga Jayasena

Symposium was inaugurated with the presence of the Guest of Honour, Prof. Lalith de Silva, Former Dean, Faculty of Architecture, University of Moratuwa. Mr. Don Ward, Chief Executive of International Council for Research and Innovation in Building and Construction (CIB) was the first keynote speaker of this event. He delivered a keynote on *"Innovation and Global Trends in Our Sector"*. The second keynote was presented by Prof. Lalith de Silva, Former Dean, Faculty of Architecture, University of Moratuwa. His speech was on the topic *"Revitalizing the Debt Structure Strategy of National Economy Using the Resilience of the Built Environment"*.

Altogether, 76 papers were selected for publication following a double-blind review process. It is worthwhile to note that the authors of the selected papers were from a range of different countries including Australia, India, Malaysia, New Zealand, Nigeria, Sri Lanka, Turkey, United Kingdom and USA. The papers covered a wide spectrum of areas such as sustainable urban development and infrastructure, knowledge management and lessons learned, cost management in construction, innovative procurement approaches, Building Information Modelling, contract administration and dispute resolution, health, safety and wellbeing, pandemic resilient construction, waste management, energy and retrofitting, green building systems, disaster resilient built environments, enhancing construction performance, innovative technologies for sustainability, circular built environment, and sustainable operation and management of facilities. Many researchers, industry practitioners and students took part in this symposium sharing ideas in the area of sustainability and resilience in the built environment. The diversity of participants stimulated a rich debate of the agenda items. After the 16 parallel sessions for paper presentations, a panel discussion was organised on the theme of *"Rebooting to a Resilient Construction Industry - Bouncing Back Better from Multiple Crises"*.

The panel discussion was moderated by Ch. QS Lalith Rathnayake, Immediate Past President of IQSSL and the panellists comprised of following eminent academics and industry professionals.

- Prof. Mohan Kumaraswamy - Honorary Professor at the University of Hong Kong & the University of Moratuwa, Joint Coordinator, CIB W122 on PPP, Editor-in-Chief, BEPAM Journal
- Eng. Nissanka Wijeratne - Secretary General/CEO of the Chamber of Construction Industry, Sri Lanka
- Dr. Asanga Gunawansa – Legal Counsel, Arbitrator, Mediator, Adjudicator and Negotiator
- Ch QS Upul Shantha - Past President of the Institute of Quantity Surveyors Sri Lanka
- Dr. Rohan Karunaratne - President of CIOB and Chairman, AKK Engineers (Pvt) Ltd.

The symposium concluded with announcing of the following award winners:

The symposium concluded with announcing of the following award winners.

BEPAM Journal Best Paper Award:

- Establishing the role of BIM towards mitigating critical project risks assessed using a fuzzy inference system - *Sulakshya Gaur and Abhay Tawalare*

BEPAM Journal Highly Commended Paper Awards:

- Economic performance of green walls: A systematic review by *U.G.D. Madushika, T. Ramachandra and D. Geekiyanage*
- A review of drivers of sustainability in mega infrastructure projects: An institutional approach by *Nicola Thounaojam, Ganesh Devkar and Boeing Laishram*

CIOB Best Paper Award:

- The effect of orientation and plant type on the thermal behaviour of living wall systems in buildings by *H. Merve Yanardag Erdener and Ecem Edis*

CIOB Highly Commended Paper Award:

- Developing a decision-making model for selecting smart retrofits by *G.H.T.D. Jayarathne and Nayanthara De Silva*
- Event Sponsors: Sripalie Contractors, AKK Engineers, Venora Group and Tudawe Brothers

Speaking on the successful conclusion of the 10th World Construction Symposium, the President of Ceylon Institute of Builders, Dr. Rohan Karunaratne and the Co-Chairs of the Organising Committee Mr. Sagara Gunawardena and Mr. Kalana Alwis mentioned *"We feel proud of the fact that we have been able to host the conference for 10th consecutive year. Today this symposium has become a looked forward to event among the academics and researches in the construction industry in Sri Lanka. Organizing of this edition of the conference has been particularly challenging due to the current economic crisis that the country is going through. But, thanks to the untiring effort by organizing committee, especially the Department of Building Economics of the University of Moratuwa, the symposium has become a grant success and was able to maintain the high standard of technical and academic excellence that is expected from an international symposium".*

Address by the Chief Guest Prof. Lalith de Silva

cib

World Construction Symposium Sri Lanka 24 June 2022

Innovation and global trends in our sector

Don Ward
Chief Executive
CIB

www.cibworld.org

Keynote Address 1 by Chief Executive of International Council for Research and Innovation in Building and Construction (CIB) Mr. Don Ward

WCS 2022

Revitalizing the Debt restructure Strategy of National Economy using the resilience of the Built Environment:

Keynote Address 2 by Former Dean, Faculty of Architecture, University of Moratuwa, Prof. Lalith de Silva,

In conclusion, the 10th World Construction Symposium 2022 can be seen as another highly successful event for the organizers. Even amidst the constraints imposed by the pandemic and socio-economic-political crisis, symposium saw a good participation by both local and international academics and industry experts who presented papers addressing a range of sustainability issues within the construction industry. The Symposium was sponsored by the following organizations:

- Platinum Sponsor – Orel Corporation
- Gold Sponsors – Multilac and Insee Cement
- Silver Sponsors - Tokyo Cement Group, Swisstek Aluminium and Alumex
- Industry Sponsor - Nawaloka Construction

The Chairperson of the Symposium, Prof. Chitra Wedikkara mentioned that she was *extremely pleased to have been associated in organizing successive World Construction Symposiums since 2012. She further said that during the last ten years, the World Construction Symposium has grown in stature to be one of the premier construction symposiums in the country and has gone a long way in addressing the pressing issues that the industry faces with regard to sustainable construction.*

Prof. Yasangika Sandanayake, Head of Department of Building Economics, Moratuwa University stated *"We are delighted to be a joint organizer of this prestigious annual event. We are hugely impressed by the diversity and high standard of submissions that we received for this year's symposium.*

Symposium Participants

Panel Discussion

Prof. Yasangika Sandanayake

Dr. Anuradha Waidyasekara.

CIOB and UoM Team

From left to right: Mr. Mahanama Jayamana, Mr. Sudath Amarasinghe, Prof. Yasangika Sandanayake, Mr. Kalana Alwis, Dr. Rohan Karunaratane, Prof. Lalith De Silva, Prof. Chitra Wedikkara, Mr. Saliya Kaluarachchi, Dr. Anuradha Waidyasekara and Mr. Ruwan De Silva.

Presenting Rapporteur's Report

We are thankful to our joint organizer, Ceylon Institute of Builders, all associate partners, keynote speakers, members of panel discussion, scientific committee members, authors who presented papers, session chairs, participants, members of the organizing committee, Symposium secretariat and all those who contributed to make this event a grant success. Our special thanks go to Editor-in-Chief of BEPAM Journal, Emerald Group Publishing and their team for their invaluable contribution to the symposium".

About the Organizers:

The **Ceylon Institute of Builders** is the premier professional body of building and construction professionals in Sri Lanka. Its membership is comprised of Architects, Engineers and allied building professionals. CIOB is affiliated to the Council of Research and Innovation in Building and Construction, Canada. In addition to disseminating modern building practices among builders and promoting competencies for the builders to reach professional standards, the institution plays a key role in providing feed back to the Government on their policies affecting the industry.

In order to promote sustainable construction in Sri Lanka, CIOB introduced the Green Building certification scheme in Sri Lanka in 2014. This certification evaluates & rates buildings, building services, building products and equipment for their environmental impact & performance. The CIOB Green Building Certification (CGBC) is awarded to following categories:

- Constructed Buildings (New & Existing)
- Building Products and Materials
- Green Building Professionals Accreditation
- Green Builders (Contractors) Certification

In addition, CIOB conducts training courses and workshops to equip the construction community with knowledge related to emerging concepts in Construction industry such as Green buildings and Lean Construction Management.

Department of Building Economics and Research of the University of Moratuwa aims to produce graduates who are capable of managing resources in the industry with perception; the ability to innovate; the ability to respond to new and unfamiliar situations with a creative use of knowledge and skills; and the ability to take advantage of new opportunities.

The Department was founded in 1983 and currently the pioneer Sri Lankan institute to offer undergraduate degree programmes in Quantity Surveying and Facilities Management. The Department is unique in nature as it is the only department which offers degree programmes in Quantity Surveying and Facilities Management fields in the whole national University system in Sri Lanka.

Symposium Venue

Governor warns of hyperinflation bringing people onto streets -

Construction industry states stopping projects without payment shall do the same

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The governor of the central bank recently addressed a parliamentary seminar and spoke on the fact that hyper-inflation may bring back people to the streets. We echo this feeling and agrees with the facts and figures presented by the governor in his speech. The Construction Industry however continue that, what the Government has done by stopping construction projects will also lead to same event where people who, without means by which to feed their families, will flood the streets pleading for their livelihood.

This is given the fact that the construction Industry employs people from all hierarchies of society, but especially because the majority of this includes some of the poorest labourers in the country. Government has stopped construction projects without settling the contractors' bills. The total amount due is over 130B, while contractors owe banks around 200B. the ordinary interest has skyrocketed to 25-8 and TOD limits are over 30%, both of which contractors cannot bear. They now have lost the luxury of lending and paying their workers. The Construction industry is one of the major industries which contributed around 10% the GDP. And in 2020 it has contributed more than 300B to GDP. There are over 1 million people involved in the industry. The construction supply chain is easily one of the largest in Sri Lanka and includes around 4000 SME including sand suppliers, rubble suppliers and brick makers. In short, Construction companies have been crushed under boot of high bank rates and unpaid government dues, leaving them unable to take care of their vast workforce and supply chains. Thus, as the governor advised the parliament, Contractors in turn advise the Governor that, unpaid dues to contractors may lead to 100s of 1000s of unemployed labourers and workers flooding the streets pleading for their survival. Contractors shall not be held responsible for this crisis.

