THE FUTURE OF CONCRETE

by

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Concrete is our world, Our world is Concrete

What is Concrete?

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Our Concrete is;

- Strong
- Resilient
- Durable
- Affordable
- Empowering
- Local
- Recyclable
- Insulating
- Statement

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CARBONEUTRAL

CARBONEUTRAL

Our Concrete is;

a wonder

a promise

a canvas

a reflection

a masterpiece

a tribute

a playground

a belief

a witness

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CARBONEUTRAL

Our Concrete is;

An innovation

An escape

A declaration

An inspiration

Our story

Our progress

Our past

Our present

Our Future

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Future of Concrete

- Our ‘Concrete Future’ sets out the positive vision for, how the cement and concrete industry will play a major role in building the sustainable world of tomorrow.
- Over the past 100 years, concrete has revolutionised the global built environment.
- It is the vital building material that has shaped our modern world.
- As we face the important challenges for future generations, addressing the need for sustainable communities and prosperity, including key infrastructure, homes, clean water and providing resilient communities as our climate changes, as well as supporting the transition to low carbon energy concrete, we are working towards building a brighter world.

Future of Concrete -Taking environmental action

- The World is growing at a pace never known or perceived before. Sky-scrappers, multi-lane roads, long bridges, smart cities, smart mobility & other infrastructure have defined the new world shaping our lives surrounded by CONCRETE JUNGLES.
- The Worlds construction sector consumes at least 45% of the total global resources and about 40% of the total energy.
- The primary materials like sand, limestone, clay, soil, crushed stones, cement steel – each requiring strength & quality checks. Let us not forget the huge volume of Fuel is used in manufacture & transportation of materials and it is also a PARTY to ENVIRONMENTAL POLLUTION.
- Not to forget the quantum of 34% of the population is employed directly or indirectly in the construction, whose lives depend on its GROWTH.

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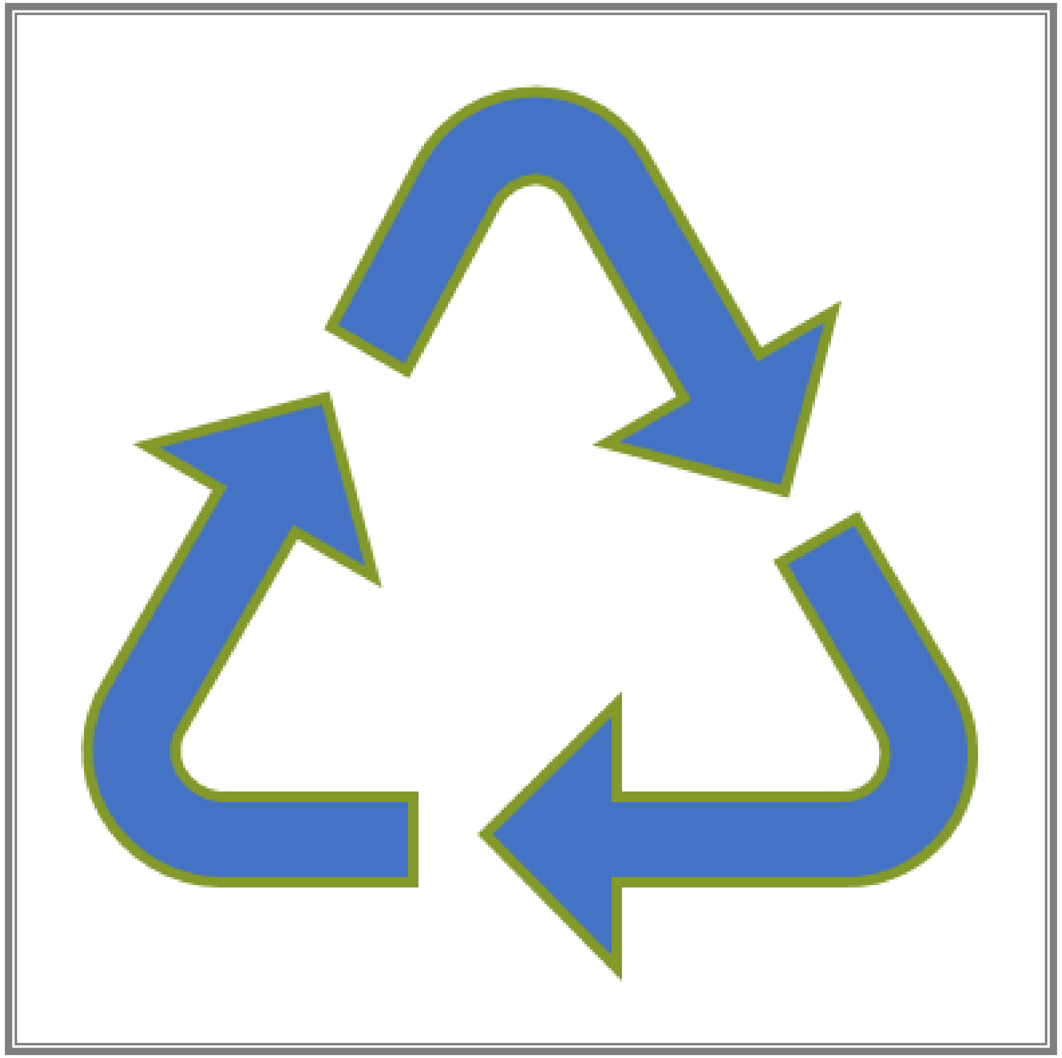
Future of Concrete -Taking environmental action

- 4 billion tons of cement are produced each year worldwide.
- Cement, the most polluting element of concrete, is responsible for 5 to 6% of global CO_2 emissions.
- Reducing concrete manufacturing's carbon footprint has thus become a priority, and the cement industry is aiming to divide its footprint by five by 2050.
- To reach this goal, several approaches are emerging: new formulas, carbon capture and storage, alternative fuels, recycling leftover demolition waste

Sustainability

REDUCE – RECYCLE - REUSE



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Future of Concrete

- Looking Green
- Sustainable
- Stronger
- Tougher and
- Better

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Trends in Concrete

- UHPC
- Structural Lightweight Concrete
- Graphic Concrete
- Carbon Absorbing Concrete
- Light Generating Concrete
- Self Healing Concrete
- Translucent Concrete
- 3D Printing
- Use of BIM, Software
- Application of IOT, DRONE, AI & VR
- Off-Site Construction

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Future of Concrete in Housing

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Present Housing Scenario

Under 12th Plan, it is estimated that over 18 million housing units needed

88% of housing units pertains to for poor and other 12% for lower income groups

% Residential Housing by Structure

Distribution	Rural	Urban
Pucca	41%	79.5%
Semi Pucca	36%	16%
Serviceble Kutcha	14.75%	6%
Un-serviceble Kutcha	8.45%	00

Housing conditions in Metros

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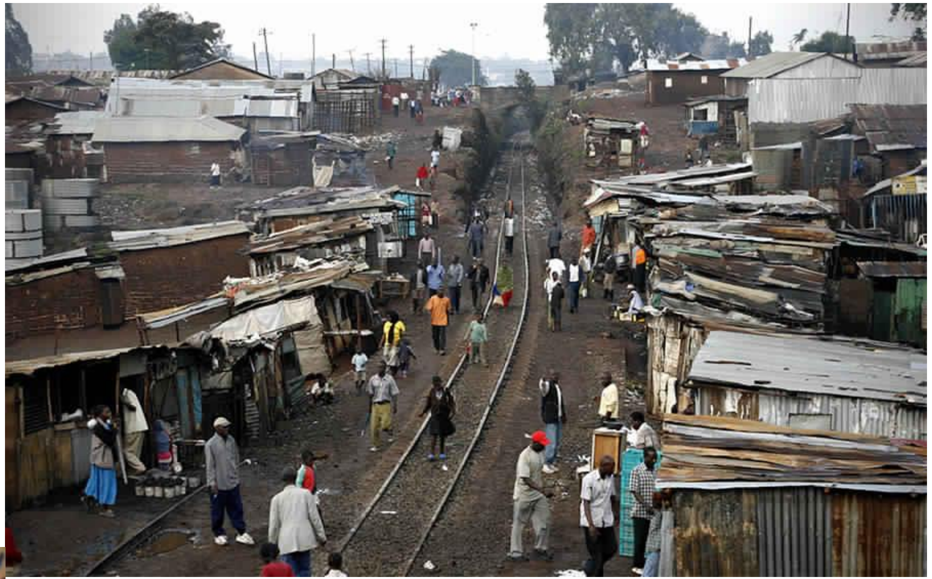
Housing condition of Urban India



