



# NIRMANA

VOLUME- 10



**DEPARTMENT OF CIVIL ENGINEERING**

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## About Department of Civil Engineering

### ABOUT THE DEPARTMENT

The Department of Civil Engineering, TIST (Estd. 2006) offers Under Graduate course B.Tech in Civil Engineering (NBA accredited up to 2023) and Post Graduate course M.Tech in Construction Engineering and Management. The department continues to conquer new frontiers of knowledge through quality research work, Conferences, QIP and FDP programs for enhancing the Teaching Learning process and moulds the students to be change agents with high professionalism, ethics and sustainability in addition to the curriculum objectives. The department is in close association with Institution of Engineers (IE), Indian Society for Technical Education (ISTE) and has an active student chapter of Indian Concrete Institute (ICI) and Indian Green Building Council (IGBC). The design wing “Rachana” of the department takes up research and consultancy work to offer technical advisory support to various leading organizations like KMRL, Naval base, STICON, PWD etc. The department also undertakes the socially relevant projects like Rebuild Kerala Initiative through which students learn humanitarian concept and their duties towards the society. The department focuses on emerging as a center of excellence in the field of cost-effective green building materials.

## **Vision of the Department**

To transform into a centre creating change agents in civil engineering with professional competency, integrity and ethical values for serving the society with the highest level of proficiency through their chosen domain.

## **Mission of the Department**

- To provide ambience to create civil engineers of global standards to serve the society collaboratively, competently and ethically.
- To provide an academic environment for lifelong learning nurturing the skills in research and development for the benefit of all stakeholders.
- To inculcate professionalism in students through team work, effective communication and leadership skills.
- To encourage and empower the faculty in the field of engineering education and mentoring for enhancing the teaching-learning process.
- To impart hands on experience to aspiring undergraduates through interdisciplinary research projects, industrial training and consultancy work.

## FORWARD

It gives us immense joy and satisfaction to finally presenting before you the 10th volume of technical magazine “NIRMANA”. It is an annual magazine launched exclusively to publish academic research papers and articles by the students on topics and issues in the area of Civil Engineering. The technical papers presented here is an outcome of continuous exploration of the research possibilities in the program of Civil Engineering. The articles incorporated in the magazine shall be an inspiration to the students of this program to understand the wide scope that they could have in their career.

NIRMANA, is thus a very good platform to all budding students of civil engineering, to showcase their research knowledge which will help them to improve their skills in writing technical papers, articles thereby improve their communication skills too.

I extend my warm regards and support to all students who have contributed their research work in the form of technical paper or articles for this edition of NIRMANA. I also thank the team of faculty members who have given the guidance to the students to bring out this edition.

Inviting your attention to the meritorious work of our students and hope you will find the articles interesting and useful.

## EDITORS MESSAGE

On behalf of our editorial team, I would like to offer a word of thanks to our readers, contributors, authors, and editors all of whom have volunteered to contribute to the success of the magazine and also for its mission to improve the quality of research in the form of publication in the sector of Civil Engineering. We are publishing our magazine once in a year with a particular emphasis on quality, safety and better outcomes of research. I am equally elated to inform you all that NIRMANA has been contributing tremendously as a reference to the academic projects and seminars in the Civil Engineering by publishing its issues regularly. It widely covers student articles, projects etc. This magazine has been prepared to meet the requirement of students getting updated in new trends of Civil Engineering. It has a direct link with the project work, that all the research done in Civil Engineering in the academic year 2021-2022 has been explained in nutshell. I hope that this magazine will be useful for all the students of Civil Engineering department of our institute. This is the tenth volume promising more of its edition in the time to come. We would like to thank all who supported the magazine heartfully.

Faculty Coordinators

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## **COST-SAVING SOLUTION FOR CITIES USING ALGORITHM**

Canada is experiencing an enormous infrastructure deficit that was estimated at \$123 billion in 2007 and is increasing by about \$2 billion annually. Thus, there is a need for more efficient use of municipalities' budgets to enhance the level of service delivered to taxpayers. To prove to city departments that it's worth it for them to coordinate their efforts, the study created an original asset management framework with multiple objectives. It considers the physical state of infrastructures, lifecycle costs, user expenses, and replacement value. The framework uses three core models: a database model containing detailed asset inventory for road and water networks; key performance indicator (KPI) computational models for measuring the impact of intervention plans; and an optimization algorithm to schedule activities. The algorithm simulates thousands of scenarios to reach an optimal one.

The Concordia researchers applied their system to road and water networks in Kelowna, B.C., where the results showed lifecycle costs could be cut by 33 per cent and user costs halved. Their test also showed the potential to include sewer, electricity, gas and telecom networks, provided information can be shared. It may sound like common sense, but proactive coordination between different city departments can be difficult. They tend to work in silos, with plans and annual reports created independently.

Better coordination would cause less disruption, which has been increasingly obvious this year, especially in the roads sector, where 2,000 potholes are repaired every day. A more integrated approach would result in an optimized expenditure of our annual budget along with an enhanced level of service, which is urgently needed given the deteriorating condition of our infrastructures.

*Aleena Josey*

## **NEW APPROACH FOR FORECASTING CORROSION WITHIN BRIDGES AND CONCRETE STRUCTURES**

An underlying concept of a chloride threshold is widely used, and all existing models to forecast corrosion performance of reinforced concrete structures exposed to chloride environments are based on this one common theoretical concept. Just before the COVID-19 pandemic hit, the international group of scientists met and discussed the severe flaws in using the chloride threshold concept for forecasting corrosion. Change is needed to address the growing challenges of aging structures losing functionality and potentially collapsing, greenhouse gas emissions, and the economy at large.

Corrosion of steel within concrete is a complex phenomenon. In the generally very high alkaline environment of concrete, where the pH may be higher than 13, steel is considered passive, which means it is covered by a thin layer of protective oxides and its corrosion rate is negligibly low. But concrete is porous, and when exposed to salts, such as seawater or road salts, chloride ions can eventually penetrate the concrete and reach the steel. At some point, the protective passive layer will be destroyed, and corrosion may start. Depending on actual exposure conditions, corrosion may occur at a faster or slower pace. In reality, steel corrosion within concrete is a continuous process rarely separable into uncoupled, sequential phases. The focus should be placed on the quantification of the time- and space-variant corrosion rate from the moment steel is placed within concrete until it reaches the end of its service life.

To achieve this, a multiscale, multidisciplinary approach combining scientific and practical contributions from materials science, corrosion science, cement/concrete research, and structural engineering is needed. Angst and his colleagues propose scientific research evolve away from the chloride threshold concept.

Despite huge amounts of research, no clear chloride threshold could be found, and the influencing factors are complex. Mainstream research is still in search of this threshold, which presents a major barrier to developing reliable corrosion forecast models.

*Punnya Praseed Ulleri*

## FUTURE SMART HOMES POWERED WITH ELECTRONICS BUILT ON STONES

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The surfaces in rooms could charge smart home devices or other small electronics without being connected to the electrical grid would be convenient. And although stone is a widely used material for floors, countertops and decorative backsplashes, it hasn't been integrated with energy storage devices, such as batteries and capacitors. But stones, even those that are polished and seem smooth, have microscopic bumps and divots, making it difficult to adhere electrical components to them. Researchers have recently figured out how to place micro supercapacitors, which have fast charging and discharging rates and excellent power supply storage, onto irregular surfaces with lasers.

The researchers patterned a copper oxide nanoparticle solution on a marble tile into two comb-like sides whose prongs were interspersed. They pointed a near-infrared laser on the nanoparticles, producing pure copper electrodes that were porous, highly conductive and strongly attached to the stone's surface. To form the micro

supercapacitor, the researchers deposited iron oxide onto one of the electrodes to form a cathode, and manganese oxide on the other to form an anode. The electrolyte layer connecting the electrodes was made from a lithium perchlorate and polymer solution. In tests, the device maintained a high energy storage capacity even after 4,000 charge-discharge cycles. When multiple microenergy devices were strung together in a three-by-three array, enough energy was stored to light an LED. In addition, the stone energy storage devices were exceptionally durable against harsh impacts and could be quickly recycled. The researchers say that stone microenergy devices could provide high-performance, customizable and conveniently accessible power from natural building materials.