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case of accidental overloading of the wires. Conduits are usually concealed in finished spaces within the framing of partition walls or above ceilings and terminate in junction boxes flush with a wall surface. The junction boxes contain terminal devices such as the convenience outlet, control switches, or the connection point for built-in light fixtures.

Residential lighting is provided primarily by movable incandescent fixtures plugged into convenience outlets, but there is often built-in lighting in kitchens, bathrooms, corridors, and closets, mostly of the incandescent type. There is also some use of fluorescent lighting, particularly in built-in fixtures. Overall interior light levels in residential uses are low, about 20–40 footcandles. Exterior lighting is used for entrances, walkways, and exterior living spaces.

The power densities of dwelling units are fairly low and are declining because of the increased use of fluorescent lighting fixtures and improvement of efficiency in electrical appliances. The decline in power consumption enhances the prospect of the widespread appearance of dwellings—particularly detached houses—with their own independent electric power generation and storage systems, unconnected to public utility grids. Photovoltaic cells, which convert sunlight directly into electricity, in combination with storage batteries can offer these residences a new kind of energy autonomy.

Low-rise commercial, institutional, and industrial buildings

The size of buildings in the commercial, institutional, and industrial market segment ranges from a few hundred to as much as 45,000 square metres (500,000 square feet). All of these buildings have public access and exit requirements, although their populations may differ considerably in density. The unit costs are generally higher than

those for dwellings (although those of simple industrial buildings may be lower), and this type includes buildings with the highest unit cost, such as hospitals and laboratories. Residential buildings are fairly static in their function, changing only at long intervals. By contrast, most commercial, institutional, and industrial buildings must respond to fairly rapid changes in their functions, and a degree of flexibility is required in their component systems. In addition, these buildings are built by contractors who utilize heavy mechanized equipment not only for foundations (pile drivers and caisson augers) but also for lifting heavy components (a wide variety of cranes and hoists). Semimanual machines such as cement finishers, terrazzo grinders, and welding generators are also used, but a large percentage of the work is done manually; the human hand and back remain major instruments of the construction industry, well adapted to the nonrepetitive character of building.

Foundations

The foundations in these buildings support considerably heavier loads than those of residential buildings. Floor loadings range from 450 to 1,500 kilograms per square metre (100 to 300 pounds per square foot), and the full range of foundation types is used for them. Spread footings are used, as are pile foundations, which are of two types, bearing and friction. A bearing pile is a device to transmit the load of the building through a layer of soil too weak to take the load to a stronger layer of soil some distance underground; the pile acts as a column to carry the load down to the bearing stratum. Solid bearing piles were originally made of timber, which is rare today; more commonly they are made of precast concrete, and sometimes steel H-piles are used. The pile length may be a maximum of about 60 metres (200 feet) but is usually much less. The piles are put in place by driving them into the ground with large mechanical hammers. Hollow steel pipes are also driven, and the interiors are excavated and filled with concrete to form bearing piles; sometimes the pipe is withdrawn as the concrete is poured. An alternative to the bearing pile is the caisson. A round hole is dug to a bearing stratum with a drilling machine and temporarily supported by a steel cylindrical shell. The hole is then filled with concrete poured around a cage of reinforcing bars; and the steel shell may or may not be left in place, depending on the surrounding soil. The diameter of caissons varies from one to three metres (three to 10 feet). The friction pile of wood or concrete is driven into soft soil where there is no harder stratum for bearing beneath the site. The building load is supported by the surface friction between the pile and the soil.

When the soil is so soft that even friction piles will not support the building load, the final option is the use of a floating foundation, making the building like a boat that obeys Archimedes' principle—it is buoyed up by the weight of the earth displaced in creating the foundation. Floating foundations consist of flat reinforced concrete slabs or mats or of reinforced concrete tubs with walls turned up around the edge of the mat to create a larger volume.

If these buildings do not have basements, in cold climates insulated concrete or masonry frost walls are placed under all exterior nonbearing walls to keep frost from under the floor slabs. Reinforced concrete foundation walls for basements must be carefully braced to resist lateral earth pressures. These walls may be built in excavations, poured into wooden forms. Sometimes a wall is created by driving interlocking steel sheet piling into the ground, excavating on the basement side, and pouring a concrete wall against it. Deeper foundation walls can also be built by the slurry wall method, in which a linear series of closely spaced caissonlike holes are successively drilled, filled with concrete, and allowed to harden; the spaces between are excavated by special clamshell buckets and also filled with concrete. During the excavation and drilling operations, the holes are filled with a high-density liquid slurry, which braces the excavation against collapse but still permits extraction of excavated material. Finally, the basement is dug adjoining the wall, and the wall is braced against earth pressure.

Timber

The structures of these buildings are mostly skeleton frames of various types, because of the larger spans their users require and the need for future flexibility. Timber is used, but on a much-reduced scale compared to residential buildings and primarily in regions where timer is readily available. The public nature of commercial and institutional buildings and the hazards of industrial buildings generally require that they be of noncombustible construction, and this largely excludes the use of light timber frames. Heavy timber construction can be used where the least dimensions of the members exceed 14 centimetres (5.5 inches); when timbers are this large they are charred but not consumed in a fire and are considered fire-resistant. Because most harvested trees are fairly small, it is difficult to obtain solid heavy timbers, and most large shapes are made up by glue laminating smaller pieces. The synthetic glues used are stronger than the wood, and members with cross sections up to 30 × 180 centimetres (12 × 72 inches) are made; these may be tapered or otherwise shaped along their length. Skeletons of glue-laminated beams and columns, joined by metal connectors, can span 30 to 35 metres (100 to 115 feet). Heavy decking made of tongue-and-groove planks up to 9.4 centimetres (3.75 inches) thick is used to span between beams to support floors and roofs.

Steel

Steel is a major structural material in these buildings. It is a strong and stiff material and yet relatively inexpensive, and it can be quickly fabricated and erected, which saves construction time. Although steel is noncombustible, it starts to lose strength when heated above 400° C (750° F), and building codes require it to be fireproofed in most multistory buildings; in small and low-hazard buildings, however, it can be left unprotected.

Nearly all structural steel—including sheets, round or square bars, tubes, angles, channels, and I beam or wide flange shapes—is formed by the hot-rolling process. Steel roof and floor deck panels are fabricated from sheet metal by further cold-rolling into corrugated profiles four to eight centimetres (1.5 to three inches) deep and 60 centimetres (24 inches) wide. They are usually welded to the supporting steel members and can span up to 4.5 metres (15 feet). The lightest and most efficient structural shape is the bar (or open web) joist, a standard truss made with angles for the top and bottom chords, joined by welding to a web made of a continuous bent rod. It is used almost exclusively to support roofs and can span up to 45 metres (150 feet). The standard rolled shapes are frequently used as beams and columns, the wide flange, or W shape, being the most common. The widely separated flanges give it the best profile for resisting the bending action of beams or the buckling action of columns. W shapes are made in various depths and can span up to 30 metres (100 feet). Where steel beams support concrete floor slabs poured onto a metal deck, they can be made to act compositely with the concrete, resulting in considerable economies in the beam sizes.

The connections of steel shapes are of two types: those made in the workshop and those made at the building site. Shop connections are usually welded, and site or field connections are usually made with bolts due to the greater labour costs and difficulties of quality control in field welding. Steel columns are joined to foundations with base plates welded to the columns and held by anchor bolts embedded in the concrete. The erection of steel frames at the building site can proceed very rapidly, because all the pieces can be handled by cranes and all the bolted connections made swiftly by workers with hand-held wrenches.

A large proportion of steel structures are built as prefabricated, pre-engineered metal buildings, which are usually for one-story industrial and commercial uses. They are manufactured by companies that specialize in making such buildings of standard steel components—usually rigid steel bents or light trusses—which are assembled into frames and enclosed with corrugated metal siding. The configurations can be adapted to the needs of individual users. The metal building industry is a rare example of a successful application of prefabrication techniques in the construction industry in the United States, where its products are ubiquitous in the suburban and rural landscape.

Concrete

Reinforced concrete is also a major structural material in these buildings. Indeed, outside of North America and western Europe, it is the dominant industrialized building material. Its component parts are readily available throughout the world at fairly low cost. Portland cement is easily manufactured by burning shale and limestone; aggregates such as sand and crushed limestone can be easily obtained. Steel minimills, which use scrap iron to feed their electric furnaces, can mass-produce reinforcing bars for regional use. In industrialized countries the mixing and delivery of liquid concrete to building sites has been mechanized with the use of central plants and mixing trucks, and this has substantially reduced its cost. In barely 100 years, reinforced concrete has risen from an experimental material to the most widespread form of building construction.

There are two methods of fabricating reinforced concrete. The first is to pour the liquid material into forms at the building site; this is so-called in situ concrete. The other method is called precast concrete, in which building components are manufactured in a central plant and later brought to the building site for assembly. The components of concrete are portland cement, coarse aggregates such as crushed stone, fine aggregates such as sand, and water. In the mix, water combines chemically with the cement to form a gel structure that bonds the stone aggregates together. In proportioning the mix, the aggregates are graded in size so the cement matrix that joins them together is minimized. The upper limit of concrete strength is set by that of the stone used in the aggregate. The bonding gel structure forms slowly, and the design strength is usually taken as that occurring 28 days after the initial setting of the mix. Thus there is a one-month lag between the time in situ concrete is poured and the time it can carry loads, which can significantly affect construction schedules.