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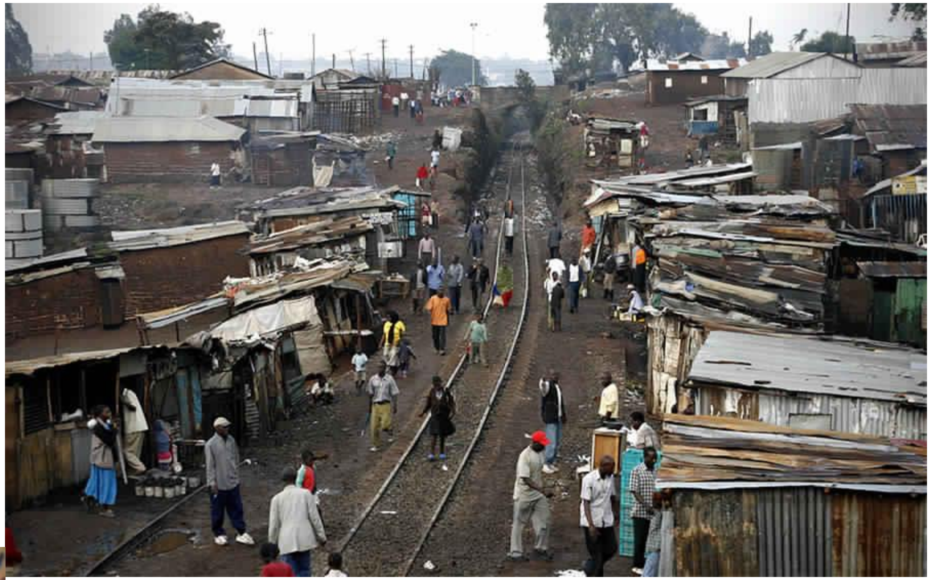
Housing condition of Urban India



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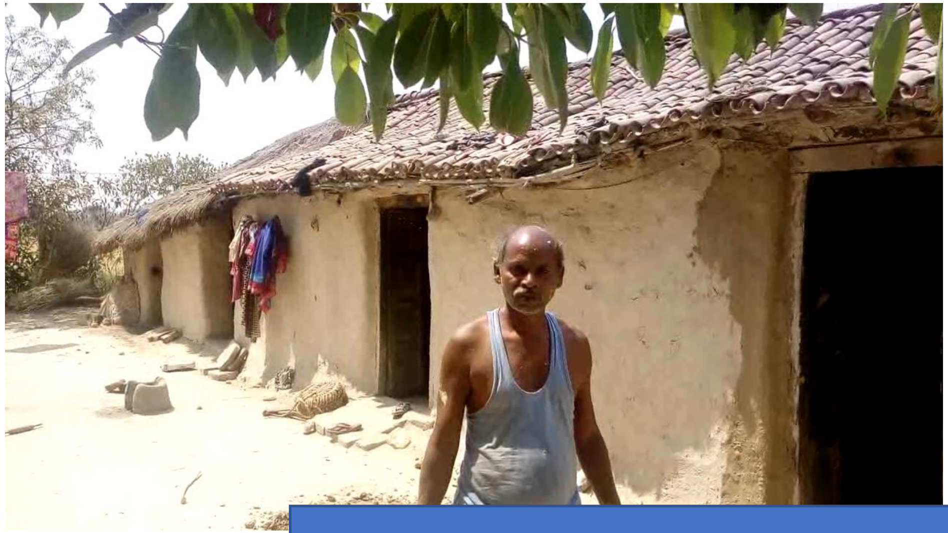
Housing condition in Rural India



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Challenges Associated with Housing Projects

Quality

Speed

Mechanization

Technology Adaption

Regulatory issue

Labour/Skills up-gradation/Training

Cost

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West Bengal & Orissa – Recent Cyclone

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Natural Disaster – Kerala Flood & Gaja Cyclone

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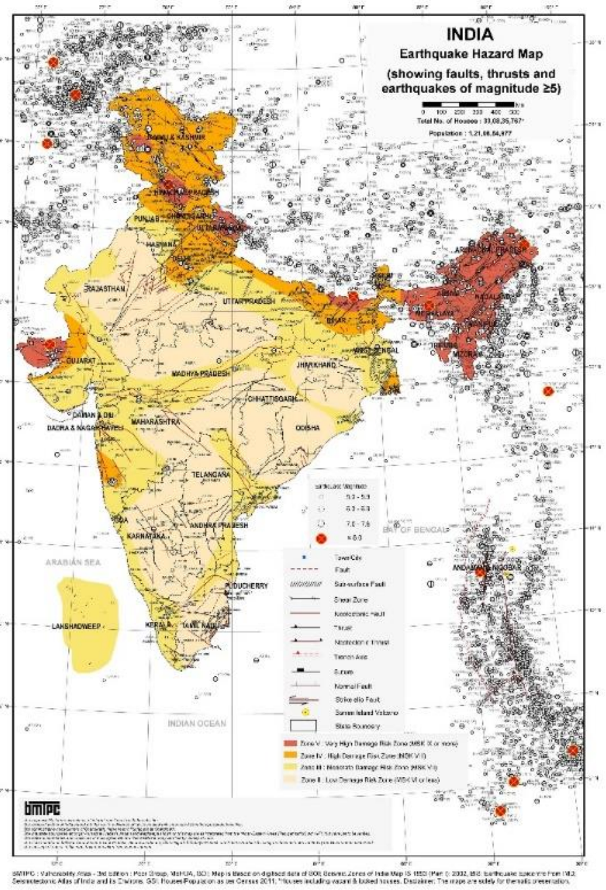
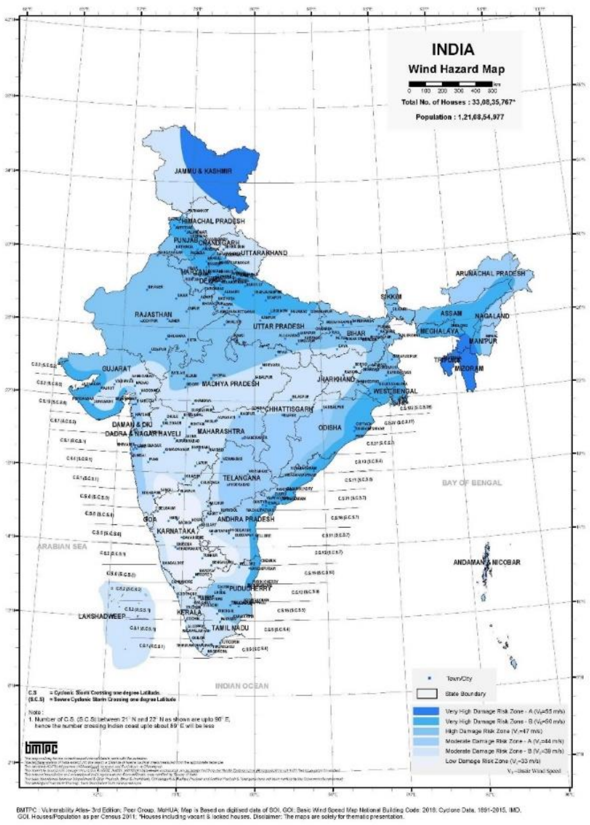
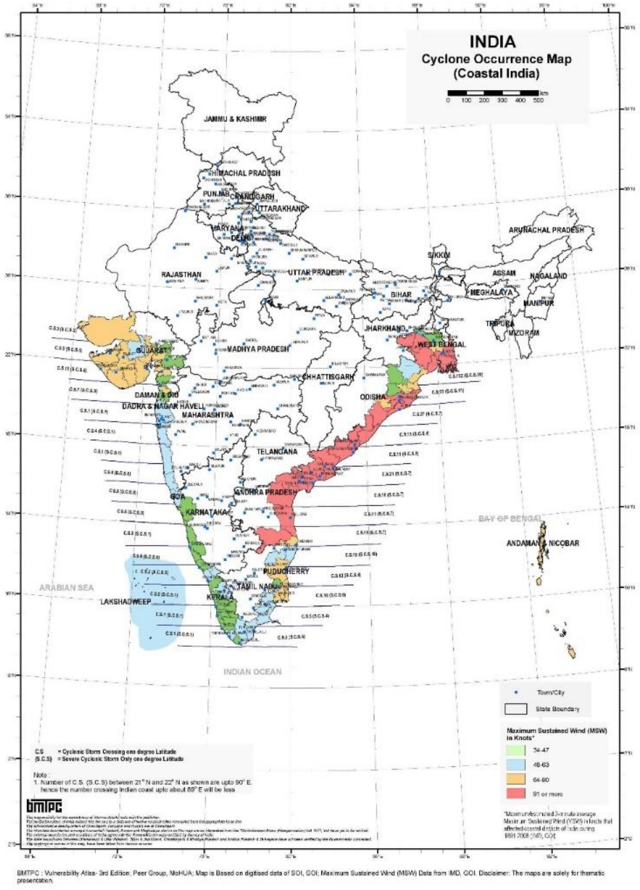
Maps of India – Earthquake, Wind & Cyclone