*Karthika S Nair*

## REDUCTION OF ROAD SALT DETERIORATION USING SUPPLEMENTARY CEMENT MATERIALS

More than 900,000 tons of deicing salt is used each winter in Pennsylvania alone. It also contributes to the thousands of miles of roads that need to be patched and repaired each year. A method created for using fly ash, slag and silica fume leftovers from coal furnaces and the smelting process in a new concrete mix that is more durable because it doesn't react with road salt. By using alternate cementitious materials to make concrete, they can avoid the destructive chemical reaction and continue to use calcium chloride and produce a concrete mix as strong as the ones currently used to build roads that contains less calcium hydroxide the ingredient that reacts with road salt to form a compound called calcium oxychloride. This chemical tends to expand when it is formed, and when that reaction happens in the pores of cement it can cause degradation and cracking. These "supplementary cement materials" could be substituted into the mix with a better result when they come in contact with calcium chloride deicing salt. There is a great push to use these power industry byproducts because they take up space and some of them can be harmful to the environment. Portions of the byproducts such as fly ash, slag and silica fume could be used to make concrete that is both durable and cheaper, because it uses recycled materials. Cement samples using varying amounts of fly ash, silica fume and slag and compared them to samples of "ordinary Portland cement" the most common type used in roads. The samples containing more cement substitute materials did not produce as much calcium oxychloride.

Damage after just eight days of exposure due to the formation of calcium oxychloride while samples with proper amount of fly ash, silica fume and slag did not show damage during the testing period. Higher concentrations of calcium chloride produce more calcium oxychloride when it reacts with concrete. Using lower concentrations of calcium chloride on roads could help extend their life, but it would also make it less effective as a deicing agent. An additional concern is that calcium oxychloride can form even if the concrete is not undergoing a freeze-thaw cycle. It is a chemical reaction that can happen at room temperature, so it can take place when the roads are pre-salted even if ice doesn't form. And as the salts remain on the surface after a snowstorm the reaction will continue to degrade the road, so it is vitally important to minimize this reaction in order to preserve the infrastructure.



*Vimaldas V*

## **FUTURE-PROOF' METHOD USING BACTERIA FOR REMOVING PHOSPHORUS FROM WASTEWATER**

Current techniques to remove phosphorus do not work well at temperatures above 25 degrees Celsius, which occur now in warm countries. This is expected to extend to more countries, with the advent of global warming. Due to the presence of diverse microbial communities in water reclamation plants in Singapore, the SCELSE-developed innovation, which is based on bacteria, would thus help to 'future-proof' the removal of the chemical. Effectively removed phosphorus from wastewater at 30<sup>0</sup>C and 35<sup>0</sup>C. Called *Candidatus Accumulibacter*, the bacterial genus is not harmful to humans or the environment and removes phosphate from wastewater and stores it internally as polyphosphate granules. The method could be used in laboratory-scale reactors and full-scale treatment plants.

Removing phosphorus from wastewater before discharging it into bodies of fresh water is important, as its presence can result in an algal bloom, which is a rapid increase in the population of algae. Algal blooms severely lower oxygen levels in natural waters when the algae die off and sometimes result in the release of high levels of toxins, killing organisms that live within the waters it affects. In Singapore, wastewater is treated at water reclamation plants located near coastal areas before it is discharged into the sea. Unlike other methods, the SCELSE-developed method to remove phosphorus from wastewater does not involve chemicals, such as iron and aluminium coagulants. These methods produce a large volume of inert sludge that needs to be treated and disposed of afterwards. The bacteria-based technology extends the temperature range of enhanced biological phosphorus removal to 35 degrees Celsius. This would help to 'future-proof' phosphorus removal, as other methods using biological approaches work only at cooler temperatures and would be rendered less effective as temperatures globally are expected to rise due to global warming. That phosphorus could be stably removed in water reclamation plants even as we expect global water temperatures to increase further. Employing a slow-feeding strategy and sufficiently high carbon input into biological reactors, limited the carbon uptake rates of competing bacteria. This allowed *Accumulibacter* to flourish and benefited a stable and efficient process, representing basic conditions suitable for future full-scale treatment plants. This will help countries experiencing high water temperatures to prepare for the effects of climate change. Solution could not only help future-proof biological phosphorus removal, but also store the element and then re-introduce it into agricultural systems.

*Irfana Muhammed*

## SEPARATION OF URINE MAKES FOR HIGHLY EFFICIENT WASTE WATER TREATMENT

Urine accounts for only 1% of the total volume of wastewater, but it contains up to 80% of all the nutrients. If it is processed separately, wastewater treatment plants can be reduced in size, water protection can be improved, and nutrients can be recycled. Separate treatment of wastewater streams thus opens up new possibilities, and there are many reasons for adopting urine source separation (“NoMix”) technology on a large scale. This is particularly important in fast developing countries such as China, where sewerage and wastewater treatment facilities cannot keep up with the rapid pace of urbanization, and water pollution arising from domestic wastewater has reached devastating levels.

While the Eawag researchers’ approach may sound straightforward, there is no guarantee that it can be implemented in practice: infrastructure that is already in place cannot be transformed overnight; the new toilets still have some defects – pipes may be blocked by urine scale; the sanitary industry as yet sees little commercial potential in the NoMix technology, and the fertilizer produced from urine cannot yet compete with low-cost artificial products. So obstacles remain to be overcome.

If urine is to be treated with the aid of decentralized systems, and nutrients are to be recovered in a concentrated form for recycling, what options offer the best prospects of implementation and the lowest environmental impact. It’s standard practice for garden waste to be separately collected. So surely it should also be possible one day for the six kilograms of concentrated phosphorus produced each year by a family of four to be separately processed.

*Athul Krishna*

## REMOVAL OF MEDICINES FROM WASTEWATER USING SEWAGE PLANTS

The two treatment methods granular activated carbon and ozonation technique reduced the concentration of a number of pharmaceuticals, including certain antidepressants and antibiotics, in water by more than 95%.

Activated sludge, a common treatment process that uses microorganisms to break down organic contaminants, serves an important purpose in wastewater treatment but was much less effective at destroying persistent drugs such as antidepressants and antibiotics. However, for plants that rely on activated sludge only, more advanced treatment like granular activated carbon and/or ozonation may be needed. Some cities are already doing this, but it can be expensive. The findings are important because any drugs discharged from treatment plants can enter the environment, where they may contribute to phenomena such as antibiotic resistance, or be consumed by wildlife. It adds to a growing body of work showing that advanced treatment methods, including ozonation and activated carbon, can be very effective at removing persistent pharmaceuticals from wastewater.

The research analyzed a variety of technologies in use at seven wastewater treatment plants in the Eastern U.S., including six full-scale plants and one large pilot-scale plant. Study's findings could guide future decision-making, especially in areas where water is scarce and in cities that may want to recycle wastewater, converting it into drinking water. The research is also important for environmental conservation. It demonstrated that larval zebrafish did not change their behavior when they were exposed to wastewater discharged from treatment plants. However, much more work is needed to understand how longer-term exposures may impact wildlife, Aga says. It was found high concentrations of antidepressants or the metabolized remnants of those drugs in the brains of numerous fish in the Niagara River, part of the Great Lakes region. Scientists still don't fully understand the behavioral and ecological impacts that may occur when chemicals from human medicines build up in wild animals over time. Though wastewater treatment plants were historically designed and operated for purposes such as removing organic matter and nitrogen from used water, the new research and other prior studies demonstrate that these facilities could also be harnessed to remove different classes of medicines.