In situ concrete is used for foundations and for structural skeleton frames. In low-rise buildings, where vertical gravity loads are the main concern, a number of framing systems are used to channel the flow of load through the floors to the columns for spans of six to 12 metres (20 to 40 feet). The oldest is the beam and girder system, whose form was derived from wood and steel construction: slabs rest on beams, beams rest on girders, and girders rest on columns in a regular pattern. This system needs much handmade timber formwork, and in economies where labour is expensive other systems are employed. One is the pan joist system, a standardized beam and girder system of constant depth formed with prefabricated sheet-metal forms. A two-way version of pan joists, called the waffle slab, uses prefabricated hollow sheet-metal domes to create a grid pattern of voids in a solid floor slab, saving material without reducing the slab's strength. The simplest and most economical floor system is the flat plate, where a plain floor slab about 20 centimetres (eight inches) thick rests on columns spaced up to 6.7 metres (22 feet) apart. If the span is larger, the increasing load requires a local thickening of the slab around the columns. When these systems are applied to spans larger than nine to 12 metres (30 to 40 feet), a technique called posttensioning is often used. The steel reinforcing takes the form of wire cables, which are contained in flexible tubes cast into the concrete. After the concrete has set and gained its full strength, the wires are permanently stretched taut using small hydraulic jacks and fastening devices, bending the entire floor into a slight upward arch. This reduces deflection, or sagging, and cracking of the concrete when the service load is applied and permits the use of somewhat shallower floor members. Concrete columns are usually of rectangular or circular profile and are cast in plywood or metal forms. The reinforcing steel never exceeds 8 percent of the cross-sectional area to guard against catastrophic brittle failure in case of accidental overloading.

Precast concrete structural members are fabricated under controlled conditions in a factory. Members that span floors and roofs are usually pretensioned, another prestressing technique, which is similar in principle to posttensioning. The reinforcement is again steel wire, but the wires are put into tension (stretched) on a fixed frame, formwork is erected around the taut wires, and concrete is poured into it. After the concrete has set and gained its full strength, the wires are cut loose from the frame. As in posttensioning, this gives the precast floor members a slight upward arch, which reduces deflection and permits the use of shallower members. Precast prestressed floor elements are made in a number of configurations. These include beams of rectangular cross section, hollow floor slabs 15 to 30 centimetres (six to 12 inches) deep and spanning up to 18 metres (60 feet), and single- and double-stem T shapes up to 1.8 metres (six feet) deep and spanning up to 45 metres (150 feet). recast concrete columns are usually not prestressed and have projecting shelves to receive floor members. At the building site, precast members are joined together by a number of methods, including welding together metal connectors cast into them or pouring a layer of in situ concrete on top of floor members, bonding them together. Precast prestressed construction is widely used, and it is the dominant form of construction in the Soviet Union and eastern Europe.

Masonry finds only a limited structural use in these buildings. Concrete block walls with brick facing and punched openings (discrete windows entirely surrounded by the facing material) spanned by concealed steel lintels can be used for exterior bearing walls where the interior is a skeleton frame of steel or timber. The use of interior bearing walls so greatly reduces the flexibility needed in these buildings that they are only rarely found.

Enclosure systems

Enclosure systems in these buildings range from rather simple forms in industrial uses to quite sophisticated assemblies in the commercial and institutional sectors. Most have in common the use of flat roofs with highly water-resistant coverings, the traditional one being a built-up membrane of at least four layers of coal-tar pitch and felt, often weighted down with a gravel ballast. Such roofs are pitched at slopes of 1 : 100 to 1 : 50 toward interior drains. In recent years the single-ply roof, made of plastic membranes of various chemistries, has found wide application. The seams between the pieces of membrane are heat- or solvent-welded together, and they are either ballasted with gravel or mechanically fastened to the underlying substrate, which is usually rigid foam insulation. Sometimes standing-seam sheet-metal roofs are also used; the best quality is continuously welded stainless steel.

The choice of transparent surfaces in these enclosures is based on three major considerations: conductive heat transfer, radiant energy transfer, and safety. All the transparent materials used in the low-rise residential sector are found, plus a number of others. In buildings with fully controlled atmospheres, double glazing is common to reduce heat transfer and both interior and exterior condensation on the glass. Commercial and institutional buildings tend to have large internal sources of heat gain, such as people and lighting, so it is desirable to exclude at least some solar gain through the transparent surfaces to reduce energy consumption in cooling. This can be done by reducing the light transmission or shading coefficient of the glass by integrally tinting it in various colours; grey, bronze, and green are common tints. This can also be accomplished by vacuum-plating partial reflective coatings of varying densities to an inner surface of double glazing; this can reflect up to 90 percent of the incident energy. Two kinds of reflecting metal are used: aluminum, which is silver in tone, and rubidium, which is gold-toned. These coatings are perceived as strong tints when the outside world is viewed through them by day: grey for aluminum and green for rubidium.

Skylights or horizontal transparent surfaces have found wide application in these types of buildings. These installations range from purely functional daylighting in industrial uses to elaborate aesthetic forms in commercial structures. In horizontal applications, and in vertical walls where people might blunder into glazed panels, safety glazing is required. Safety glazing is of four types: certain plastics that are flexible and difficult to break; wire-embedded glass, which holds together when broken; tempered glass, which is very strong and breaks into tiny and relatively harmless fragments; and laminated glass, which consists of two layers of glass heat-welded together by an intermediate plastic film. Laminated glass can also be made with tinted lamination film, producing many colours not available in integrally coloured glass.

Because many of these buildings have skeleton structures, their vertical surfaces are enclosed in nonstructural curtain walls that resist wind forces and provide weatherproofing. Curtain walls are of several types; the most common is one supported by a metal (typically aluminum) gridwork attached to the building structure. The vertical members, called mullions, are attached to the building at every floor and are spaced 1.5 to three metres (five to 10 feet) apart; the horizontal members, called muntins, are attached between the mullions. The rectangles between the grid of mullions and muntins are filled with transparent or opaque panels. The transparent surfaces can be any of those just described, and the opaque panels include opaque coloured glass, painted or anodized aluminum sheets, porcelain enameled steel sheets, fibreglass-reinforced cement, and stone wafers of granite, marble, or limestone cut with diamond-edged tools. All of these materials are usually backed up by rigid insulation to slow heat transfer. Metal sandwich panels are also used for economy of material; two thin layers of metal are separated by a core of different material, often with a high U-value for insulating effect. The separation of the thin layers of strong metal greatly increases the overall stiffness of the panel. The joints between panels and the supporting grid are weatherproofed with elastomeric sealants (cold-setting synthetic rubbers) or by prefabricated rubber gaskets. In glazed areas of curtain walls, mullions of structural glass are an alternative to metal mullions; they are more expensive, but they give an effect of greater transparency where this is desired.

Another type of curtain wall is the panel type. It has no gridwork of mullions and muntins but is made of large prefabricated rigid panels connected to the floors and spanning between them, with transparent openings made as holes cut out of the panel. The panels can be made of precast concrete, aluminum, or steel, often in sandwich form; elastomeric sealants are used to close the joints.

The finishes of metals in curtain walls include anodizing of aluminum, an electrolytic process that builds up the natural colourless oxide of aluminum into a thick adherent layer; it often includes the introduction of colour into the oxide layer itself. Durable paint coatings (with lifetimes of up to 40 years) can be applied to the metal in the factory; more conventional paints that must be renewed at shorter intervals are also used.

Interior finishes
Partitions

Space-division systems in these buildings make use of gypsum board partitions, usually applied to a framework of formed sheet-metal members attached to the building structure. They are readily demolished and rebuilt at relatively low cost, meeting the need for flexibility in such buildings. They are often used for fire-resistive protective enclosures, for which a number of layers are laminated to achieve the specified fire resistance. Transparent and translucent partitions are also used, with different types of glass set in metal frames. Office buildings may contain prefabricated movable metal partitions, which typically use metal sandwich panel construction to create panels with both transparent and opaque surfaces as well as doors. These partitions are expensive compared with gypsum board and must be moved often to justify the greater initial cost. Concrete block is used in unfinished spaces and for fire-resistive partitions. Glazed ceramic block or ceramic tile applied over concrete block or gypsum board is used in wet areas and where cleanliness is a problem, such as in kitchens and toilet rooms. Occasionally walls with wood paneling or stone veneer are used for aesthetic effect. Doors are usually set in formed sheet-metal frames, although some wood frames are used. The doors themselves are usually made of solid timbers glue-laminated together and covered with thin decorative wood veneers; painted hollow sheet-metal doors are used for exterior doors and in areas of hard use.

Ceiling finishes

Ceiling finishes in these buildings create a sandwich space below the roof or floor slab above, which conceals projecting structural elements, recessed light fixtures, electrical wiring conduits, and air-handling ductwork. The ceiling must be accessible to change or maintain the service elements located above it, and the most common ceiling system is composed of wet felted mineral fibre panels, painted and perforated on one side for sound absorption. The removable panels are supported on a grid of formed sheet-metal tee bars or zee tracks, which are suspended by wires from the structure above. Where accessibility is not important and a smooth finish is desired, suspended gypsum board ceilings can be used.

Floor finishes

Floor finishes in commercial and institutional uses make considerable use of synthetic-fibre carpeting and vinyl composition tile. In areas of higher traffic harder surfaces may be used—for example, cut stone tiles of marble or granite, ceramic tile applied with epoxy adhesive to the substrate, or terrazzo. Terrazzo is made in two ways, traditional and thin-set. In the traditional form a four-centimetre (1.5-inch) layer of cement and sand grout is poured over the substrate; a grid of metal divider strips to control shrinkage cracks is set on the hardened surface, and grout mix of coloured cement and marble chips is poured between the strips. After hardening, the surface is machine polished to expose the marble chips and metal dividers. Thin-set terrazzo is made by placing the metal strips and pouring the binder and marble chips directly onto the subfloor, without the underbed of cement and sand. It is generally possible only when epoxy resins are used in place of cement binders. Terrazzo is available in many colours, and it forms a hard, smooth, and durable surface that is easily cleaned.