Types of Buildings

- Residential
- Highrise Building
- Commercial Buildings
- Hospitals/Universities
- IT Parks/Parking Lots
- Industrial Building
- Wearhouse Buildings

Building Technologies

Conventional construction

- Brick/Block wall Construction
- Beam-Column Construction

Modern/Fast Track Technologies

- RMD Technology/Monolithic Construction
- Precast Panel Technology
- Precast 3D Building Technology
- Composite Building Technology
- Pre-engineered Building
- Hollow core wall/roof Technology
- LGS-LWC building Technology
- Sandwich Panel Construction
- 3D Printing Technology

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3D Precast Technology

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3D Modular Precast Construction

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RMD /Monlithic Construction






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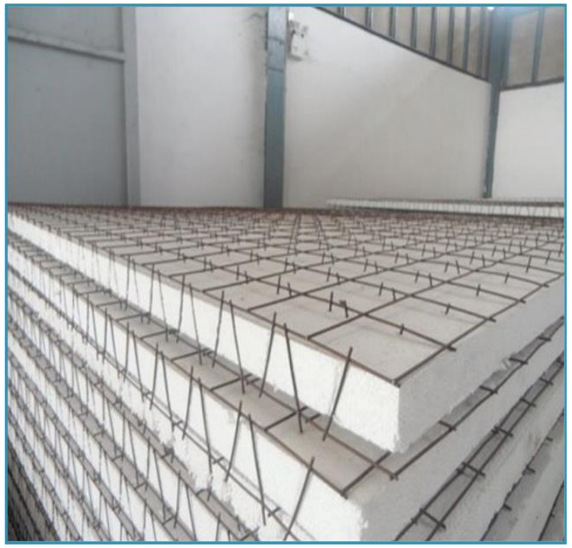
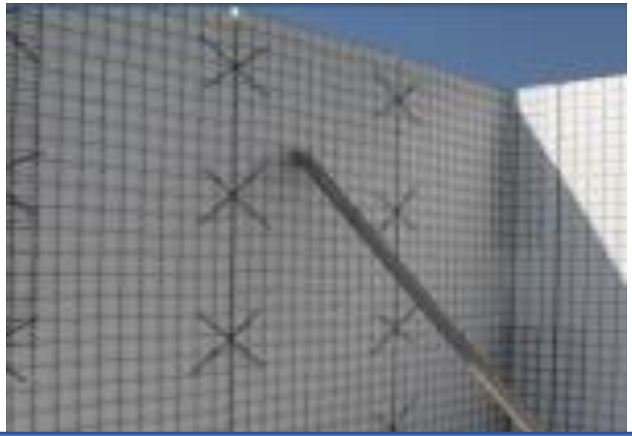
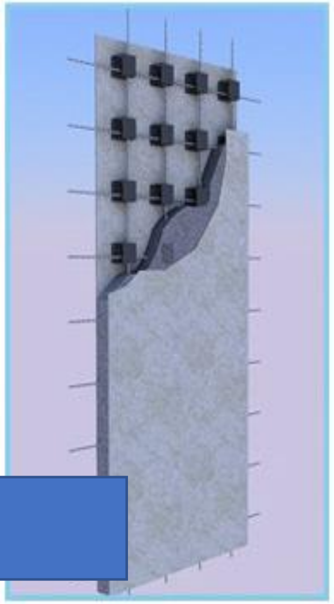
Sandwich Panel Technology







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LGS-LWC Technology

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Pre-Engineered Buildings

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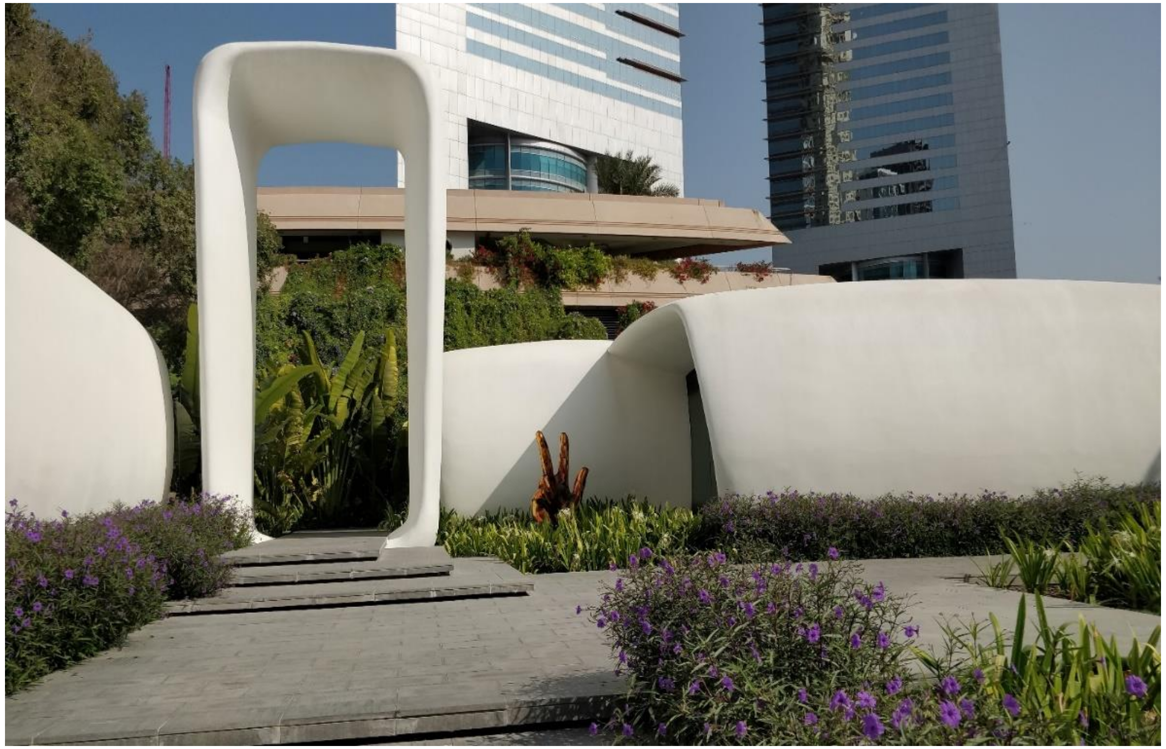
3D Printed Building at Dubai