*Anagha Dinesh*

## 'GREENER' WAY FOR CLEANING WASTEWATER TREATMENT FILTERS

Dirty wastewater filters are unclogged with strong acids, bases or oxidants. Chlorine-containing oxidants such as bleach can break down the most stubborn organic debris. But they also damage polyamide membranes, which are in most commercial nanofiltration systems, and they produce toxic byproducts. A milder alternative to bleach is hydrogen peroxide, but it decomposes contaminants slowly. Previously, scientists have combined hydrogen peroxide with iron oxide to form hydroxyl radicals that improve hydrogen peroxide's efficiency in a process known as the Fenton reaction. Yet in order for the Fenton reaction to clean filters, extra hydrogen peroxide and acid are needed, increasing financial and environmental costs. One way to avoid these additional chemicals is to use the enzyme glucose oxidase, which simultaneously forms hydrogen peroxide and gluconic acid from glucose and oxygen. Combine glucose oxidase and iron oxide nanoparticles into a system that catalyzes the Fenton-based breakdown of contaminants, creating an efficient and delicate cleaning system for membrane filters.

First, the researchers compared the removal of organic contaminants from polyamide filters by the glucose oxidase enzyme and iron oxide nanoparticles to other cleaning methods, including the traditional Fenton reaction. They found this approach was superior at breaking down the common contaminants bisphenol A and methylene blue, while also preserving more of the membrane structure. Encouraged by their initial results, the team combined glucose oxidase and iron oxide into a single nanoparticle, connecting them with an amino bridge. Finally, they tested the new nanoparticle's ability to clean methylene blue-soaked nanofiltration membranes, which they fouled and cleaned for three cycles. After each cleaning cycle, the nanoparticles were retrieved with a magnet and reused with fresh glucose to activate the catalyst. The nanoparticles were highly effective at cleaning the membranes, returning them to 94% of their initial water filtration capacity. Because the nanoparticles don't require strong chemicals and are easily recoverable, the researchers say their new system is a "greener" and more cost-effective approach for cleaning nanofiltration membranes.

*Faizal Muhammed*



## WASTE WATER PURIFICATION BY FREEZING

In practice, this method could be used by leaving waste water from mines to freeze in special pools under the open sky, after which the cleaner part could be removed by breaking the ice. After that the ice would be taken away using a machine designed for that purpose to another pool where the treated waste water would be recycled, or undergo further treatment using membrane filtration, for example, for the needs of various processes. Recycling water from the industrial process would reduce the amount of fresh water that is used.

The method is being developed for application mainly in the extractive industry, which produces large amounts of waste water. The freezing of water or to use chemical terminology, its crystallisation requires seven times less energy than its evaporation.

Equipment developed includes a winter simulator which makes it possible to study how the temperature of cooling air affects freezing. The simulator has been used to study the growth rate of the layer of ice that emerges, and the degree of purity when salt solutions of different concentrations are used. Last winter researchers also took samples on the ice of Lake Saimaa. Took samples of both the lake water and the ice and we examined the amount of impurities that they contained. The result was that the lake water contained about ten times more impurities than the ice. The slower the layer of ice grows, the cleaner the ice is. Therefore, the purity of the ice is directly dependent on its rate of growth. And aimed at an extensive examination of different types of waste water pools and the purity of their layers of ice and the implementation of freezing experiments with waste water samples in mining areas.

*Aswin Saji*

## WASTE WATER TREATMENT PLANT MUD AS 'GREEN' FUEL

Dependency on oil and coal could be coming to an end. Researchers analysed the environmental and human health impacts of an alternative fuel that solves various problems simultaneously. This is the solid waste from the water treatment plants of large cities and carried out the first study into this method at a cement plant which has been producing cement for more than 100 years. The best option for getting rid of mud that would have had to be dumped elsewhere, while also powering the plant.

As this mud is already waste, burning it does not enter into the atmospheric CO<sub>2</sub> emissions assigned to each country under the Kyoto Protocol. This would enable plants producing cement, one of the most contaminating industries in terms of CO<sub>2</sub> as well as emissions of dioxins, furans and heavy metals, to consume energy in a more environmentally-friendly way. Up to 20% of the fossil fuel energy used at the plant has now been substituted for the fuel from waste water treatment plant mud. From an economic point of view, cement plants could increase their profits by using this method, but “they will not have to pay anything to exceed their agreed emissions. The economic benefits of this system also depend on the price of fuel.

One of the most important issues for the URV scientists is the reduction in environmental impact, and consequently the health risks for people living near the plants. The experiment with the mud has led to a 140,000 tonne reduction in CO<sub>2</sub> emissions between 2003 and 2006, and will have limited the potential deaths from exposure to chemical pollutants. In addition, the study shows that using this green fuel would reduce the cancer rate by 4.56 per million inhabitants. It is essential to carry out separate studies for each plant because still don't know whether this will be positive for the whole cement industry. However, if the conditions are right, using mud from waste water treatment plants in cement factories is a very good solution.

*Vishal Shaji*

## WASTEWATER TREATMENT FOR CAPTURING CARBON DIOXIDE

The treatment method, known as Microbial Electrolytic Carbon Capture (MECC), purifies wastewater in an environmentally-friendly fashion by using an electrochemical reaction that absorbs more CO<sub>2</sub> than it releases while creating renewable energy in the process. This energy-positive, carbon-negative method could potentially contain huge benefits for a number of emission-heavy industries. Wastewater treatment typically produces CO<sub>2</sub> emissions in two ways: the fossil fuels burned to power the machinery, and the decomposition of organic material within the wastewater itself. Plus, existing wastewater treatment technologies consume high amounts of energy. Public utilities in the United States treat an estimated 12 trillion gallons of municipal wastewater each year and consume approximately 3 percent of the nation's grid energy.

Existing carbon capture technologies are energy-intensive and often entail costly transportation and storage procedures. MECC uses the natural conductivity of saline wastewater to facilitate an electrochemical reaction that is designed to absorb CO<sub>2</sub> from both the water and the air. The process transforms CO<sub>2</sub> into stable mineral carbonates and bicarbonates that can be used as raw materials by the construction industry, used as a chemical buffer in the wastewater treatment cycle itself or used to counter acidity downstream from the process such as in the ocean. The reaction also yields excess hydrogen gas, which can be stored and harnessed as energy in a fuel cell. It has the possibility that wastewater could be treated effectively on-site without the risks or costs typically associated with disposal. Further research is needed to determine the optimal MECC system design and assess the potential for scalability is a proof-of-concept with promising implications for a wide range of industries

The Environmental Protection Agency's Clean Power Plan, will require power plants to comply with reduced CO<sub>2</sub> emission levels. It has positive long-term implications for the world's oceans. Approximately 25 percent of CO<sub>2</sub> emissions are subsequently absorbed by the sea, which lowers pH, alters ocean chemistry and hence threatens marine organisms, especially coral reefs and shellfish. Dissolved carbonates and bicarbonates produced via MECC, however, could act to chemically counter these effects if added to the ocean. This treatment system generates alkalinity through electrochemical means and could potentially use that to help offset the effects of ocean acidification. Many wastewater treatment plants are located on coastlines, raising the possibility that future MECC implementation in these facilities could couple both CO<sub>2</sub> and ocean acidity mitigation.

*Adhityan V Santhosh*

## **ADVANCES IN DESIGNING CONSTRUCTION MATERIALS USING ANIMAL EXOSKELETONS**

The new pattern, adding to the eight known and common biological structural design patterns, can add a high strength motif to commonly used building materials such as composites and cement, and may help reduce carbon emissions. The cement industry is one of the largest producers of carbon dioxide, creating up to 8% of worldwide human-made emissions of this gas; this discovery will assist in reducing the use of cement by improving the material's damage tolerance.

The research team replicated the design motif in cement material, one of the most consumed construction materials in the world. They adopted a 3D printing technique combined with nanotechnology and artificial intelligence to fabricate a lightweight cement composite which adopted this segmental design motif, demonstrating a superior load-bearing capacity and a unique progressive failure pattern. Demonstrated the application of this design motif in producing a high strength, damage tolerant lightweight cement material. In addition, this design motif can also be applied to various materials such as ceramic, glass, polymeric and metallic materials for advanced materials design, energy storage/conversion and architectural structures.