Life-safety systems

Most important in the hierarchy of interior elements are life-safety systems to protect and evacuate the building population in emergencies. These include life-threatening events, such as fire and smoke and earthquakes, and less critical ones, such as electric power failures. To deal with the threat of fire and smoke there is an array of fire-detection and fire-suppression systems. These include electronic heat and smoke detectors that can activate audible alarm devices to warn the building population and automatically notify local fire departments. For fire suppression hand-operated fire extinguishers must be provided, but many buildings have a separate piping system to provide water for fire fighting. If public water mains cannot provide adequate water pressure, an electric pump is included, and there is also a connection outside the building to attach portable fire truck pumps. The piping terminates in an array of sprinkler heads located throughout the building in the ceiling plane in a density ranging from eight to 18 square metres (90 to 200 square feet) per head. Typically there is always water in the pipes (a wet system), though dry systems are used in unheated buildings or where leakage might damage the contents. The head is opened to spray water by a fusible link made of metal that melts at a fairly low temperature when the air surrounding it is heated by a fire. Sprinkler systems have proved to be a highly reliable and effective means of fire suppression. Smoke can be as dangerous as fire to building occupants, and protective measures include the automatic shutdown of mechanical ventilating systems and the division of the building into smokeproof compartments to prevent the spread of smoke.

The evacuation of occupants in emergencies is accomplished by a system of protected exits leading to the exterior; all building areas must be within a specified travel distance of such an exit, varying from 30 to 90 metres (100 to 300 feet). For one-story buildings the exit usually consists simply of exterior doors, but for multistory buildings the exits are enclosed stairways that also lead to the exterior. The stairways have fire-rated enclosures and are often pressurized to exclude smoke; their width is determined by the maximum predicted number of occupants per floor. Travel paths to the exit must be clearly marked by illuminated directional exit signs, and battery-powered emergency lighting is required in the travel path and in the exit itself, in case of power failure. Some buildings of this type, such as hospitals, have large diesel- or natural gas-powered emergency electric generating systems that provide power and lighting for critical areas (such as operating rooms).

Another of the life-safety elements in these buildings is the fire-resistance requirements for building materials. These include the application of cementitious fireproofing or insulation to structural steel frames, the fire-resistive construction of the enclosures around exits, the flame-spread ratings of finish materials such as carpeting and wall coverings, and the use of such inherently fire-resistant materials as reinforced concrete and heavy timber. The fire-resistive ratings of various construction materials and assemblies are established by laboratory fire tests.

Vertical transportation

Vertical transportation systems in these low buildings include stairways, sometimes only those provided as life-safety exits but more often open, well-lighted ones as well. Where large numbers of people need to be moved vertically a short distance, escalators, or moving stairways, powered by electric motors are often provided. For moving smaller volumes of people and freight, hydraulic elevators are used; the cabs of these elevators are moved by a telescoping tubular piston underneath, which is raised and lowered by pumping oil in and out of it with an electric pump. Hydraulic elevators move slowly, but they are the least expensive type and are well suited for low buildings.

Plumbing

Plumbing systems for water supply and wastewater removal are very similar to those used in residential buildings, but the higher population densities of commercial, institutional, and industrial buildings require larger toilet rooms for public multiperson use. These often include pressure-valve water closets placed in partitioned cubicles and urinals in men's toilet rooms. Some fixtures in each toilet room must be carefully arranged for easy access by handicapped persons. The internal drainage of large flat roofs introduces another piping system, similar to that for sanitary wastewater, to carry away storm water to separate underground storm sewers. Heavy rainstorms can introduce huge influxes of water into storm sewers, and sometimes this surge effect is tempered by the use of storm water retention ponds on the building site; runoff from the roof and paved areas is temporarily stored in these ponds while it flows into the sewer at a slower rate. Hospitals, laboratories, and factories have many other types of plumbing systems for various gases and liquids; these require special materials and construction. The sites of commercial, institutional, or industrial buildings may have underground networks of irrigation piping that terminate in flush sprinkler heads to water grass and plantings.

Environmental control

The atmosphere systems of industrial buildings are usually simple, involving only winter heating and possibly humidity control if the manufacturing process is sensitive to it. A commonly used element is the unit heater, in which an electric fan blows air through a coil heated by hot water, steam, electric resistance, or gas combustion and provides a directed supply of warm air where needed. Another system involves radiant heating using electric resistance coils backed by reflectors or continuous reflector-backed metal pipes that radiate heat from gas burned inside them. Ventilation in industrial buildings is sometimes done with operable windows but more often with unit ventilators, which penetrate walls or roofs and use electric fans to exhaust interior air that is replaced by air flowing in through operable louvres.

Commercial and institutional low-rise buildings generally have fully controlled atmospheres with heating, cooling, and humidification. An economical method of providing this controlled atmosphere is with rooftop single or multizone package units. Each unit contains an electric fan to move conditioned air; heating elements, which can be gas or oil-fired or electric resistance coils; cooling coils, which use the compressive cooling cycle with compressor, cooling coils, and condensor coils to liberate heat; as well as a fresh-air intake and air exhaust. All of these elements are prefabricated in a rectangular enclosed unit that is simply set on the roof over an opening through which it is connected to the supply and exhaust ducts. The airflow over the heating and cooling elements can be partitioned to provide different conditioned airstreams to serve different zones of the building. The conditioned air is fed at a constant volume into treelike systems of insulated sheet-metal ductwork for transmission to the zones served. The conditioned air enters the occupied space through diffusers placed in the ceiling system and connected to the ducts by flexible spiral reinforced fabric tubes. Thermostats within the space sense temperatures and send signals by electricity or compressed airflow to the unit to adjust heating and cooling as required; relative humidity is held to a range of 20 to 40 percent. The return of air from the occupied space to the unit for reconditioning is sometimes done through a reverse tree of ductwork leading back to the unit, but more often in commercial buildings this is accomplished by placing the entire sandwich space between the ceiling and the structural deck above under negative pressure to make what is called a return-air plenum. The negative pressure is created by an opening into the plenum from the return side of the rooftop unit, and perforated openings or grills in the ceiling plane admit the return air from the occupied space. Return air can also be made to enter the plenum by passing over the lamps of fluorescent light fixtures; this permits the direct recovery of heat generated by the lamps, which can be recycled to the occupied space in winter.

The rooftop unit is best used in one-story buildings or smaller multistory ones. For larger multistory buildings, centralized atmosphere systems are used. These are built up of separate components, most of which are housed in mechanical equipment rooms or in penthouses at roof level. The components include fans for moving air, humidification devices, air-filtering devices, and refrigeration machines. Where large refrigeration machines are used, the condensor coils that liberate heat are no longer placed outside the building as in residential units or rooftop units but are located in a water jacket near the compressor. This water is circulated through a piping system to carry away the heat to a cooling tower outside the building where the water is sprayed into the atmosphere and partially evaporated to liberate heat, then recovered and returned at a lower temperature to the condensor coil jacket. Mechanical equipment rooms for atmosphere systems require a minimum of 5 percent of the floor space in a commercial building and can range up to 20 percent in hospitals and 40 percent in laboratory buildings; if the building is large, there can be more than one fan room with centralized refrigeration machines and cooling towers. The distribution of conditioned air in buildings with centralized atmosphere systems is usually done through an insulated ductwork tree, using the variable air volume (VAV) method. This method supplies conditioned air in variable amounts as required to maintain the desired temperature in occupied spaces; it results in considerable energy economies over constant volume air supply methods. Separate exhaust systems are used for areas generating heat and odours, such as kitchens, laboratories, and toilet rooms.

Electrical systems

Electrical systems in these buildings begin at a step-down transformer provided by the utility company and located within or very close to the building. The transformer reduces the standard line potential to two dual voltage systems, which then pass through master switches and electric meters to record the subscriber's usage. Each of the voltages provided serves a separate category of use; different levels are required for incandescent lights and small appliances, large appliances, ceiling-mounted non-incandescent lighting, and heavy machinery. Each voltage pair has a separate distribution system of wiring leading from the meters and master switches to circuit breaker panels, where it is further broken down into circuits similar to residential uses. Because high-voltage wiring is considered hazardous, the switches controlling overhead lighting use lower voltages, and each heavy machine has its own fused switch. From the circuit breaker panel, low-voltage power conduit and wiring is typically distributed through partitions and ceiling sandwich spaces, but, in large open areas of commercial buildings, there may be wireways embedded in the floor slab. These wireways can be either rectangular metal tubes inserted into the concrete slab before pouring or closed cells of formed steel deck; the wireways are tapped where desired to provide convenience outlets at floor level.

Lighting in these buildings is predominantly fluorescent. Lamps range in size and wattage, and the available colours can range from warm white to cool white. Incandescent tungsten-filament lamps are used mostly for accent lighting, since their light-output efficiency is low. Mercury-vapour and metal halide-vapour lamps have the same efficiency as fluorescent lamps, but certain types may have longer operating lives. High-pressure sodium-vapour lamps have even higher efficiencies and are used in industrial applications; their marked orange colour and high intensity has limited their commercial and institutional use, however. Each of these types of lamp is used in a variety of fixtures to produce different lighting conditions. Incandescent lamps can be placed in translucent glass globes for diffuse effects, or in recessed ceiling-mounted fixtures with various types of reflectors to evenly light walls or floors. Fluorescent lamps are typically installed in recessed rectangular fixtures with clear prismatic lenses, but there are many other fixture types, including indirect cove lights and luminous ceilings with lamps placed above suspended plastic or metal eggcrate diffuser grids. Mercury-vapour and high-pressure sodium-vapour lamps are placed in simple reflectors in high-ceilinged industrial spaces, in pole-mounted light fixtures for outdoor applications on parking lots and roadways, and in indirect up-lighting fixtures for commercial applications. Mathematical models can accurately predict the performance of lighting in most applications. The zonal cavity method, which takes into account the lamps, fixtures, shape of room, and colours of room surfaces, is one example. The usual measure of light intensity is in footcandles on a horizontal surface, such as the floor of a room or a desk. The intensity ranges from 15 footcandles for a minimum ambient light level to 70 footcandles for an office or classroom and 100–200 footcandles for very precise visual tasks such as drafting; direct sunlight at noon, by comparison, is about 1,000 footcandles. In most of these buildings, the required lighting level is achieved with fixtures mounted at ceiling level; having all lighting at ceiling level allows flexibility in using building spaces. But the intensity of light varies inversely with the square of the distance from the source; thus, if a light fixture gives an intensity of 40 footcandles at a distance of one metre, it will produce an intensity of 10 footcandles at two metres. Therefore, considerable energy savings can be realized by having a minimal ambient light level (say 15 footcandles) produced by ceiling-mounted fixtures and providing task lighting close to work surfaces where higher intensities are needed. Daylighting from windows and skylights is also utilized in these buildings, and mathematical models have been developed that accurately predict its performance.