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Process of 3D Printing of a House(24hours)

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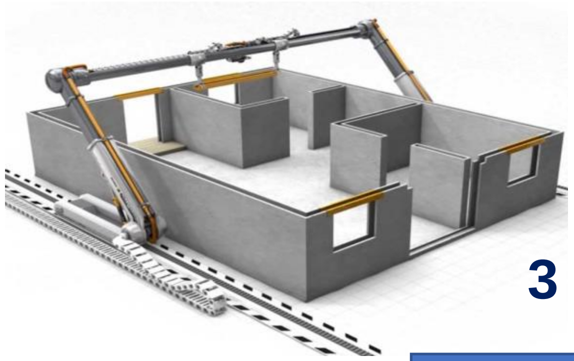

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3D Printer –locally developed

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Design for Disassembly(DfD)

Design for disassembly

Designing a concrete building for easy disassembly could enable the reuse of its component parts in other construction projects, reducing use of raw materials and lowering waste.

- The aim of design for dis-assembly (DfD) is to aid deconstruction (demolition) through planning and design. It allows components and materials to be removed more easily, facilitating their subsequent reuse.
- The cyclical model proposed by DfD requires new ways of designing structures and buildings, as well as developing new assemblies, components, materials, construction techniques, and information and management systems.
- For example, elements such as columns, walls, beams, and slabs can be disassembled without material loss or pollution to be reused in extending existing buildings or in the production of new ones. DfD also enables flexibility and convertibility of whole buildings.
- In this way, DfD provides economic and environmental benefits to builders, occupants, and communities. It also helps to reduce the consumption of raw materials, as well as lowering waste during construction, renovation, and demolition.
- Designing elements in concrete for disassembly will maximise their reuse potential, as well as increase their reuse options, and therefore has the potential to reduce the environmental impact of construction through resource recycling, material reprocessing, component reuse and building relocation.

Structure as Finish (SaF)

Structure as finish

Concrete as a finished surface (e.g ceiling, wall or floor) lowers material usage in construction and future maintenance needs. And it needn't be dull: concrete can come in a huge range of colours and textures!

- According to various studies, internal finishes account for around 12-14% of the total embodied emissions associated with office buildings of which suspended ceilings are a significant component. It therefore follows that the ability to design them out in favour of an exposed concrete soffits, will provide a worthwhile reduction in carbon emissions.
- In terms of the physical quantity of materials used, designing out suspended ceilings could save up to 6 MT of material for every 1,000m^2 of floor space. Future savings may also be realized by avoiding the need to replace the suspended ceilings, which have a lifespan of around 20 years.
- As concrete floors are already a standard requirement in most buildings, it can also make good sense to use this, as finished surface, avoiding the need for additional coverings, such as tiles, lino, or carpet. This significantly reduces the materials needed, as well as reducing landfill during construction (wastage as high about 20% for carpet) and at end of-life.
- A wide range of highly durable polished concrete finishes are possible, requiring little ongoing maintenance. Concrete can also include different coloured constituents and pigments to provide a near infinite range of colours, while it can also be formed in a large variety of ways to give different textures and visual appearances.

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3D Printing (Placement)

Wide range of placements

The huge variety of concrete placement techniques (robotic placement) allows the use of concrete in a wide range of applications, enabling designers and contractors to choose the optimum technique to deliver efficient projects.

- Digital construction in the form of additive manufacturing and 3D printing is transitioning from research and development to bespoke applications and offers a good example of concrete's versatility. It offers several benefits that include:
  - Potential cost-effective geometric flexibility in the shape of buildings, allowing the creation of more complex structures, such as double curved walls. For such bespoke and complex geometries, it also promises faster construction than if attempted in traditional means.
  - The constraints on construction site location are potentially reduced: if the 3-D printer and input material can be delivered to site, construction is possible, which may be simpler than delivering large offsite manufactured modules to remote locations or congested cities.
  - 3D printing has the potential to be less expensive than traditional construction, due to the more efficient use of materials and a more structured and faster building process.
  - 3D printing offers a direct transfer of information from the 3D design model to construction operations, improving accuracy and reduce material consumption.

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Structural Light Weight Concrete

Structural low-density (lightweight) concrete is structural concrete made with low-density aggregate having an air-dried density of not more than 1850 kg/m3 and a 28 day compressive strength of more than than 17 MPa [ACI 213R].

It was first introduced by Romans in the second century where ‘The Patheon’ was constructed by using Pumice, the most common type of aggregate used.

Porous lightweight aggregate of low specific gravity is used in this concrete. such as pumice, scoria and most of volcanic origin and the artificial aggregate such as expanded blast-furnace slag, vermiculite and clinker aggregate

The results showed that the unit weight of concrete was reduced by 20% to 30% when compared with the normal weight concrete (NWC).

The compressive strength of the developed LWC was sufficient to be used as structural concrete, particularly of those mixtures containing 10% and 15% perlite aggregate.

The durability of LWC was comparable to NWC in terms of chloride diffusion and resistance of concrete to corrosion of reinforcing steel.

The tangible outcomes also include the superior thermal insulation properties of LWC compared to NWC.

High performance concrete

- High-performance concrete is defined based on performance criteria, namely, high durability, high strength, and high workability.
- The composition of HPC usually consists of **cement, water, coarse fine sand, superplasticizer, fly ash and silica fume**. Sometimes, quartz flour and fiber are the components as well for HPC having ultra strength and ultra ductility, respectively.

Green Concrete

- Green Concrete is a term given to a concrete that has had extra steps taken in the mix design and placement to insure a sustainable structure and with a long life cycle & a low maintenance.
- Green concrete can be produced by using materials like ggbs, flyash, CD recycled aggregates, geo polymers etc..

Self-healing Concrete – longevity of structures

In Traditional concrete, if it is in contact with water, has a mechanism for self-healing called autogenous healing. Because of unhydrated cement remains in the matrix which will get hydrated and 'heals' the crack.

Research has shown to achieve concrete's self-healing properties with following ways:

- Superabsorbent polymers (SAP), or hydrogels, which can take up a large amount of fluid (up to 500 times their own weight) and to retain it in their structure without dissolving. When cracks occur, SAP are exposed to the environment and swell, partly sealing the crack. After swelling, SAP particles desorb and provide the fluid to the surrounding matrix for internal curing, further hydration, and the precipitation of $CaCO_3$. In this way, cracks may close completely.
- Micro-organisms that precipitate calcium carbonate. These organisms are embedded in the concrete matrix after immobilisation on diatomaceous earth in microcapsules or in SAP and will start the precipitation of $CaCO_3$ when a crack occurs. Through this process, the bacterial cell will be coated with a layer of calcium carbonate, resulting in crack filling.
- Encapsulated polymers that break open during cracking, releasing their content. Due to capillary action, the agent will flow into the crack. After reaction, the crack faces are bonded together, healing the crack.
- Self-healing concretes reduce the need to detect and repair cracks and this address corrosion risk. Thus, can overcome/reduce the maintenance and /or increase longevity of structure.