Since the 1972 discovery of the helical structure, one of the most common structural patterns in biology, there has been a drive to extract design motifs from more than 7 million living species in the world to aid the fabrication of structured/structural materials. After almost 50 years of research, remarkable repetitions have been confirmed in most classes of species but only eight categories of design motifs have ever been extracted and adopted in materials design, until now. The new design structure has been identified in various species such as the exoskeletons of arthropods, the legs of mammals, amphibians and reptiles. These design motifs are valuable sources of inspiration for modern materials design and aid the fabrication of structural material.

Compared to the current design motif, our segmental design motif dissipates the energy by segment rotation. The beauty of our discovered design motif is that the material can exhibit a unique periodic progressive failure behaviour. It means we can contain the damage within a particular region of material, while the rest of the structure can still maintain the integrity and most (around 80%) of load-bearing capacity.

*Jayalakshmi S*

## MINIMALLY INVASIVE BUILDING RENOVATIONS WITH PREFABRICATED WINDOW MODULES

Normally, building improvement work to reduce energy consumption and CO<sub>2</sub> emissions is carried out by separate specialized contractors, including insulation and window installers, heating engineers, electricians, and plumbers. But these different tasks are often not coordinated, a situation that can result in construction defects and prolong the duration of the renovation project. Meanwhile, the inhabitants of the building have to put up with all the noise and mess, especially if a new air-conditioning or heating system is being installed at the same time. Sometimes it is even necessary to wait for the apartments to be vacated before the renovation work can be started. Multifunctional window modules enable on-site installation times to be shortened, considerably reducing the stress experienced by the tenants. In addition to the actual window and window frame, the modules are equipped with a technical systems box and a surrounding insulation panel, consisting for example of a polystyrene-based composite system. The self-supporting units are inserted in the existing window opening from the exterior, and provide additional external insulation around it. An alternative version permits architects to use a solution consisting of a timber frame in combination with a mineral insulating material such as fiberglass or rock wool. The removable technical systems box is located under the window sill. It provides room for installing components such as heat exchangers, decentralized micro-pumps for heating-system control, air filters, and even power sockets, ventilation channels, or Internet cabling. Electrical wiring and water pipes are installed on the outside wall underneath the insulation panel and routed into the building through cutouts in the technical systems box.

Numerous additional activities such as installing cable conduits and plumbing systems thus become superfluous. The entire unit, including the box, is delivered fully assembled by the window manufacturer, significantly reducing the on-site installation time. Another advantage of installing all these components in an easily accessible box underneath the windowsill is that it simplifies maintenance. If repairs are necessary, any component can be retrofitted or replaced immediately. By integrating heat exchangers and air circulation units in the renovation system, can limit heat loss through the building envelope and ventilation. And by ensuring a high quality of workmanship, can guarantee a perfectly airtight seal and avoid thermal bridges, in other words, no warm air can escape. All in all, the new system reduces energy consumption. Because the insulation panels are constructed as self-supporting units, they are strong enough to envisage equipping them with solar collectors or photovoltaic cells.

*Bhagyalakshmi Sasidharan*

## **LONG-SPAN CONSTRUCTION: ULTRA LIGHT-WEIGHT CLOUD ARCH ARCHITECTURAL TECHNOLOGY FOR SUSTAINABLE CONSTRUCTION**

Cloud Arch™, an innovative, ultra-light architecture that will revolutionize the way large open public spaces, such as market, airport, stadium, concert hall, factory, are built that harnesses ultra-light materials to meet the construction needs of sustainable future.

Shed is one of the most primitive forms of architecture creating column-free space in a way that saves materials and time, by using ultra lightweight materials. Use Expanded Polystyrene (EPS) foam, a widely used packaging material. More than 95% of this material is air, and its composite can be fire-resistant. After two years of prototyping and structural testing, successfully developed a technique to control the composite material and applied it for the construction of long-span structures. And developed several prototypes starting from a mere 4-metre span, to the current design comprising two sets of 14-metre span in the form of the Pavilion. As the design looks like a floating cloud, called it Cloud Arch™, Structurally optimised forms are often doubly curved. By applying digital fabrication technology on the EPS foam, shape complex forms in a fast and cost-efficient manner. As the material is extremely lightweight, achieve significant savings in terms transportation cost as well as the time taken to set up and dismantle the structures and reduce the construction cost by one-third and construction time by half.

EPS foam has almost similar compression strength to weight ratio as concrete and is currently used as landfill for landscape works. Also testing its composite properties when reinforced with bonded fabric as a possible material for permanent construction and needed to increase the EPS composite thickness for the longer spans, but only to reinforce its composite strength. This implies that Cloud Arch's advantageous ultra-lightweight, will be further realised when the target spans get longer. The Centre will continue to push the boundaries of innovation and explore new possibilities in sustainable industrial infrastructure solutions, land intensification, planning and design, and systems integration and optimisation, to support the transformation and growth of industrial landscape. The innovative use of fire-resistant structural foam coupled with technological research and rigorous testing, is a commendable effort on the part of the architect-designers behind Cloud Arch™. The efficiently spanned arched roof immediately achieves a 'wow' factor together with relative ease and speed of construction. In today's context of the industry's drive towards enhanced productivity and buildability, Cloud Arch™ represents great promise in material technology advancement.

*Arya Arun Pillai*

## **B TECH PROJECTS**

## DESIGN OF CABLE STAYED BRIDGE

Bridges are structures built over some physical obstacles such as a body of water, valley, or road, purpose being crossing over that obstacle. Owing to their excellent structural characteristics, aesthetic appearance, low maintenance cost, and efficient use of structural materials, cable stayed bridges have gained much popularity in recent decades. A cable stayed bridge is a structure in which the deck of the bridge is supported by inclined cables connected to the towers. The load from the bridge is transferred to the towers through cables. This project designs a cablestayed bridge across Bharathapuzha at Ponnani using the software SAP2000. The proposed bridge connects Ponnaniharbour with Padinjarekkara across Bharathapuzha. By the introduction of the proposed bridge, the difficulty in travel through ferry and the present road travel which is almost 20km gets eased thus developing the area and making it into a tourist location. The cable stayed portion of the total bridge structure consists of 400m, the deck spanning between the two towers is 200m, while there is 100m long deck on either side of the towers totaling the length of the cable stayed portion to be 400m. The total width of the bridge is 23m making it into a 4 lane bridge. The deck of the bridge is a reinforced concrete box girder section; the towers being designed using RCC while high strength steel is used to design the cables. The total structure is modelled in SAP2000 and the loads corresponding to IRC-6, IS 875 Part III, IS 1893 Part 1 are applied on the structure. Internal forces are calculated on solving the structure in SAP2000 and the design of various components of the structure, the deck, tower and the cables are carried out.

Keywords: Cable-Stayed Bridge, SAP2000

*Nihal Babu*

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## EXPERIMENTAL INVESTIGATION OF POROUS CONCRETE USING E-WASTE

Modern scientific and technological advancements have altered the way of living of a common man. Instead of going through the trouble of having an old appliance repaired, most would prefer to get a new one. Such a trend not only leads to an increase in the volume of electronic waste but also poses a serious threat to public health and the environment. Discarded, obsolete, and unusable electronic equipment is known as electronic waste or E-waste. Efforts are made in the construction industry to use the non-biodegradable components of E-waste as a partial replacement for coarse aggregates or fine aggregates in concrete. The major objective of this project is to reduce the accumulation of used and discarded electronic equipment as far as possible. The study was conducted on porous concrete, which is a special variety of concrete with high porosity created from a mixture of cement, coarse aggregates, and water. Mix proportion of porous concrete block was 1:0:2.54. E-plastic waste was used to replace 0%, 10%, 15%, and 20% of the coarse aggregates in porous concrete. Compressive strength and permeability were studied. The compressive strength of control mix is higher than that of replacements with E-waste as the weight decreases with addition of E-waste. However, there was a slight increase in the compressive strength for 10% E-waste compared to 5% replacement. In order to use more E-waste, the optimum percentage was taken as 10%. The utilization of HDPE used in electronics will reduce the requirement for coarse aggregates thereby resulting in the conservation of natural resources.