Communications systems are of growing significance and complexity in commercial, institutional, and industrial buildings. Thus communications wires for telephones, public-address systems, and computer data are free to take many paths through the building, including vertical risers, ceiling sandwich spaces, and wireways in floor slabs similar to those of electrical power wires. Where the density of wires rises to very high levels—for example, in computer rooms or where many small computer terminals are installed—raised floor systems are used. Rmovable floor panels are mounted on tubular metal frameworks resting on the structural floor slab, creating a plenum space to carry the necessary wiring.

A number of building systems are controlled by computers or microprocessors. In certain atmosphere systems both the interior sensors (such as thermostats) and the exterior weather sensors feed data to a computer that adjusts the system for minimal energy expenditure. Other examples include security, fire, and emergency alarm systems.

Historic Engineering Feats……………

The World's 20 Most Impressive Ancient Builds

By - TIM NEWCOMB

Suspension bridges and skyscrapers are marvels of modern engineering, but some of the world's most impressive constructions are thousands of years behind us. The Roman Colosseum is one such wonder of ancient architecture, marking a crucial transition point between two vastly different ages of construction.

➡ **You love badass builds. So do we. Let's nerd out over them together.**

For our list of the 20 most impressive ancient achitecture builds (at least ones that are still partially around) we'll use the Great Wall of China as our starting point and dip further back in time to explore the depth and breadth of building before the common era.

The Great Wall of China

ANCIENT BUILD FACT

COVERS NEARLY **4,000 MILES**

Northern China, 210 B.C.

Nobody wants barbarians from the north entering their land. That's why Chinese Emperor Qin Shi Huang commissioned the start of what is now the Great Wall of China in the third century B.C

Made up of sections of walls that cover nearly 4,000 miles—not including another roughly 1,500 miles of natural barriers—the east-west wall uses stone, brick, wood, and earth to create a physical and psychological barrier. Much of the original wall didn't stand the test of time, but the Ming dynasty in the 1300s started a building push that made the Great Wall the wonder it is today.

Temple of Hera

ANCIENT BUILD FACT

STORED DOZENS OF EXAMPLES OF **ANCIENT GREEK SCULPTURE**

Originally surrounded by 40 stone columns (originally wood) the Doric style exterior of the low-slung Temple of Hera was built on the south slopes of Kronos hill, complete with three distinct interior chambers. Interior walls broke up worship areas for different Greek gods, rooms which later became a home for some of Rome's ancient relics.

The temple has a limestone base which runs east to west, longer than it is wide. Mud bricks, meanwhile, form the upper portion with wood and terracotta adorning the temple's interior. Unfortunately, most of it was destroyed during an earthquake in the 4th century AD.

Ancient Greek Parthenon on the Acropolis

ANCIENT BUILD FACT

HOUSED A **GOLD AND IVORY STATUE** OF ATHENA

Athens, 432 B.C.

The first buildings constructed on the the rocky outcrop of the Acropolis of Athens were destroyed by Persians around 480 B.C., but that didn't stop a second 15-year effort from finishing a complete reconstruction that wrapped up around 432 B.C. The highlight of the Acropolis was the Parthenon and its gold and ivory statue of Athena, but there was plenty of other stuff to see, including the limestone foundation and columns made from Pentelic marble, an early use of the material.

Gobekli Tepe

ANCIENT BUILD FACT

200 STONE PILLARS AND ANCIENT STONE STATUES

Turkey, 9000 B.C.

Considered to be the world's first temple, the Gobekli Tepe contains at least 20 circular installations that contain several pillars surrounded by walls, some 200 pillars throughout the whole temple. The site is also home to rock statues with carvings of animals—foxes, snakes, wild boars, cranes and wild ducks—that could date back as far as 10,000 BC. Perhaps most interestingly, some of the construction features pillars that are T-shaped and weigh over 60 tons, leaving experts unsure of how such primitive humans accomplished such a difficult and complex task.

Tumulus of Bougon

ANCIENT BUILD FACT

90-TON CAPSTONE ROOF

France, 4700 B.C.

On a limestone plateau near the river Bougon is a stepped mound with a rectangular chamber, the Tumulus of Bougon. Inside the ancient mound is a series of passages and chamber walls formed by human-shaped orthostats, or more simply "upright stones." A 90-ton capstone covers the main chamber,

with the monolithic pillars dividing the room up into smaller subsections.

When discovered, the location was filled with several vertical layers of skeletons and lots of pottery, which helped archaeologists identify the timeline of construction and discover just how early and impressive this structure is.

Stonehenge

ANCIENT BUILD FACT

A **30-TON** STONE CARRIED FOR 20 MILES

England, 3000 B.C.

The widely famous Stonehenge is built from a mix of large sarsen stones—a type of sandstone found naturally in the south of England—and smaller bluestones. The largest sarsen stone, believed to be from Marlborough Downs about 20 miles from the site, weighs about 30 tons. The Wales-derived blue stones weigh between two and five tons each and were likely carried over 150 miles to reach their final resting place at the Stonehenge site.

Carnac stones

ANCIENT BUILD FACT

OVER **3,000** STANDING STONES

France, 3300 B.C.

Does the year 3300 B.C. sound a little too recent for the world's largest collection of standing stones? It's actually a relatively conservative guess. Some historians believe some of the stones that form the array known as the Carnac Stones in the Brittany region of France date all the way back to 4500 B.C.

Many have guessed at the possible purpose of the megalithic site, which may have been used to track to movement of the sun or the stars. We may never really know, but the sheer intensity of hundreds and hundreds of carved stones placed in such a regimented order is compelling food for speculation.

Knap of Howar

ANCIENT BUILD FACT

OLDEST **STONE HOUSE** IN NORTHERN EUROPE

Scotland, 3700 B.C.

It may seem like just a stone house, but the Knap of Howar in Scotland is actually the oldest preserved stone house in northern Europe. The farmstead's two buildings connected by a passage were built with split stone to a height of just over five feet and feature doorways facing the sea. A hole in the roof indicates the home was likely heated by fire and stone furniture found provides an even stronger indication that this was once an ancient residence.

Megalithic Temples

ANCIENT BUILD FACT

SOME OF THE OLDEST **FREE-STANDING** STRUCTURES ON EARTH

Malta, 3,500 B.C.

A collection of six different temples built over hundreds of years in Malta, the Megalithic Temples are noteworthy not only for their originality and complexity, but due to the advanced technical skill that would have been required to build some of the earliest known freestanding stone structures. Each monument had a different articulation and construction, and the exteriors were often hard coralline limestone, while softer globigerina limestone use used for a more delicate and ornate interior.

Newgrange

ANCIENT BUILD FACT

PERFECTLY DESIGNED TO CAPTURE THE WINTER SOLSTICE SUN

Ireland, 3200 B.C.

On roughly 4 days every year, the winter solstice sun pokes through the top of this Stone Age monument and onto the floor of the interior chamber, filling the ancient temple with light for about 17 minutes. Built before Stonehenge, Newgrange was likely used to track the passing of the years with a precision ahead of its time. With an earthen mound and stone forming passageways and chambers inside Newgrange, the site likely also served as a passage tomb and ceremonial location as well as highly engineered clock.

to be continue next issue

Biophilic design in built environments

The words "bio" and "philia" are combined to generate the term "biophilia"

Dr. Ashan Senel Asmone

[1]. Bio is short for "life, alive" and Philias are "the attraction and good emotions people have for specific living spaces, acts, and creatures in the natural environment," as opposed to phobias, which are deep fears that people feel about things in the natural world

[2]. A rising amount of scientific research has demonstrated how people's physical and mental health, performance, and wellbeing are significantly impacted by most of our ingrained instincts to identify with nature

[3]. The idea of biophilia incorporated with buildings, or "biophilic design" has evolved to incorporate natural materials and situations and has been applied to promote physical, social,

intellectual, and psychological wellbeing in the built envirment.According to Ryan and Browning [4]. biophilic design is the “process of basing decisions about the built environment on intuition or credible research – derived from either an appetency for nature or measurable biological responses, respectively – to achieve the best possible health outcomes.”

There are numerous benefits of reintegrating nature into the built environment, according to modern environmental science and psychology specialists who have examined the consequences of human engagement with the natural environment. Several studies demonstrate that even slight exposure to nature and few alterations to current structures, which including adding plants or providing a view of a natural environment, can have considerable positive benefits on workers ’ health and well-being [5]. To help explain how people's health and well-being are influenced by their surroundings, a variety of cognitive, psychological, and physiological theories have been investigated and proven in laboratory or field investigations.