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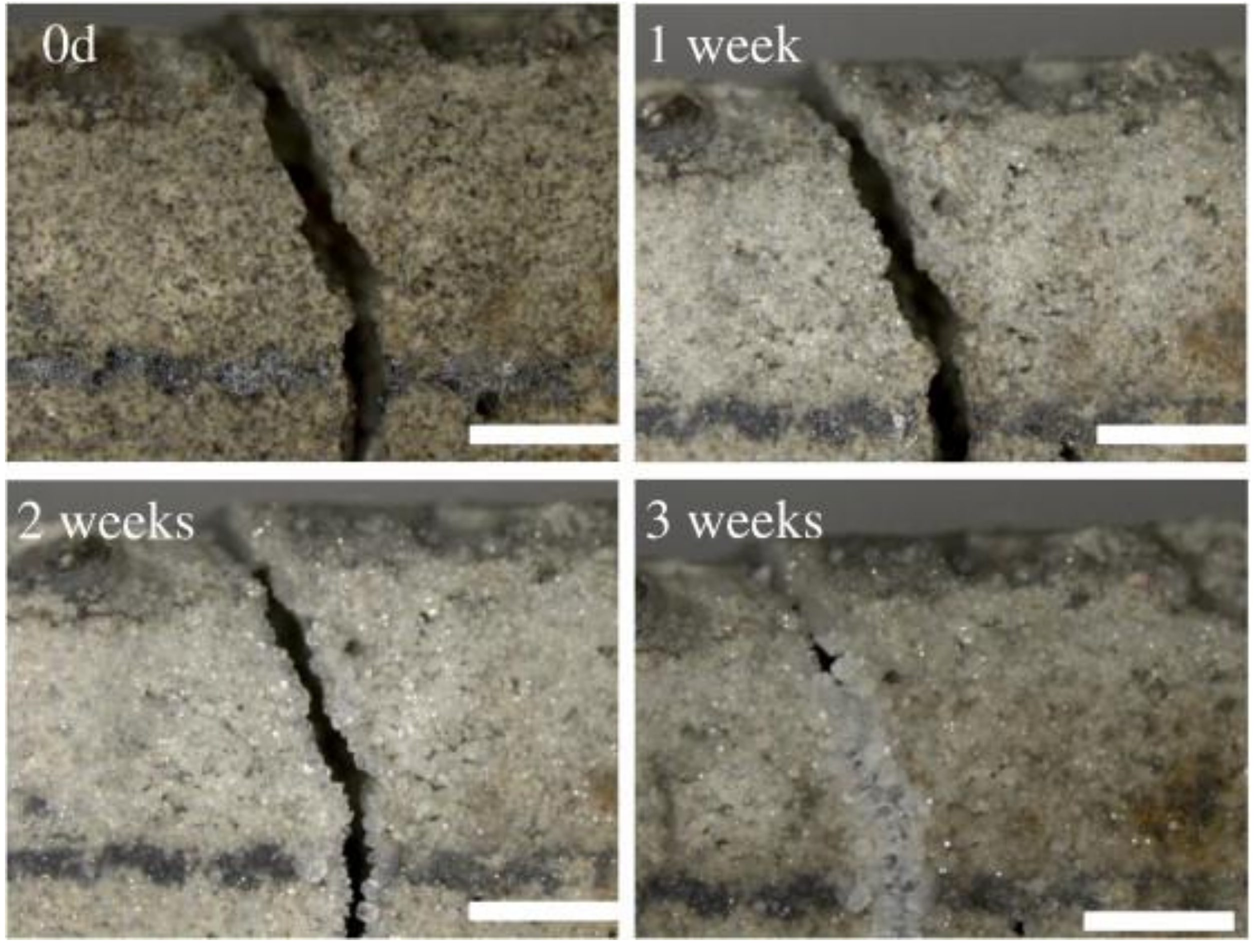
Self-healing concrete by use of microencapsulated bacterial spores



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Antifungal Concrete

- Anti-fungal mortar and concrete are developed using micro-encapsulated fungus-resisting material. D-Limonene is selected for the core anti-fungal material and Zeolite and Zeocarbon are used for reinforcing the capsule membranes.
- Used in of ICUs, Hospital wards, Sewer lines, waterbodies etc..

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Translucent Concrete

Translucent concrete has been first mentioned in a 1935 Canadian patent. But since the development of optical glass fibers and polymer based optical fibers the rate of inventions and developments in this field has drastically increased.

Today several companies produce translucent concrete with very different production systems. Some manufacturers are:

- ✓ Florak Bauunternehmung GmbH, Heinsberg/Germany
- ✓ LBM EFO, Berching/Germany
- ✓ LiTraCon Bt, Csongrád/Hungary
- ✓ LUCEM GmbH, Aachen/Germany
- ✓ Luccon Lichtbeton GmbH, Klaus/Austria
- Republic

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Translucent Concrete

- Lucem GmbH is currently involved in a very remarkable project in Amman, the capital city of Jordan. A bank building under construction will feature a stairwell wall paneling of translucent concrete which, according to the manufacturer, is unique in the world.
- The design was based on the idea to have nature flow through the stairwell in the form of its light.
- With the use of translucent concrete, both the architects from Paradigm Design House and the light designers from Ideal Concepts (both based Amman) are setting an impressive example of how exterior walls can resolve the contradiction between solidity and translucence.

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Translucent Concrete road panels (precast) –used as pavement in smart city roads.

- LCT light & concrete technology is a major international supplier of translucent concrete. Its technology has been patented worldwide and combines concrete and plastics whilst integrating LED lighting systems.
- LCT manufactures translucent floor slabs, curbstones and façade panels; the company primarily targets the public sector and the construction industry

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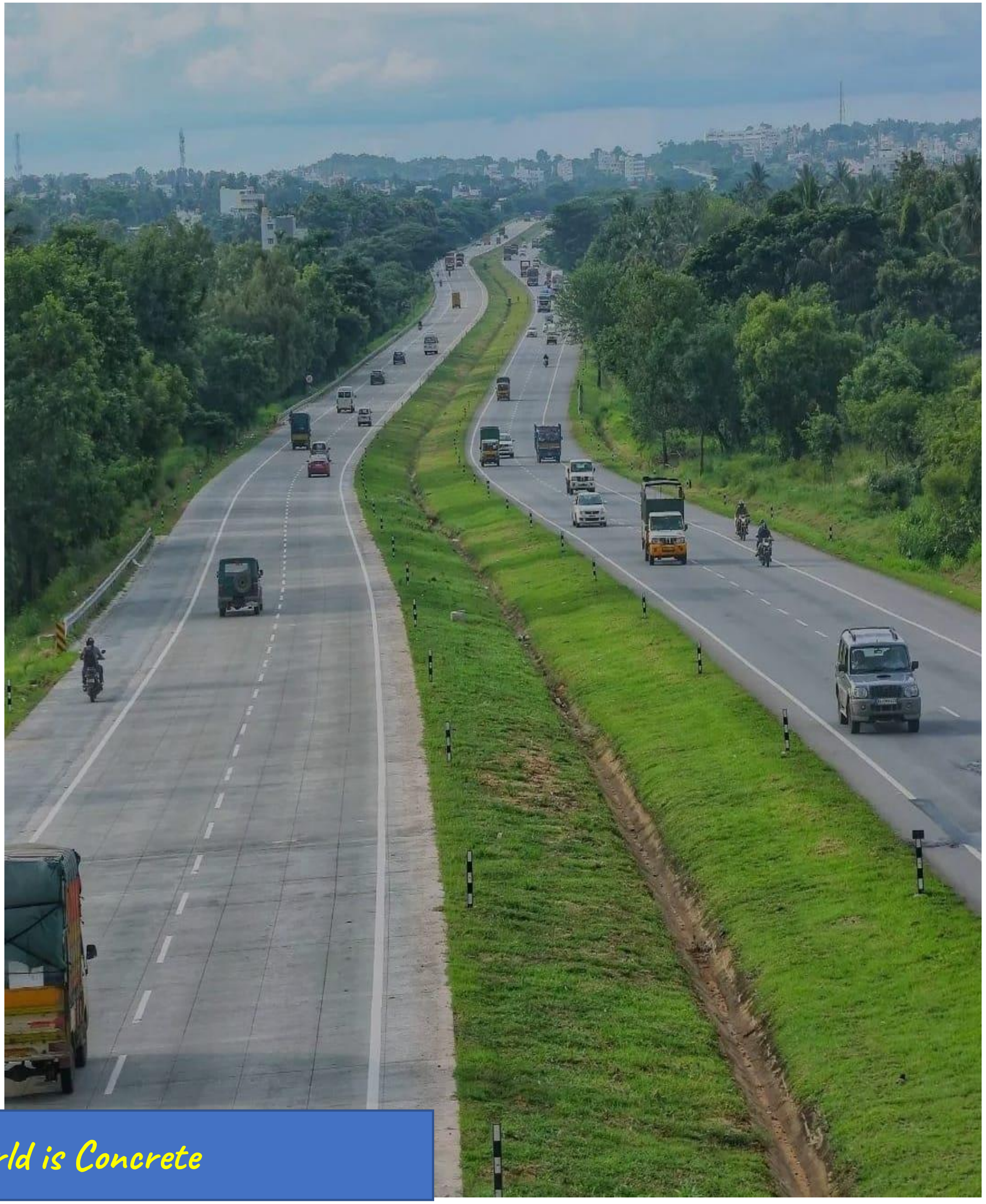
Future of Concrete in Infrastructure