Keywords: E-waste, Non-Biodegradable, Porous Concrete, E-Plastic Waste, HDPE, Coarse Aggregates

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## INVESTIGATION ON PROPERTIES OF CONCRETE WITH COCONUT SHELL AND GGBS

Concrete is a heterogeneous material consisting of cement, aggregates, water and admixtures. Major volume of concrete is contributed by the aggregates, such as coarse aggregate and fine aggregate and cement. Demand of construction material is increased due to infrastructural development across the world. The high demand for concrete in the construction using normal weight aggregate such as gravel and ordinary Portland cement, drastically reduces the natural stone deposits and calcareous & argillaceous materials. This has damaged the environment thereby causing ecological imbalance. So, there is a need to explore and to find suitable replacement materials. In this project, the properties of concrete using coconut shell (CS) as coarse aggregate and ground granulated blast furnace slag (GGBS) as cement is studied. Coconut shell wastes are effectively utilized because it is environment friendly. The cement has been replaced by GGBS in the range of 10%, 20% and 30% by weight of cement and coarse aggregate has replaced by CS in the range of 10%, 15% and 20% by volume of coarse aggregate for M30 grade mix. Strength tests were done after 7 and 28 days. The results showed that 10% of coconut shell replacement was optimum and it exhibited a fall in compressive strength and split tensile strength to about 9.85% and 4.13% respectively whereas 20% of GGBS replacement showed the maximum compressive strength and split tensile strength compared to other percentages and the strength was increased by 11.65% and 11.35% respectively. Therefore, concrete made from GGBS and coconut shell may results in good strength.

**Keywords:** Concrete, Calcareous Materials, Argillaceous Materials, Portland Cement, Coconutshell (CS), Ground granulated blast furnace slag(GGBS), Compressive strength, Split tensile strength.

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## **EXPERIMENTAL INVESTIGATION OF POLYMER IN BITUMINOUS CONCRETE**

Rapid increase in traffic density and adverse climatic conditions affects the performance of roads and decreases its service life. There is a need for modified bituminous mixtures which will improve the performance of pavements in various conditions. Overwhelming increase in plastic waste due to industrialization and population growth and disposal of plastic waste creates serious environmental issues. Plastic modified bituminous mixtures is an effective way of utilization of waste plastic to a considerable extent. This study aims at utilizing waste plastic in bituminous concrete and evaluating its effect on it. The shredded plastic waste was added at 3%,6%,9%,12%by weight of total aggregates into bituminous mix. The Marshall Test method is used to determine the optimum bitumen content(OBC) and to evaluate Marshall properties of plastic modified asphalt mix. Indirect Tensile Strength on Marshall sample specimens at optimum plastic content is conducted to evaluate the moisture susceptibility characteristics. Marshall test results show that strength and stability of bituminous concrete increases with plastic content. Optimum plastic content is determined from the Marshall Test results which is 8.5% by weight of total aggregates in the mix. It was found that Indirect Tensile Strength and Tensile Strength Ratio of optimum plastic bituminous mix is increased which indicates increase in moisture resistance.

Keywords: Plastic Waste, Bituminous Concrete, Marshall Test, Indirect Tensile Strength Test.

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## **EXPERIMENTAL INVESTIGATION ON SELF HEALING BITUMINOUS CONCRETE**

Roads make a crucial contribution to economic development, growth and bring important social benefits. Due to the lack of proper maintenance, and high traffic conditions it leads to the formation of cracks in roads .As the time progresses these cracks increase and lead to pothole formation and finally the disintegration of the roads and the surface wear takes place. This makes it difficult for the passengers to travel and increases accident rates on roads. So in order to solve this problem there comes a solution of using self -healing bituminous concrete. The self-healing bituminous concrete is made by adding waste steel fibres to bituminous concrete. Addition of waste steel fibres to bituminous concrete ensures that it becomes conductive and the cracked surface can be healed with induction heating rather than reconstructing the pavement. In this study, a bituminous concrete mix with waste steel fibres having the ability to heal cracks under the application of heating using an induction heating apparatus was developed and Marshall properties of the same are analyzed.

Keywords: Bitumen, Steel fibres, Self-healing bituminous concrete, Induction heating apparatus.

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## GROUNDWATER QUALITY MAPPING OF MULANTHURUTHYGRAMA PANCHAYATH USING GIS

Groundwater is the water that occurs under the ground. Groundwater is an important component of our nation's fresh water resources. It can exist in spaces between loose particles of dirt and rock, or in cracks and crevices in the rocks. It plays a key role in meeting the water needs of various user-sectors in the country. The natural resource cannot be optimally used and sustained unless the quality of water is assessed. Geographical Information System (GIS) is used to assess groundwater quality. GIS is a computer software capable of creating, storing, managing, analyzing, and displaying geographically referenced information. In this project, groundwater quality of Mulanthuruthy Gramapanchayath, Ernakulam district, Kerala is assessed and mapping is carried out to analyze the quality of groundwater. For the study, a total of 64 well water samples (4 samples each from 16 wards) are collected from Mulanthuruthy Gramapanchayath. The samples are analyzed by testing the various physicochemical characteristics including pH, chloride, sulphide, total hardness, turbidity, fluoride, nitrate, e-coli and ammonia of water samples. The ArcGIS 10.5 is preferred for the generation of various thematic maps and final groundwater quality mapping is prepared based on Water Quality Index (WQI). The purpose of this project is to provide an overview of present groundwater quality, to determine spatial distribution of groundwater quality parameters and to map groundwater quality based on WQI using GIS.

Keywords: Sulphide, Total Hardness, Turbidity

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## **DEVELOPMENT OF WASTE WATER FILTER USING GROUNDNUT SHELL AND RICE HUSK TO TREAT HEAVY METALS**

Wastewater is produced from various sources like households, farms, and industries. Industrial wastewater is produced during the manufacturing process or the cleaning activities related to the process. It is toxic as it contains heavy metals in dissolved form. Wastewater treatment and disposal is a serious issue to look into. Recently, experiments have been conducted to develop simple and environment friendly wastewater treatment methods. In this study, activated rice husk and groundnut shell are used to modify the sand filter to remove the heavy metals from the wastewater. Groundnut shell and rice husk are agro based waste materials which are environment friendly and easily available. Modification of the sand filter was done by partial replacement of sand and gravel. The synthetic wastewater was prepared using heavy metals like cadmium, chromium, copper, iron, lead separately and then passed through both sand filter and modified sand filter to compare the efficiency to remove heavy metals from wastewater. It was found that the efficiency of the modified sand filter was much higher than the conventional sand filter. Therefore it can be concluded that modified sand filter can be used to remove heavy metals. It was found that agro based waste materials like groundnut shell and rice husk can be effectively used.

Keywords: Groundnut Shell ,Rice Husk

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## **DESIGN OF COMPONENTS OF WATER SUPPLY SYSTEM TO FOUR PANCHAYATS IN ERNAKULAM DISTRICT UNDER JJM**

Water is the most consumed resource on earth. Even though 70% of the earth constitutes water, only less than 1% of total water is available as drinking water to meet the requirements of rising population. The increased water demand urged the government to initiate public water supply systems. A water supply system is an infrastructure for collection, transmission, treatment, storage and distribution of water for homes and public needs. Jal Jeevan Mission (JJM) is a Government of India initiative to ensure that every rural household has Functional Household Tap Connection (FHTC) by 2024 and water in adequate quantity of prescribed quality is made available on a regular basis. This study presents the design of components of water supply system to Maneed, Mulanthuruthy, Amballur and Edakkattuvayal Panchayats of Ernakulam district in Kerala under Jal Jeevan Mission. The existing system for water supply in these panchayats is not efficient as the population has increased, pipe networks have deteriorated and system exceeded design lifetime. Hence, it is essential to design a new system to ensure permanent water supply for the inhabitants of these Panchayats. This study includes design of treatment plant, storage tanks, pumps, pumping mains, distribution network and cost estimation. For the design, general features of the study area, like population, water demand, water source and pipe material were required. The location of houses, ground elevations and length of pipes were obtained from Google Earth Pro. EPANET 2.2 software was used to design the distribution network, while PRICE software was used to estimate its cost. The results obtained verified that the design is feasible enough to provide adequate water to the network in the study area.