Benefits of biophilia is not limited to the interactions with employee health and nature. As some researchers have demonstrated [2], by looking at a number of industries and sectors in today's society, including the workplace, healthcare, retail, educational institutions, and communities, biophilic design has been found to bring about significant economic benefits as well. These may be attributed to the effects of well-designed facilities incorporated with biophilia helping to lessen poor performance, absenteeism, loss of focus, unhappy moods, and ill health at workplaces. Further factors contributing to economic gains include the calming nature of biophilic design attracting customers to retail spaces; improved medical outcomes lowering staffing and patient care costs when used in hospitals; and improved focus, behaviour and learning rates at schools.

On the other hand, compelling evidence is laid over the fact that disregarding nature during conventional design approaches may even have detrimental effects on worker satisfaction, child development, community safety, and human health.

Although the visual sense has been the subject of a lot of research on restorative environments, strengthens the claim that natural experiences are multisensory, more recent studies have found that the auditory and olfactory senses are becoming more important [6]. Examples to such biophilic design in built environments include slight aromatic plants, inclusion of water flow, bird voice and other natural sounds in indoor spaces. Designers and scientists alike are currently in the process of re-integrating nature into the built environment in pursuit of sustainable development. Such a framework for biophilic design suggested by [7]. is given in Figure 1.

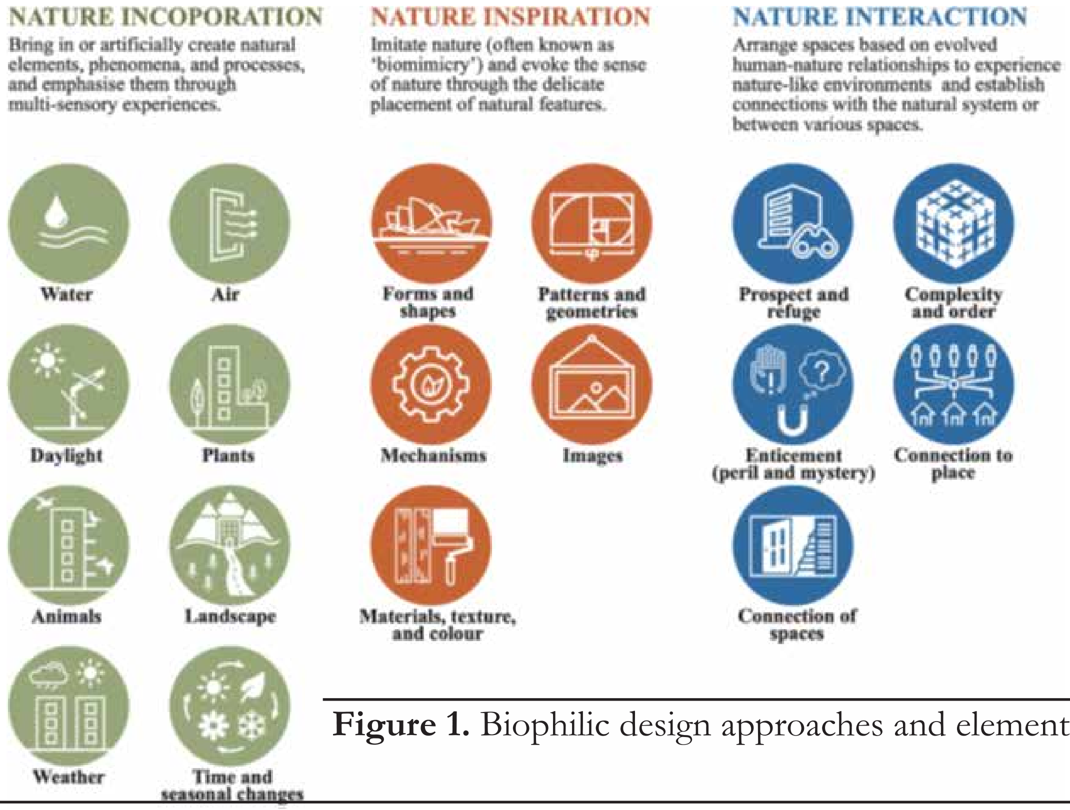
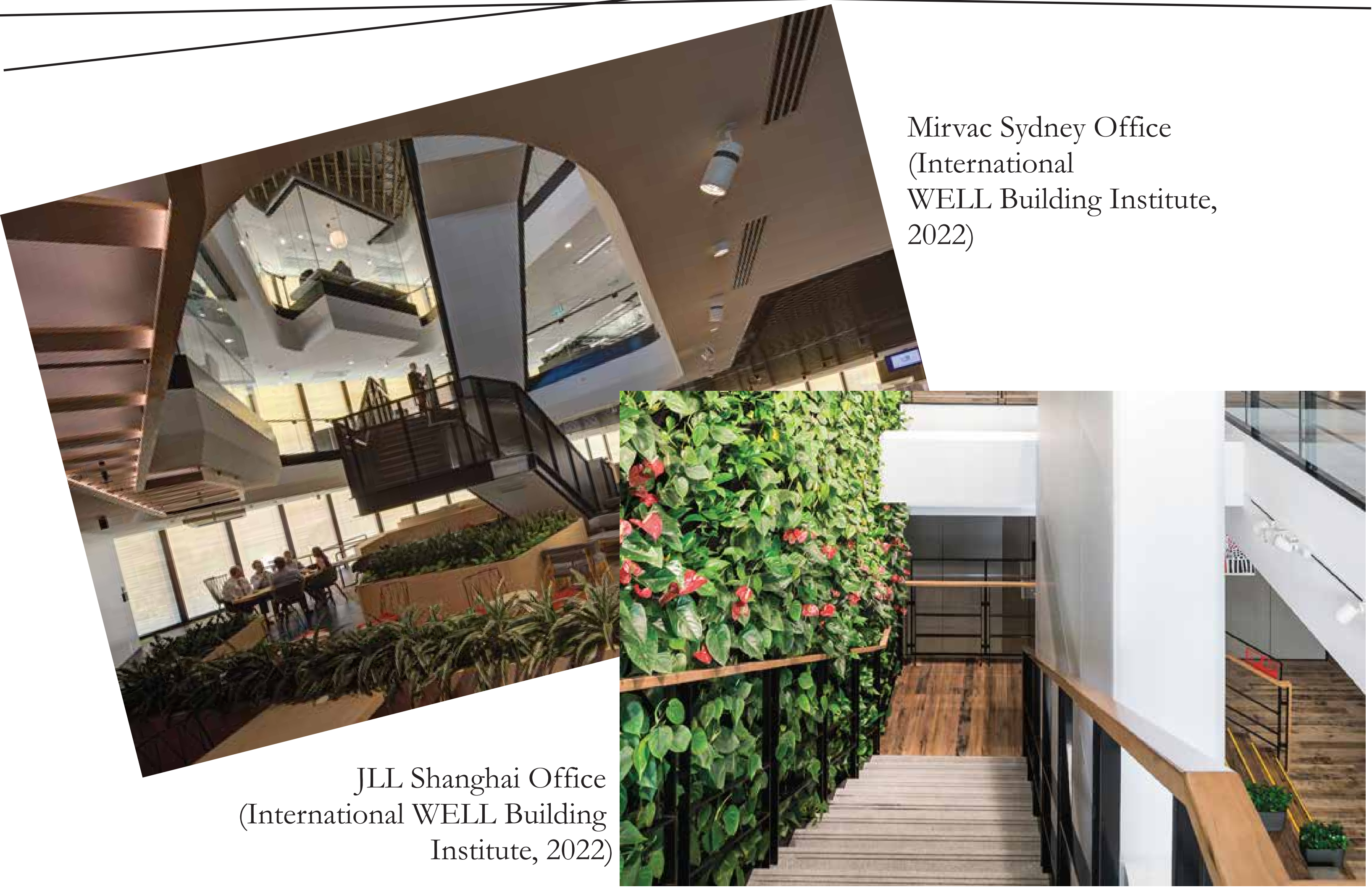


Figure 1. Biophilic design approaches and elements (Source: [7])



Mirvac Sydney Office (International WELL Building Institute, 2022)

JLL Shanghai Office (International WELL Building Institute, 2022)

Recent advances in green building rating systems, such as in the Living Building Challenge and the WELL Building Standard includes dedicated provisions for biophilia to promote its wider usage in the built environment [8]. The advantage of introducing biophilic design into a rating system is that ratings can change the way people talk about biophilia within the context of buildings. Green building rating systems, such as LEED, BREEAM, and GreenMark grading systems, have demonstrated this in recent years.

It is long held that association with nature can enhance us humans' cognitive, psychological, and spiritual satisfaction. If we can optimize, through biophilia, our direct and indirect experience of nature and our experiences within our built environments we can create places and spaces which are far more comfortable, convenient, healthy, and safe for us humans to work and to live in.

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These 13 Buildings Redefined Architecture in the Past 5 Years

From Santiago Calatrava's Oculus to the Louvre Abu Dhabi by Jean Nouvel, these structures go above and beyond their vertical height in redefining the ever-changing world of architecture

The design of office buildings, museums, airports, train stations, and homes, can't always be revolutionary. In fact, much of architecture consists of those banal platitudes that are necessary for cities to grow and humanity to advance. Every so often, however, a building is completed that almost universally turns heads, and in the process, veers the collective practice of architecture in a new direction.

Take Foster + Partners' Apple Park, which—from its fully solar panel–clad rooftop to its ability to maintain an interior temperature of 68 to 77 degrees Fahrenheit by using an intake and release of natural air from the outdoors—has revolutionized the way in which modern company headquarters are designed. Or CopenHill, a project started in 2013 by Bjarke Ingels Group (BIG) that has gone on to redefine our notion that eco-friendly architecture can be done with high design. Located in Copenhagen, Ingels's structure burns waste into enough clean energy to annually power 60,000 homes in the area. Yet, unlike every other waste management plant before it, BIG's takes its one step further. Atop the structure's roof is a nearly 1,500-foot-long ski slope, paved with paths designated for beginners, intermediates, and experts.