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Smart Mobility

As Vehicles continue to get heavier, smarter, and more technologically advanced, it makes sense that traditional asphalt roads may soon change. Look at some potential innovations for smart roads and the smart solutions.

- Whitetopping
- Precast Pavements
- UHPC Roads
- Solar Roadways
- Electric charge lanes
- Glow in the dark streets
- Data Roads/Digital Roads

Whitetopping

Concrete roads

- As per IRC: SP: 76-2015, White Topping is defined as a Portland Cement Concrete (PCC) overlay constructed on top of an existing bituminous pavement
- It is thus a PCC resurfacing, as a rehabilitation or structural strengthening alternative, on bituminous pavement
- White Topping offers extended service life, increased structural capacity, reduced maintenance and lower lifecycle costs when compared with the bituminous overlay alternative.
- **Types of White Topping**
- **Thin White Topping** is 100-200 mm thick and is suitable for heavy traffic volume. It is designed as bonded or unbonded, and concrete with fibres or without.
- **Ultra-thin White Topping** is <100mm thick and is suitable for light duty uses, such as roads with low traffic volume, parking lots, small lanes/interior roads, etc. Ultra-thin White Topping is always designed as bonded overlay and concrete with fibres used in construction (Revised IRC SP 76-2015 excluded this)

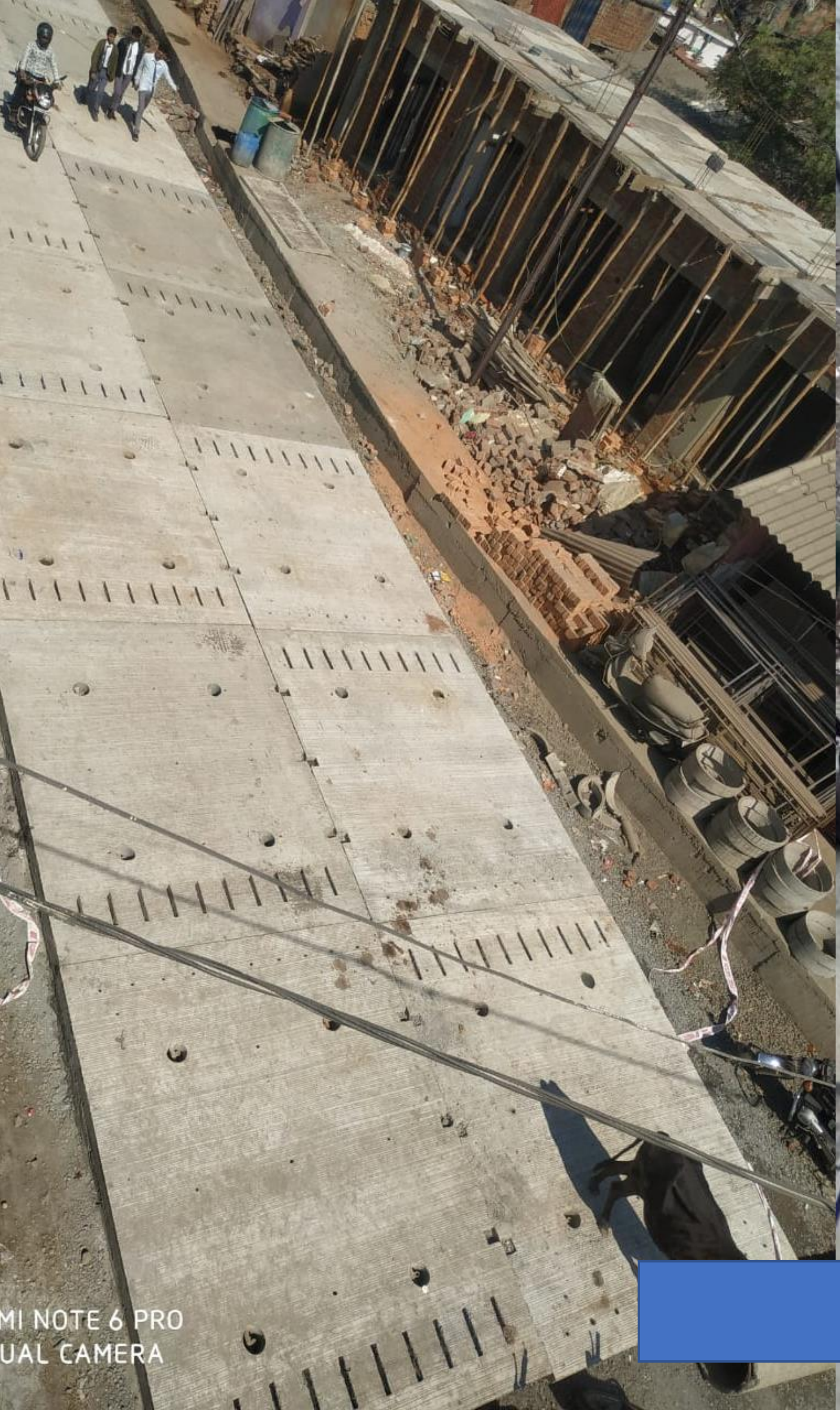
Rapid Roads System

Concrete roads

✓ The Industrialisation of the Road sector is the need of the hour and the future. Thus, the cost, speed, quality, and durability will be the critical factors. The Way to Go Sustainable roads with lower maintenance and lower cost.

- ✓ In precast concrete pavement construction, adjacent panels are assembled sequentially and tied together onsite through post-tensioning or cast-in-load transfer systems.
- ✓ Precast concrete pavement systems can be used for single-lane replacements, multiple-lane replacement (an additional lane may be needed to accommodate materials and equipment) or full-width road construction.
- ✓ Prefabrication of any structural component made off-site during highway/road construction (or reconstruction) offers major time and user cost savings in comparison with the traditional cast-in-place methods of construction.
- ✓ Precast Pre-stressed road pavement' technology offers increase in durability, substantially decreasing construction time and cost.
- ✓ It also brings substantial safety advantages, lowers disruption to traffic and increases overall convenience for the road users

PPCP & JPCP

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Ultra High Performance Concrete

- *Ultra High Performance Concrete* is a new class of concrete that has been developed in recent decades for its exceptional properties of strength and durability.
- This high performance concrete can be utilized in long span bridges, rapid roads system, metros, high speed rail, precast industry, structural rehabilitation and several other applications.