**Keywords :** Water supply system, Jal Jeevan Mission, EPANET 2.2, PRICE software.

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## **INVESTIGATION ON THE STRUCTURAL PERFORMANCE OF FLOOD AFFECTED COMMERCIAL BUILDINGS**

Structural health monitoring is a useful tool for ensuring the safety and integrity and also in detecting the evolution of damages in any infrastructure. Different external and internal factors will affect the structural performance of the building. The 2018 Kerala flood has contributed many damages to the buildings as well as living things. The structural performance of buildings which is important aspect to be evaluated. Structural health monitoring can be used for the investigation of structural performance of the buildings that are damaged by any natural hazard such as flood. SHM includes various non-destructive evaluation (NDE) and visual inspection to investigate the structural performance of flood affected buildings. In this study the geometric location selected via GIS as Aluva, a town in Ernakulam district, Kerala. A demographic survey is conducted on the flood affected area and analyzed the severity as well as various tests are conducted on these buildings. The test results are analyzed and the buildings are classified on the basis of its strength.

Keywords: Structural Health Monitoring, Structural Performance, Non-Destructive Evaluation

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## **EXPERIMENTAL INVESTIGATION ON THE EFFECTS OF WET AND DRY PROCESS ON KUTTANAD CLAY STABILIZED WITH LIME AND RICE STRAW FIBERS**

The basis of a construction is its stability. For a stable foundation it requires a good soil condition. One of the drawbacks of Kuttanad clay is that; it is very difficult to build any type of structure as the soil is weak in shear strength and low drainage capacity. In this situation, the detailed study about the properties of Kuttanad clay during completely saturated and unsaturated conditions need to be noted. In addition, we are mixing lime and rice straw fibers into the clay to get to know about the strength parameters. During the flood period the Kuttanad area will be under the water for almost a week or more. This study will help to know the changes in the treated clay during the wetting and drying period. To analyze the condition of Kuttanad clay during the saturated and unsaturated period, we are keeping the Kuttanad clay which is treated with Lime and Rice straw fibers for wetting and drying. The treated Kuttanad clay is submerged in water for one week and then it is kept for another one week for drying. After that Triaxial tests are done on the treated clay to determine the strength.

Keywords: Kuttanad clay, Lime, Rice straw fibers, Triaxial tests, Saturated and unsaturated period

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## **EXPERIMENTAL INVESTIGATION ON PROPERTIES OF LIGHTWEIGHT CONCRETE BLOCKS INCORPORATED WITH CLOTH PIECES.**

Million tons of waste clothes are deposited in landfills worldwide. To reduce the pollution caused by waste clothes, they can be incorporated into concrete. This project deals with the experimental investigation of properties of lightweight concrete blocks incorporated with cloth pieces using expanded perlite lightweight aggregate. The materials used in making concrete blocks are cement, fine aggregates, coarse aggregates, expanded perlite, old waste cloth pieces, starch and water. Old clothes originated from the household consumer sector and collected from local tailor shops are utilized for the project. They are shredded into small sizes similar to that of fine aggregate. Starch from food waste is added as a plasticizer, and which also acts as a binder. 400mm x 200mm x 200 mm moulds are used for the casting concrete blocks with cement aggregate ratio of 1:3 and w/c ratio of 0.45. Cloth pieces are added at a rate of 0.25%, 0.50%, 0.75%, and 1.0% by volume of fine aggregate. Coarse aggregates are replaced by expanded perlite by 40% of its volume. The blocks are casted and tested for block density, compressive strength, and water absorption. The results show that all of the specimens fall into the lightweight category. It was observed that at 0.25% addition of cloth pieces, the maximum compressive strength obtained was 1.96 N/mm<sup>2</sup> and 9.01 N/mm<sup>2</sup> at 7th day and 28th day respectively. Water absorption increases with increasing cloth content. The cost of a LWCB is high compared to conventional blocks. Since the load is less than conventional blocks, it can be used as partition wall, garden bench etc. Approximate 0.54 kg of cloth waste can be utilized in 1m<sup>3</sup> of concrete.

Keywords: Fine Aggregates, Coarse Aggregates, Expanded Perlite, Old Waste Cloth Pieces, Starch

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## **MTECH PROJECTS**

## **EXPERIMENTAL INVESTIGATION ON FLYASH BASED SELF COMPACTING CONCRETE WITH WASTE CERAMIC**

In recent constructions, the consumption of ceramic materials is increasing day by day in the form of tiles, sanitary fittings, electrical insulators etc. But a large quantity of ceramic materials changes into wastage during processing, transporting and fixing due to its brittle nature. Therefore, using these wastes in concrete production could be an effective measure in maintaining the environment and improving the properties of concrete. The reuse of ceramic waste as a substitute for coarse aggregate in concrete has been investigated. This study intends to use of ceramic tile aggregate in concrete production. Ceramic tiles were obtained from manufacturing industries, from construction sites and demolition sites, these waste ceramic tiles can be a source of environmental pollution. The utilization of crushed tile as coarse aggregate in concrete would also have a positive effect on the economy and environmental as it reduces the use of natural aggregates. Therefore, reuse of these ceramic wastes in concrete production could be an effective measure in maintaining the environment and improving the properties of concrete. In the present study, Ceramic tile waste is used in self- compacting concrete as a replacement for natural coarse aggregate with 0%, 10%, 20%, 30% and 40% of the substitution and fly ash as replacement of cement with 5%, 10%, 15%, and 20%. Compressive Strength and Split Tensile were tested on 7 & 28 days to get optimum percentage of waste ceramic tile and fly ash. SC concrete with optimum percentage of fly ash and waste ceramic tile were tested for durability properties.

**Keywords:** Waste ceramic tile, SC Concrete, Fly ash

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## **DEVELOPMENT OF A MODEL FOR SUSTAINABLE ON- SITE CONSTRUCTION WASTEMANAGEMENT USING REGRESSION ANALYSIS**

Construction creates a 150 million tonnes of waste in India. The waste generated can be of different materials, leftover bars, cement, and concrete, large amounts of dirt and other hazardous chemicals required in the construction. The construction projects are usually focused on completing the work on time. Most of the time the proper waste management is neglected. This creates a hazardous environment to construction workers and the amount of waste going to landfills are considerably increases. The amount of waste generated could also be linked to poor planning and execution. Proper planning and execution is not possible without prediction of construction waste quantities linked to the project execution plan. This study developed models for sustainable on-site construction waste (cement, aggregates, steel and brick) management of multi-storey residential building projects using machine learning technique by considering the factors analysed through questionnaire survey using frequency- severity importance index method. The proposed models can predict construction waste beforehand of every project and helps the builders improve on-site waste management.

Keywords: Machine learning, Frequency-Severity Importance Index, Regression Model, Python.

*Alka Ann Raju*

## **PREDICTIVE MODELLING OF OCCUPANT'S THERMAL COMFORT IN OFFICE BUILDINGS USING MATLAB**

Buildings consume a major portion of globally-produced energy. A significant amount of this energy is used to provide sufficient comfort levels to the building occupants. Occupant's thermal comfort level in a building will depend on the factors like temperature, humidity etc. The main aim of the project is to propose a model for predicting occupant's thermal comfort level in the office buildings using machine learning techniques. The various factors influencing the thermal comfort are studied and identified from the literature survey. The factors are then determined using questionnaire survey and field study. Based on the data collected, the critical factors are identified. From the study, prediction model is developed using machine learning. Then it is tested and the accuracy of the model is checked in order to minimize errors and is validated using a case study. This prediction model can be used to improve occupant's productivity and well-being in a building.