As BIG's design proves, great architecture is always a point of departure. On one end, it's a structure that's using the past for inspiration in function. But it's simultaneously looking forward in attempts to better its role in the world. Indeed, culture progresses in fits and starts, never strides. And to witness a revolutionary work of architecture is to journey to the near future, by way of the near past. We believe these 13 buildings do just that.

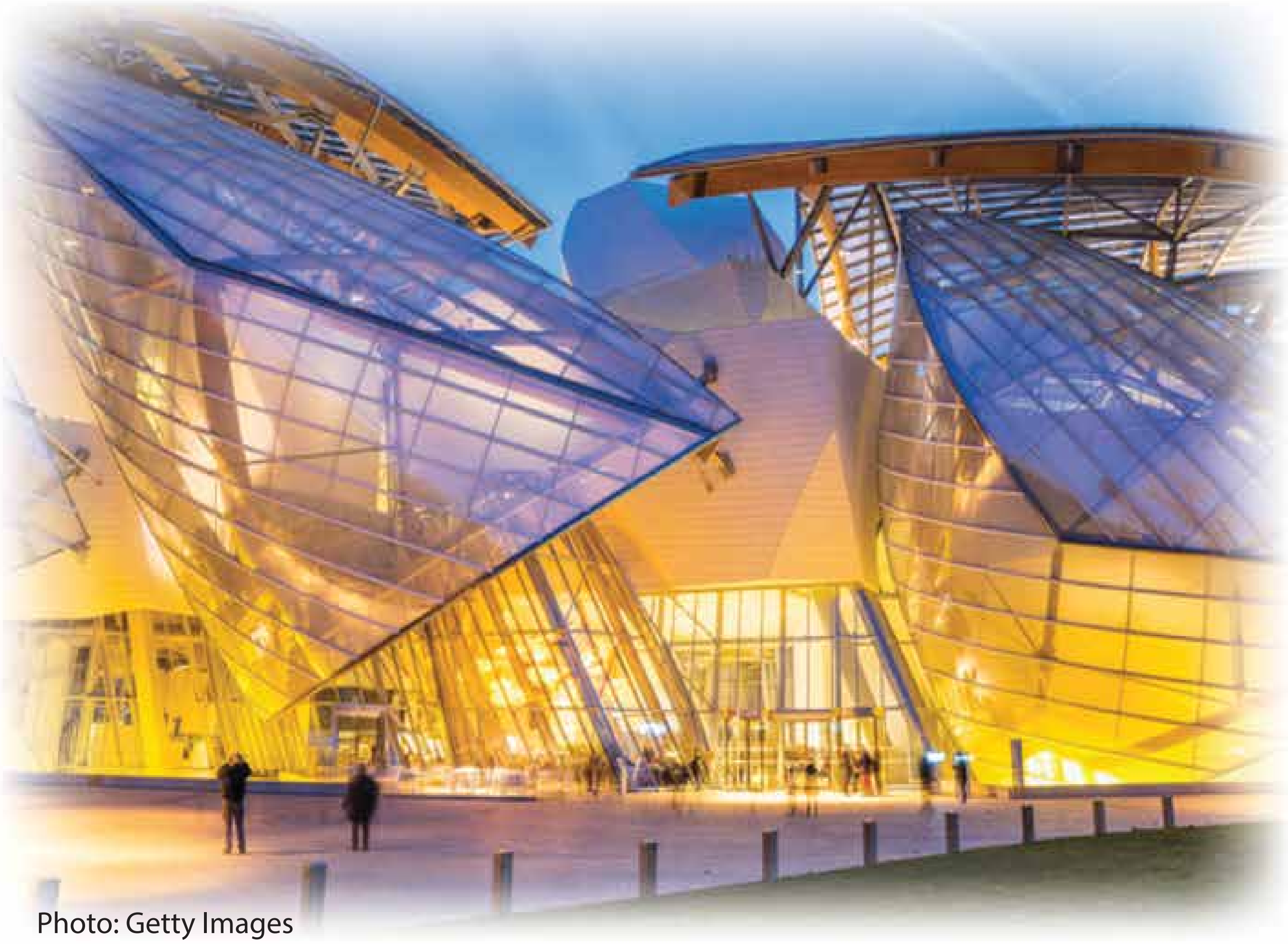

Photo: Getty Images

Fondation Louis Vuitton (2014)

by Frank Gehry (Paris)

Due to its strict building codes, and architectural pedigree, Paris is among the world's most difficult places to successfully design modern architecture. Yet, leave it to the most lyrical of all starchitects, Frank Gehry, and his phenomenal Fondation Louis Vuitton, to accomplish such a feat. Completed in 2014, the vessel-shaped glass structure sits among the trees and lawns of Paris's Bois de Boulogne. The building is filled with LVMH's impressive art collection, with works ranging from Kusama and Abramovi´c to Matisse and Giacometti spread throughout the 126,000-square-foot, two-and-a-half-story space. For his inspiration, Gehry looked back to several great designs of the 19th century. "I've always loved the glass greenhouse buildings in French and British gardens. When we were confronted with a site in the Bois de Boulogne, glass seemed like the best way to add a structure to the beautiful garden," says Gehry. "Of course, in a museum structure, you can't hang paintings on glass, so we had to design a more enclosed building inside the glass exterior." This play between solid and glass works to perfection within the verdant atmosphere of the Bois de Boulogne. It's a structure that's both whimsical and sturdy, much like the meandering paths and endless row of trees that surround it.

Shanghai Tower (2015)

by Gensler (Shanghai)

Designed by Gensler and completed in 2015, the 2,073 foot-tall Shanghai Tower (pictured in the center) has a seemingly endless list of records: tallest building in China, second tallest in the world, world's tallest observation deck, and the world's second-fastest elevator system. Yet, shockingly, that list almost pales in comparison with the fact that the firm's design of the building—an asymmetrical form with rounded corners—saved some $58 million in material cost versus a traditional angular build of the same size. "The tower's asymmetrical form, its tapering profile, and its rounded corners allows the building to withstand the typhoon-force winds that are common in Shanghai," says Xiaomei Lee, Gensler's regional managing principal in China, and project director of the Shanghai Tower. "Using a wind tunnel test conducted in a Canadian lab, Gensler refined the tower's form, which reduced building wind loads by 24 percent. The result came in the form of a lighter structure, saving $58 million in costs for required materials."

Photo: Getty Images

432 Park Avenue (2015)

by Rafael Viñoly (New York)

Rafael Viñoly's 432 Park Avenue is the tallest completed residential building in the Western Hemisphere, and as such, demands one's attention in a way that no residential building ever has. Located in the heart of midtown Manhattan, the 1,396 foot-tall skyscraper can be seen from all five boroughs. Its silhouette dominates New York's skyline from every angle—in cars, trains, and airplanes alike—a fact that was not lost on the world-renowned Uruguayan architect. "To make such a prominent and lasting mark on the most iconic skyline in the world is a great responsibility. From the start, I was aware that it needed to have a timeless quality—as free as possible of passing aesthetic fads," says Viñoly. Proponents of the design will say that there's a certain elegance to the all-white, uniform shape, while skeptics argue it lacks character. Whatever the case may be, the feat of engineering needed to build this structure has taken architecture to a higher level. Or, as Viñoly says, "The design simply expresses the structural solution to an enormous engineering challenge, while also reflecting the other defining urban feature of New York, the city's grid." The building is essentially six separate structures built atop each other, with a central, uninterrupted core that consists of the elevator shafts and all the building's mechanical services. Outside of this backbone, all the livable space fills in the structure. While there has been some criticism of Viñoly's design, there's no doubting the fact that his vision has ushered in a new era of slender super towers.

Photo: Halkin Mason Photography

The Broad (2015)

by Diller Scofidio + Renfro in collaboration with Gensler (Los Angeles)

In many ways, the architects at Diller Scofidio + Renfro are modern-day magicians. Take, for example, their design of The Broad in Los Angeles. The structure itself holds a nearly 2,000-piece collection of contemporary art, making it, in theory, like any other museum in the world. Yet, that's where the similarities abruptly end. The 50,000-square-foot building acts as a seamless buffer between the inside and outside world. "Most museums are opaque to the street and inwardly focused. The Broad uses a semi-porous system—which we dubbed 'the veil'—to foster more of an urban interface," says Elizabeth Diller, partner and cofounder of the New York–based firm, DS+R. "The veil's porosity suggests two-way vision. It tempts you from the street through its lifted corner, while views from within the gallery are oblique so visitors are not distracted, without being entirely cut off from the world." This honeycomb-like design also enhances the artwork housed within the structure, making the striking exterior multi-functional in its aesthetics. "The veil's walls are also engineered so that, despite the movement of the sun, no direct sunlight will ever penetrate the space. The cellular structure all around acts like a sponge absorbing and transmitting light as needed."

Photo: Courtesy of DS+R/Iwan Baan

Photo: Getty Images/Dennis K. Johnson

The Oculus (2016)

by Santiago Calatrava (New York)

Santiago Calatrava has built a reputation for creating structures so dynamic, they appear poised to take flight at any moment. And the Spanish-born's design of the Oculus is no exception. While the structure is built of steel, concrete, stone, and glass, it takes the shape of a bird, specifically a phoenix, in mid-flight. The symbolism of a phoenix rising from the ashes is immediate, as the building is located mere feet from the September 11th Memorial and Museum in downtown Manhattan. But it's not just the symbolism, it's also the design—the ability of visitors to move with ease through a space that connects 11 subway lines and countless retail and office spaces—that makes this transportation hub such an architectural marvel. "I wanted to build a station that anyone can easily find their way around. Why? Because finding one’s way in a station is essential," explains Calatrava. "The idea of going underground through long escalators, entering dim places, this is our everyday life in New York. But does it have to be so dark? No. I wanted to create a place that delivers the people a sense of comfort through its orientation, while also delivering a sense of security by opening everything to the naked eye." For anyone who has visited Calatrava's Oculus, it's evident he's done this in spades.