UHPC Bridges & Roads

UHPC (130-150MPa)

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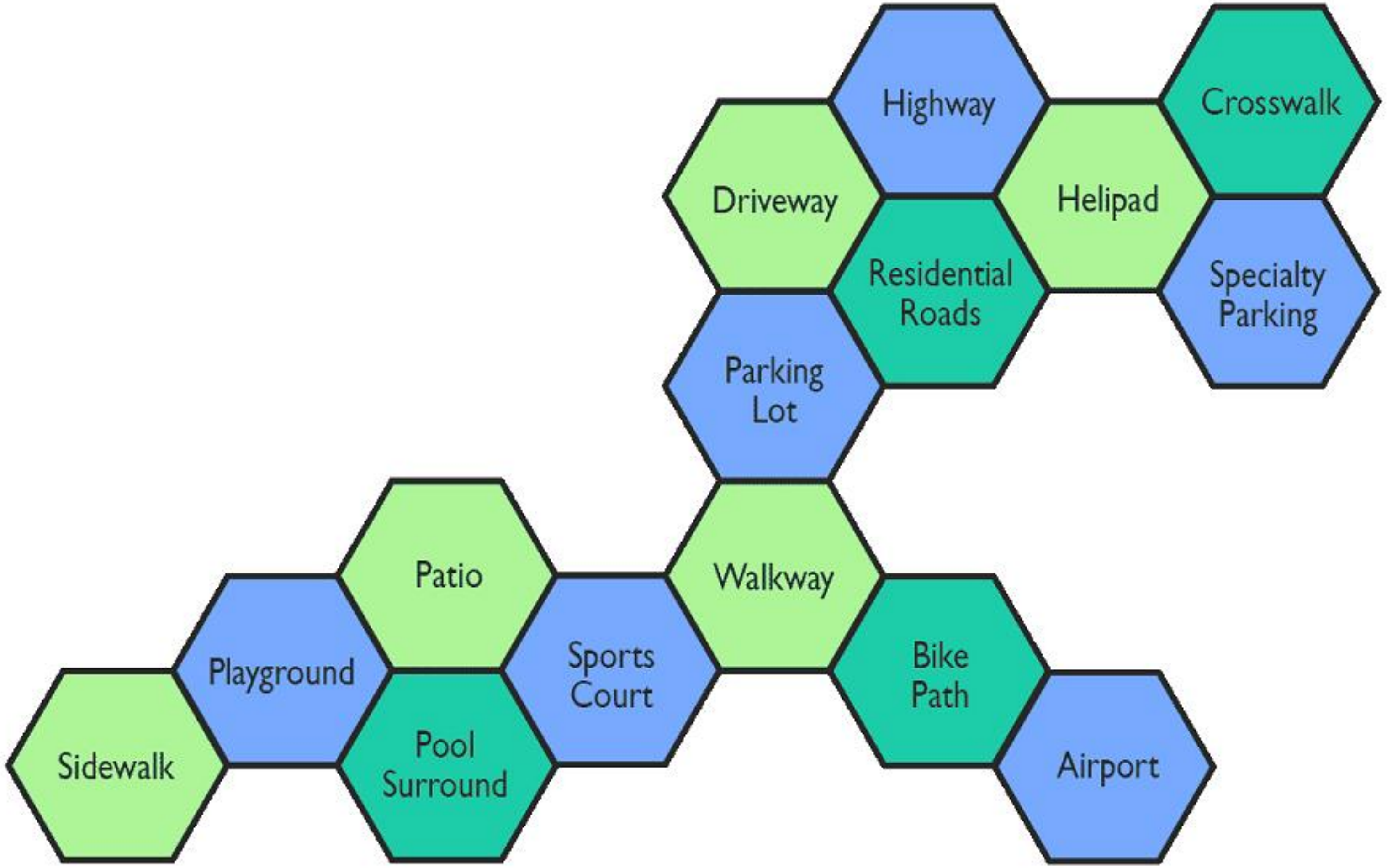
Solar Concrete Panel Road Construction

Solar roads are **created using photovoltaic cells installed into road systems**.

The idea behind these projects is to be able to melt snow, power street lights and even eliminate the need to paint white or yellow lines on asphalt.

Solar Roadways -Application



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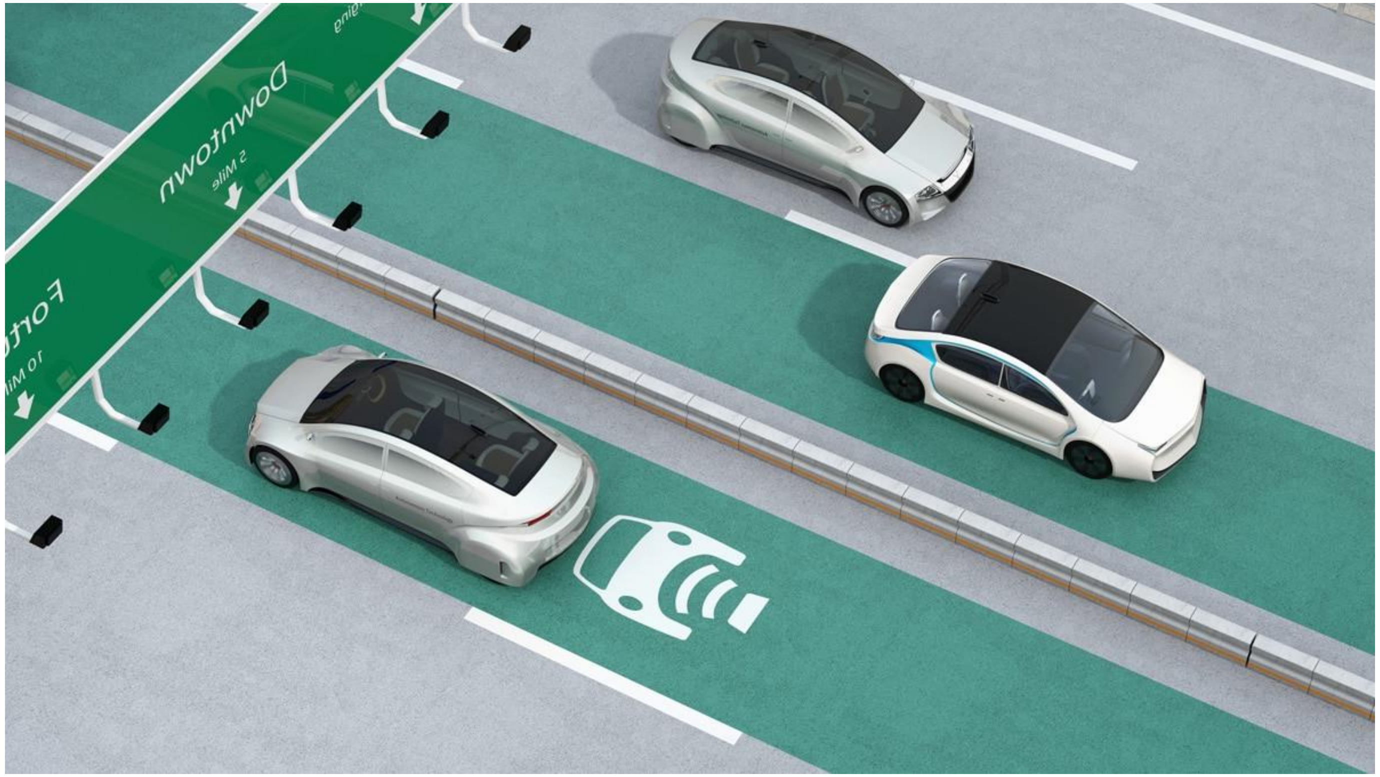
Electric Charge lanes

- Similar to using solar panel roadways to charge electric vehicles, another idea includes creating special “electric priority” lanes that would use magnetic fields to allow drivers to charge their cars as they drive.



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Glow in the dark (Reflective Concrete)

- Glow-in-the-dark driveways are trending right now, but making your pathway look like a starry night is not just pretty — it's also better for the environment. Instead of lighting up your driveway or walkways with costly, energy-sucking lights, you can use luminescent products that will light your way, no electricity required.
- You can use a product like CORE Glow, which are photo-luminescent pebbles that store light from the sun during the day and then slowly release their glow during the night (for up to 12 hours).
- The CORE Glow products are available in recycled glass, marble or pebbles (plastic),
- Another pre-made option is Unime pebbles, which are made of photo-lumines

Data Roads

- Another leading innovation includes using sensors to provide insight into real-time weather and atmospheric conditions and their impact on roads.
- This will enable transportation managers to make roads safer by assessing conditions before they become dangerous. Additionally, by collecting this type of data, industry professionals will e able to better pinpoint road use, traffic patterns and how accidents occur.