Key words: Occupant's thermal comfort, Questionnaire survey, Machine learning

*Ashamol Thomas*

## ASSESSMENT OF THE ENERGY PERFORMANCE OF A NEARLY ZERO ENERGY BUILDING

The construction industry is the global priority action areas for the achievement of smart and sustainable growth. The energy demand by the construction industry is about 40% of the world's energy production. The solution to this fact results in zero energy buildings (ZEB) being future buildings, net zero buildings (NZB), or nearly zero energy buildings (NZEB). An NZEB is defined as a building with very high energy performance, ie., very low energy requirements, supplied by renewable energy sources to a significant extent, preferentially by on-site generation. This project aims to study ZEB's, and various strategies that can be implemented in designing an NZEB apt for the Indian climate, and also a two-storied residential conventional building is modeled using Autodesk Revit. By employing the active and passive strategies in the conventional building model following the Indian green building council code (IGBC), the conventional building model is modified into an NZEB model. To show how efficient the building is, the energy performance results of the conventional and NZEB models are compared using REVIT INSIGHT. Managing and decreasing carbon footprints as part of a low carbon strategy is important in building design. Regarding this, there has been increasing interest in developing ZEB's to meet zero energy goals, and in response, federal government agencies and many state and local governments are beginning to move towards zero energy building targets.

Keywords: Sustainable Growth, Active and Passive Strategies, IGBC Code, Energy-Efficient, Carbon Footprints

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## EXPERIMENTAL INVESTIGATION OF IRON SLAG AND CRUSHED COCONUT SHELL IN GEOPOLYMER CONCRETE

Geopolymer is a new development in the world of concrete in which cement is totally replaced by pozzolanic materials like fly ash and activated by highly alkaline solutions to act as a binder in the concrete mix. For the selection of suitable ingredients of geopolymer concrete to achieve de-sire strength at required workability, an experimental investigation has been carried out for the gradation of geopolymer concrete and a mix design procedure is proposed on the basis of quantity and fineness of fly ash, quantity of water, grading of fine aggregate, fine to total aggregate ratio. Sodium silicate solution with  $\text{Na}_2\text{O} = 16.37\%$ ,  $\text{SiO}_2 = 34.35\%$  and  $\text{H}_2\text{O} = 49.28\%$  and sodium hydroxide solution having 8M concentration were obtained throughout the experiment. Geopolymer concrete is considered an environmentally friendly construction material because its manufacturing emits much less  $\text{CO}_2$  gas than the manufacturing of Portland cement concrete.  $\text{NaOH}$  and  $\text{Na}_2\text{SO}_4$  are more commonly used as it leads to higher geopolymerisation rate. Water- to-geopolymer binder ratio of 0.40, alkaline solution- to- fly ash ratio of 0.35 and sodium silicate-to-sodium hydroxide ratio of 2.0 by mass were fixed on the basis of workability and cube compressive strength. Cube were cast and tested for compressive strength after specified period of oven heating. GPC specimens were cured at 60to 800C for 24 hr., all followed by 7 days and 28 days of ambient curing. Fine aggregate is replaced with 10%, 20%, 30% and 40% of iron slag by weight. Then optimum percentage of crushed coconut shell in iron slag incorporated GPC by partial replacement of coarse aggregate with 10%, 20% and 30% by the volume. Various tests were done for compressive, split tensile strength and durability properties suchas resistance to sulphate attack and water absorption up to the age of 56 days.

Keywords: Geopolymer concrete, tensile strength, compressive strength, iron slag

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## **ANALYSIS OF ARCHITECTURAL, STRUCTURAL AND HVAC CLASHES IN A HOSPITAL BUILDING USING BIM**

The construction industry's productivity has been substantially lower than that of other industries, with the main reason being the lack of implementation of new technologies. The main causes of the lack of development in the construction sector are the use of 2D Computer-Aided Design (CAD) technology and the adoption of industry's conventional project management technique. Current planning procedures in India's construction industry are still mostly based on two-dimensional (2D) drawings. This indicates that the construction sector is lagging behind in terms of technological adoption. Building Information Modelling (BIM) is a promising technology to the construction industry. The importance of Building Information Modelling to the construction sector is its potential to reduce cost, increase productivity, reduce errors, and improve the quality of the work products and to improve the built environment. As such, it can be valuable in facilitating successful collaboration and coordination during the pre-design phase. Clash identification remains the main requirement for any multidisciplinary project. This project focus on the analysis of architectural, structural and HVAC clashes in a multi-storey hospital building and also evaluates the quantity and cost of the hospital building. The findings of this work help to recognize the types of clashes in a building structure. It enables potential problems to be identified early in the design phase and helps to resolve problems before start of construction in an effective manner.

Keywords: BIM, construction industry, clash identification

*Ashna Hameed*

## **EXPERIMENTAL INVESTIGATION ON CORROSION BEHAVIOR OF STEEL IN REINFORCED CONCRETE WITH SCMs**

Demand for concrete as a construction material is increasing so as the production of cement. Increasing construction leads to utilization of various resources which causes harmful emissions and scarcity of resources on the environment. To produce environmental friendly concrete, the raw materials have to be replaced with some other materials which should not be creating any bad effect on environment. The use of industrial by products can reduce the problem. The effect of Supplementary Cementitious Materials (fly ash, metakaolin and rice husk ash) on concrete and also the corrosion behavior of SCMs added concrete is studied through the research work. From previous studies, the addition of SCM improves the strength and durability properties of concrete as compared to conventional concrete. The experimental research work consist of investigating the mechanical properties of M40 grade fly ash based concrete (10% fly ash) by replacing cement with metakaolin (5%, 10% & 15%) and rice husk ash (5%, 10% & 15%) separately. Compressive strength and split tensile strength tests are conducted for finding the mechanical properties. The research work also consist of investigating the corrosion behavior of steel in reinforced concrete with fly ash, optimum percentage of metakaolin and optimum percentage of rice husk ash separately by half-cell potential test.

**Keywords:** Durability, Fly ash, Metakaolin, Rice Husk Ash, SCM

*Athira Ashok*



## EXPERIMENTAL INVESTIGATION ON EFFECT OF FLY ASH AND JHAMA BRICKS IN CONCRETE

Concrete is considered as the world's most used construction material. Typical concrete mixtures are comprised of water, sand, cement and an aggregate of rock. Jhama bricks are rejected bricks which are either over burned or not shaped according to the specification. The best way to recycle these bricks is by using them in making concrete. These rejected bricks can also be a potential source of coarse aggregate. In this project the coarse aggregate is replaced by jhama class brick bats of size 20mm and cement is replaced with fly ash. To study the use of fly ash in concrete, cement is replaced partially by fly ash in concrete. Replacement of coarse aggregate is done at 10%, 20%, 30% and 40% while the cement is replaced at 0%, 10%, 15% and 20% in M40 grade of concrete. Mechanical properties such as compressive strength, split tensile strength are studied. Durability studies such as acid resistance test, water absorption are also carried out in this project. When compared with coarse aggregate the weight of concrete is decreased by use of jhama brick. Also it is cost effective. Jhama bricks is available in plenty which makes it a cheap substitute for coarse aggregate. These rejected bricks cannot be use in masonry work because their shape and size got change due to nonconformity.

Keywords: jhama bricks, coarse aggregate, cement, concrete, fly ash

*Athul S*

## **CIVIL CONSTRUCTION SUBCONTRACTOR SELECTION USING FUZZY LOGIC IN MATLAB**

Construction contractors and subcontractors have big influence on projects and their success. Selection of an appropriate subcontractor to deliver the project under consideration as per requirements is one of the most crucial challenge faced in construction industry. It is important that subcontractor selection should not be done considering tender price alone. Accepting the lowest tender price is the basic reason of many project delivery problems and lowering the price results in lowering the quality. Selection of an appropriate subcontractor considering multiple criteria is one of the most crucial challenge faced in construction industry. In reality, the application of the classic multi-criteria decision making methods has practical constraints in the selection, because of the criteria containing vagueness inherent in the information. Fuzzy logic methodology can be used to tackle this type of problem. The overall aim is to implement a fuzzy logic based decision model for the selection of civil construction subcontractor using MATLAB software. The study takes an integrated approach to link the relative importance index method into fuzzy logic technique to analyse both quantitative and qualitative criteria together. The model implementation provides a way to improve the process for assessing and selecting subcontractors, thus avoiding the failure of projects due to inefficient subcontractor and attain project success.