In its most basic form, Herzog & de Meuron's design for the Elbphilharmonie Hamburg is physical evidence that adaptive reuse can be done to stunning, head-turning effect. Glass completely covers the upper portion of the structure, making it appear more like an avant-garde ship than a space for musical performances. Completed in 2017, the bottom half of building (on which Elbphilharmonie Hamburg sits atop) has a history that actually dates back further than that. The foundation of Herzog & de Meuron's design is a brick building that was a former warehouse built in 1963. The location of this warehouse was significant, as it sat along the mouth of the Elbe river in the geographical heart of the city. When the warehouse, along with many other older 19th-century brick buildings, became derelict, a plan was put in place to transform these industrial spaces into popular waterfront developments. No one could have predicted the popularity of the Elbphilharmonie Hamburg. Tickets are constantly sold out for its musical performances (due in part to the affordable value of tickets in comparison with other philharmonics around the world). The interior of the venue is also democratic in layout, meaning that all 2,100 seats are situated around the main stage, making each of them equal in status and in their quality of experience. Adding to the buildings all-people-being-equal ethos, in March 2017, during the height of what many referred to as the refugee crisis in Europe, the Elbphilharmonie used its popularity in a positive way: by presenting a festival dedicated to Syrian music and culture that brought together residents and new arrivals to the city.

Elbphilharmonie Hamburg (2017)

by Herzog & de Meuron (Hamburg)

Photo: Courtesy of Herzog and de Meuron/Iwan Baan

Photo: Getty Images

Apple Park (2017)

by Foster + Partners (Cupertino, California)

For some, Apple Park will always be remembered as the final vision of the firm's inimitable founder, Steve Jobs. For countless more, however, Apple's latest headquarters will be considered the crowning architectural achievement for how the campus of a forward-thinking company should be designed. Created by the firm Foster + Partners, the 175-acre campus was the culmination of a dream that Jobs had in 2004 while walking through London's Hyde Park. It was while there that the iconic founder decided to house his company in a new environment where the barrier between building and nature seamlessly disappeared. To fulfill that lofty ambition, Jobs turned to Pritzker Prize–winning architect Norman Foster. "In my first meeting with Steve Jobs in 2009, he recalled the region [of central California] being the fruit bowl of America and the idea was born of re-creating such a landscape as an integral part of the concept," says Foster. "In this approach the buildings and their setting are inseparable and specific to the needs of Apple. Steve and I shared a vision for the project; Apple Park is the result of the coming together of two teams to ultimately become one." This vision includes a main, ring-shaped building that runs on fully sustainable energy, much of which comes from the solar panels that line the top of the spaceship-like structure. For a company as cutting-edge as Apple, solar-energy almost seems archaic. That's why it pushed Foster and his team further to create a building that actually breathes. Between each floor is a canopy that slightly sticks out, its main purpose being to protect employees from the intense California sun. Tucked within each canopy is a ventilation system that funnels air in and out of the building. Jobs (who was not a fan of air conditioning) wanted his employees to feel any passing breeze as if they were sitting outside. Through a variety of sensors, the building maintains a temperature of 68 to 77 degrees Fahrenheit, all by using an intake and release of natural air. The campus also houses 9,000 trees, many of them apple, plum, apricot, and other fruit trees. The verdant setting is not merely for aesthetics, however: They're all drought-tolerant varieties, planted to withstand climate change.

Louvre Abu Dhabi (2017)

by Jean Nouvel

(Abu Dhabi, United Arab Emirates)

Photo: Getty Images/Luc Castel

If the past decade can be viewed as a modern Arab Renaissance for the oil-rich nation of United Arab Emirates, then the Louvre Abu Dhabi is most certainly the centerpiece of this movement. Completed in 2017, the estimated $650 million building located in Abu Dhabi is, if nothing else, a milestone for a city that, as of the 1950s, didn't have paved roads, electricity, or running water. The 258,333-square-foot structure, which was designed by Jean Nouvel, features a stainless-steel and aluminum dome that's been cut and layered to dazzling affect. When the intense Middle Eastern sun beats down on the dome, light beams come through in the form of star-shaped patterns. It took eight years of construction for the stars to align in this building, which is the largest art museum in the Arabian Peninsula. Unlike the National Museum of Qatar (which was highly nationalistic and built two years later, some 355 miles away by car), the Louvre Abu Dhabi promotes the impressivearray of Western art spread throughout 23 galleries that are either owned by or on loan to the UAE (including an 1877 Van Gogh self-portrait, Monet's 1877 painting of the Saint-Lazare railroad station, Jacques-Louis David's famous portrait of Napoleon crossing the Alps on a white horse, and Mondrian's 1922 Composition With Blue, Red, Yellow and Black).

CopenHill (2017)

by Bjarke Ingels Group (Copenhagen)

Bjarke Ingels, the founding partner and creative director of Bjarke Ingels Group (BIG), is no stranger to radical architecture. The 44-year-old architect has a résumé that would satisfy architects twice his age. Yet, it's the design of CopenHill, a structure in his hometown of Copenhagen, that displays the sheer genius of the young architect. At its core, CopenHill is proof that eco-friendly architecture can be accomplished with high design. To that end, the eco-friendly waste-to-energy power plant emits no toxins into the atmosphere. Far from it. The structure can burn 400,000 tons of waste annually into enough clean energy to power 60,000 homes in the area. But it's not just about waste management—it's about having fun too. While Denmark receives a healthy amount of snow, the country is rather flat and not an ideal terrain for ski lovers. BIG took that fact and used it as an asset in its scheme. Atop the CopenHill roof is a nearly 1,500-foot-long ski slope, which is accessible through an elevator inside the building. There are three paths for skiers: one for beginners, another for intermediates, and, finally, one for experts. "What I love about this project is that it also shows you the world-changing power of 'Formgiving,' which is giving form to that which does not yet exist—to give form to the future," says Ingels. "I have a nine-month-old son, and he will grow up in a world not knowing that there was ever a time when you couldn't ski on the roof of a power plant."

Photo: Courtesy of BIG/Rasmus Hjortshoj

The National Memorial for Peace and Justice (2018)

by MASS Design Group

in collaboration with the Equal Justice Initiative (Montgomery, Alabama)s (2016)

The National Memorial for Peace and Justice is a name that, on the surface, would appear to console its visitors. Yet, rightfully so, the structure does anything but that. Designed by the Boston-based firm, MASS Design Group, the open-air memorial was created to commemorate the victims of lynching in the United States. As visitors enter the memorial, patrons walk alongside dark red columns. These columns include both the names of victims and the counties where these unthinkable events took place (like when, in 1877, Arthur St. Clair, a Florida minister, was lynched for performing the wedding of a black man and white woman, or in 1930, when Lacy Mitchell was lynched in Georgia for testifying against a white man accused of raping a black woman). As visitors slowly take in these names, the ground slowly slopes downward, while the columns remain at the same level, eventually hanging above the visitors in a manner that evokes the lynchings that occurred around the country. From there, the museum opens up to a central space where visitors stand and look back upon all the hanging columns. The National Memorial for Peace and Justice is an educational, if not harrowing, experience for every visitor. What more can we ask from a structure meant to shed light on such a dark past?

Photo: Getty Images/Bob Miller

Photo: Courtesy of Toshiko Mori Architect/Iwan Baan

Fass School and Teachers' Residence (2019)

by Toshiko Mori (Fass, Senegal)

Much of architecture is about taking a big vision and localizing it at the community level. And perhaps nowhere is that more evident than in the Fass School and Teachers' Residence, an elementary school on the coast of Senegal. Designed by Toshiko Mori—the founder and principal of New York–based Toshiko Mori Architect—the circular structure was shaped by the history of the land. "The design is based on a vernacular paradigm of the Senegalese's ancient collective housing structures," says Mori. "The standard schools in that area are made up of rectangular concrete-block walls and corrugated metal roofs—very unfriendly and alienating structures which become very hot under the sun and incredibly noisy during rainfall." For the Fass School and Teachers' Residence, however, Mori sourced the land for mud-brick walls that are supported by steel and bamboo. The walls were then painted white, an important step that deflects the sun's rays. The school's rooftop is a combination of bamboo and grass, another element that keeps temperatures down in the classroom (temperatures can regularly exceed 100 degrees Fahrenheit in Fass). The school, which houses some 300 students between the ages of 5 and 10, is the first in the area that teaches children to read and write in their native language, Pulaar, as well as in French. "Architecturally speaking, I wanted to expand the potential of a familiar, vernacular building typology and to transform it into a new, contemporary icon of their own public institution with shared functions and spaces," explains Mori. In other words, the Japanese-born architect successfully took a big vision and localized it in a meaningful way.

to be continue
next issue

Archinect News

Encircling the Burj Khalifa high up in the sky, Dubai architects propose a massive 'gated community' megastructure

By Josh Niland

Downtown Circle is made up of five levels and would sit on five points, or pillars, embedded into the ground. The massive span of the circle itself would be composed of twomain rings held together by a continuous green belt named the Skypark which vertically connects the floors with each other creating a connected three-dimensional urban green eco-system. — The National

The National mentions that the (supposedly) self-sustaining 550-meter-tall (1,804-foot) structure would include a tram system and incredible landscaped features such as swamps and a waterfall in and around its three-kilometer (1.86-mile) long tract. ZNera Space, the Dubai-based firm behind the proposal, mentioned it in terms of the NEOM project's recently-announced 'The Line' megastructure, stating that its concept differs within an urban context, but that the radical design, which was thought up during the pandemic, "raises the discussion of what we can do better" in terms of agricultural production and social division. "Our roles as architects is to come up with these ideas," co-founder Najmus Chowdry said. "We want people to comment on it, criticise it, to see how we can think about building topographies."

By Josh Niland, Aug 19, '22 12:03 PM EST

News

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Burj l Khalifa, Dubai

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