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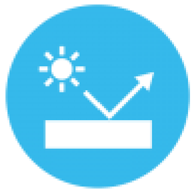
Albedo


Albedo

As a lighter material, concrete reflects more of the sun's radiation than other building materials, helping reduce warming, particularly in urban areas.

- Albedo is the fraction of solar radiation reflected from a materials' surface. Concrete has an albedo of 0.4, while asphalt has an albedo of just 0.1 (the higher the value, the higher the reflectivity). When used on vertical (buildings façades) and horizontal surfaces (roofs and pavements), concrete therefore has surface temperatures lower than darker solutions.
- The use of concrete thereby helps to reduce the temperature increase experienced in urban heat islands (UHI), mitigating the impacts of climate warming. It can also help limit the use of cooling systems in buildings, as the external temperature around the building is lower due to the more moderate UHI, with the knock-on effect of reducing energy consumption.
- Finally, reducing UHI lowers the risk of smog, as smog is more likely to form in higher temperature environments, with subsequent benefits to public health.

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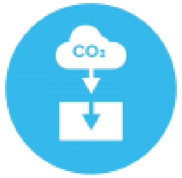
Carbon Uptake



Carbon uptake

Everyone knows that making cement produces CO_2. But did you know that concrete reabsorbs a significant amount of that CO_2 over its lifetime in a process known as carbon uptake or recarbonation?

- Recarbonation is a natural process, occurring when concrete reacts with CO_2 in the air. The exact amount of CO_2 that concrete can reabsorb has a maximum of 100% of that emitted during the calcination of limestone in the cement manufacturing process. (These are known as process CO_2 emissions and are the cause of approximately 60% of the embodied CO_2 of concrete.)
- The actual amount of carbon uptake will depend on a range of parameters including the resistance class, exposure conditions, thickness of the concrete element, recycling scenario and secondary use. A practical estimate of the global carbon sink provided by all concrete is 25% of the process CO_2 emissions released during cement production.
- The carbon uptake process also happens at different speeds, occurring relatively quickly in non-reinforced products or thin/porous applications (renders, mortars, concrete blocks and mineral foams), but more slowly in reinforced concrete and thicker elements. Non-reinforced porous applications, such as masonry, that are exposed to air, can fully recarbonate within a few years, and it is estimated that such applications account for about two-thirds of the concrete global carbon sink.
- Another significant portion of concrete carbon uptake occurs when reinforced concrete structures are demolished, as the increased surface area and exposure to air accelerates the process. The amount of carbon uptake is even greater when stockpiles of crushed concrete are left exposed to the air before reuse.

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Concrete for Heating (Electro-conductive)

Concrete for heating (Electro-conductive)

Combining concrete with 2D materials such as graphene produces a material that can be used to produce heating panels for indoor and outdoor use.

- Electro-conductive concrete combines the mechanical properties of traditional concrete with the electrical properties of 2D materials, such as graphene, in order to obtain a product that has the properties of both, in a few mm of thickness. An electrical current can be passed through the electro-conductive concrete and due to the joule effect, heat is released. Thus, concrete can be used as heating panels, both for indoor and outdoor applications.
- For indoor use, both in vertical and horizontal applications, the uniform layers of electrical conduction provide a stable temperature and improve the energy efficiency of buildings. Further benefits, saving space in rooms or buildings as a central heating unit is no longer required.
- For outdoor applications, using of electro-conductive concrete panels for roads, footpaths, pedestrian walkways could assist de-icing, helping to avoid the use of de-icing products, such as salts harmful to the environment, and reduce slippage injuries to pedestrians.

Photocatalytic Concrete(Self Cleaning)

Photocatalytic concrete

The use of photocatalytic concrete can help to remove air pollutants, providing clean air in our cities and towns.

- Photocatalytic concrete is being made with photocatalytic Portland cement, available from the Italcementi Group. Two cements are available TX Active Arca and TX Active Aria both of which are self cleaning, but the latter is also air depolluting.
- Uses have included the Jubilee Church in Rome, The Air France Headquarters at Roisyy-Charles de Gaulle International Airport, Paris and Hotel de Police in Bordeaux.
- Other uses include precast concrete pavers and roadways, putting depollution near car exhausts.
- In Japan, photocatalysts have been popular to remove odours and improve indoor air quality, neutralizing VOCs from photocopier toner dust and cleaning chemicals.
- The white color of photocatalytic concrete also reflects much of the heat from the sun, reducing heat gain, keeping urban areas cooler and reducing air conditioning use.

Porous Concrete

Porous concrete

Porous concrete helps to reduce the risk of flooding in urban areas, draining and filtering rainwater into soil improves the water level underneath, benefits the citizens safety and health.

- Sustainable urban drainage systems (SUDS) are increasingly important component of urban areas, as more frequent and severe rainfall events occur because of climate change. These in-turn increase the risk of surface flooding (flash floods). This is further elevated by the lack of good drainage & ground surface available to absorb water, thus increasing water runoff.
- Porous concrete offers a solution to this challenge and can produced with little to no fine fine aggregate content in concrete, it will typically comprise 15%-25% voids. These voids allow water to flow through the concrete at rates, around 0.34 cm/s (480 in./hr), which is 200 L/m^2/min (5 gal/ft^2/ min).
- The use of porous concrete reduces the risk of flash flooding, minimises stormwater runoff to surrounding waterways, and allows natural filtration to recharge local groundwater suppliers.
- It also helps to treat pollutants from vehicles and other sources (in the form of hydrocarbons and heavy metals, as well as sediment accumulate on the surface), allowing clean water to pass through the pavement into the native soil beneath.

Contribution to achieve Net Zero

- Efficiency in design & construction(22%)
- Efficiency in concrete production(11%)
- Savings in cement & binders(9%)
- Savings in clinker production(11%)
- Carbon capture & Utilisation/storage (CCUS)(36%)
- De carbonization of electricity(5%)
- Co2 sink – recarbonation(6%)

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Future of Industry

- Innovation / Mechanisation
- AI/VR/IOT/BIM/DRONE
- Green & Sustainable
- Speed & Quality

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PPE

- Helmets
- Safety Shoes
- Safety Belt
- Hand Gloves
- Gum boots
- Masks
- Reflective Jacket
- Safety Glass
- Ear Plug

Emerging India

- Students are unaware of the scope and the future of Civil Engineering in India in the next ten years. So, let us delve into the understanding of what the future of Civil Engineering entails.
- Demand – Housing & Infrastructure
- Growth – Over 15%
- Emerging sectors – Materials, Technologies, Smart Cities, Airports, High Speed Rail, Green Building, Logistic parks, Urban mobility, Green Highways etc..
- International Market – can go global

Future of Civil Engineers

The future of Civil Engineering is not just limited to the geographical boundaries of our country.

According to a report by Global Market Insights Inc. the Civil Engineering industry is expected to reach a size of USD 11.72 trillion by 2025.

One of the main reasons for such rapid development of this engineering discipline is the rise in population and urbanisation.

By completing a programme from one of the best engineering institutes, students can work on sustainable infrastructure solutions, green [illegible] e globe.

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Conclusion

- In the context of phrases such as "Concrete Jungle" and "Concreting over the country", the very fact that there are concrete solutions to the climate change risks, from the concrete itself, demonstrates 'Concrete's Sustainable Value'.
- To build the Concrete Future requires the collective action of all the stake holders, but cannot achieve it alone.
- It also requires the input, support and action of others.
- Need to call on policymakers, governments, investors, researchers, innovators, customers, end users and financial institutions, to play their part.

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Thank You