**Keywords:** Fuzzy logic, fuzzy model implementation, subcontractor selection, decision making, MATLAB

*Femin Maria I X*

## **EXPERIMENTAL STUDY ON THE EFFECT OF HYPO SLUDGE AND COCONUT FIBRE IN CONCRETE**

Present day's more than 300 million tons of waste are being created per year by paper industries in India. Each Indian paper mills produces an average of 40 over dry tons of sludge per day. These materials possess disposal, health hazards and aesthetic problems. Present day, because of low accessibility of natural resources, the ordinary Portland cement is being used rapidly in the world because of construction industries, residential buildings and other concrete based structures. So, the production and utilization of concrete has been rapidly increased. Lot of heat is emitted into the atmosphere due to hydration action of cement. So to reduce the amount of cement in concrete, use of hypo sludge as partial replacement of cement with addition coconut fibre in concrete is studied. The particles of hypo sludge are extremely fine. The partial replacement of hypo sludge in cement, which may help to reduce the disposal problem of hypo sludge and enhance the engineering properties of concrete. The replacement of hypo sludge, improves the mechanical properties of concrete. The project work includes partial replacement of cement by hypo sludge at different percentages such as 5%, 7%, 10% and 15% by the weight of cement to find out the optimum percentage of hypo sludge content. This project aims at producing low cost concrete by the addition of coconut fibre (1%, 3% & 5% by the volume of cement) of 2.5cm, 5cm & 7.5cm length with optimum percentage of hypo sludge content in concrete mix. Also the durability properties and cost analysis of concrete mix with optimum percentage of hypo sludge and coconut fibre content is studied.

Keywords: Hypo Sludge, Flow Ability, Compressive strength, Split tensile strength, Flexural strength

*Jasmy Tomy*

## **EXPERIMENTAL STUDY ON PROPERTIES OF CONCRETE WITH DOLOMITE POWDER AND COPPER SLAG**

Concrete plays an important role in construction. However, production of concrete has also caused heavy environmental problems as a result of its global contribution to CO<sub>2</sub> emission. Because of the carbon emission and depletion of existing resources urge us to find suitable alternative to overcome the crisis. Dolomite, is a type of natural carbonate mineral, have similar effect on strength development as limestone additions when used as powder. Copper slag is an industrial by-product material produced from the process of manufacturing copper. Use of copper slag in the concrete industry as a replacement for cement and fine aggregates can have the benefits of reducing the costs of disposal and helps protecting the environment. This paper is an experimental investigation to study the properties of the concrete with partial replacement of cement by dolomite powder and fine aggregate by copper slag. The experimental research work consists of comparing the properties of M40 concrete with partial replacement of cement with dolomite powder (5%,10%,15%,20%) and partial replacement of fine aggregate with copper slag (30%, 40%, 50%). Mechanical and Durability testing of concrete with dolomite powder and optimum copper slag content (compressive strength test, split tensile strength test, flexural test, acid test) are planned to conduct for comparing the properties.

**Keywords:** Dolomite powder, Copper slag, Compressive strength, Split tensile strength test, Flexural strength test, Acid test

*Jibi Kurian*

## **EXPERIMENTAL INVESTIGATION ON CONCRETE MIXED WITH STEEL FIBERS AND WASTEPLASTIC FIBERS**

In the current scenario, concrete is an integral part of construction activity. Concrete is the most widely used building material in the construction industry. Its high strength and durability are the main reasons for its popularity. Today, the world is moving so fast that our environment is changing more and more. Attention is paid to the protection of the environment and natural resources and the recycling of waste. Landfilling plastic is also dangerous due to its slow deterioration rate and bulky nature. Large amounts of waste can impede the flow of groundwater and also impede the movement of roots. Plastic waste also contains a variety of toxic elements that can mix with rainwater and pollute soil and water, especially cadmium and lead. Since plastic is a hydrocarbon-based material, its high calorific value can be used for incineration and other high temperature processes. However, burning plastic releases a variety of toxic chemicals into the atmosphere, including one of the most toxic substances, dioxins. One of the new wastes used in the concrete industry is plastic waste. Reuse of plastics in the concrete industry is considered to be the most feasible application for resolving the disposal of large amounts of plastic materials. Historically, steel has been used as the material of choice for tensile reinforcement in concrete. Unlike conventional reinforcing bars, which are specifically designed and placed in the tensile zone of the concrete member, fibers are thin, short and distributed randomly throughout the concrete member. The random distribution results in a loss of efficiency as compared to conventional rebars, but the closely spaced fibers improve toughness and tensile properties of concrete and help to control cracking. Concrete generally becomes more brittle as it becomes stronger. This is a major drawback as brittleness can cause sudden catastrophic failures, especially in structures exposed to earthquakes, explosions, or sudden loads. Realizing the improved performance of the different fibers in concrete, hybrid utilization of fibers are made in concrete.

**Key Words:** Durability, Recycling, Toxic, Dioxins, Tensile, Toughness, Cracking, Brittle, Catastrophic, Hybrid.

*M Sanjay*

## **PROPOSAL OF A MODEL TO ASSESS RISK INCURRED IN RESIDENTIAL BUILDING PROJECTSDURING UNCERTAINTY CONDITION**

Risk identification and analysis is an important step in risk management. While considering the scenario of Covid-19 in Kerala, many risk factors had been introduced in residential building projects. Large projects are already equipped with risk management while in small projects like residential projects risk management procedure is always neglected. All of this have resulted in high original project price hike and delay in the projects, which is the main risk factor affecting project success. In this study major risk factors affecting residential building projects during uncertainties are identified through literature survey and data collection. By the method of qualitative risk analysis, major risk factors affecting residential projects were identified and ranked according to their impact on the project. Cost estimating model developed by regression analysis helps to reduce price hike in the project caused by several risk factors. While suggesting an econ framework provides better understanding about risk management in residential building projects in Kerala. The project aims to find a way to raise awareness of the potential benefits of risk analysis and management in residential building projects during uncertainty conditions in Kerala.

Keywords: risk analysis, risk management, uncertainty, cost

*Ryssa K M*

## **EXPERIMENTAL STUDY ON STRENGTH AND DURABILITY OF BASALT AND POLYESTERHYBRID FIBRE REINFORCED CONCRETE**

Hybrid fibre reinforced concrete is the combination of two or more fibres having different material properties. The combination of fibres improves the concrete properties. The work aims to investigate the improvement in the properties of concrete when incorporated with hybrid fibres. The fibres used here are basalt fibres and polyester fibres. Basalt fibres are a better alternative to costly carbon and glass fibres with sustainable production process. Polyester fibres are synthetic fibres hence added to concrete leads to sustainability. Basalt fibres were incorporated at 0.1%, 0.2%, 0.3%, 0.4%, and 0.5% of the weight of the cement and optimum content was obtained. In the mix with the optimum content of basalt fibres, polyester fibres were incorporated at 0.1%, 0.2%, and 0.3% of the weight of the cement. The strength and durability properties of M40 grade concrete were compared and evaluated. The experimental investigation suggested that the compressive strength, split tensile strength and flexural strength was increased by 2.209%, 40.87% and 23.77% than control mix when basalt fibre is 0.2% by weight of the cement. The optimum content of polyester fibre was selected as 0.1% by weight of cement in concrete with 0.2% of basalt fibre. The compressive strength, split tensile strength and flexural strength of hybrid fibre reinforced concrete with 0.1% of polyester fibre and 0.2% of basalt fibre was increased by 17.02%, 56.604% and 39.49% respectively than control mix. The hybrid fibre with 0.2% of basalt fibre and 0.1% of polyester fibre exhibited better durability.

**KEY WORDS:** Hybrid fibre reinforced concrete, Basalt fibre, and Polyester fibre

*Sajmin Salim*

## **EXPERIMENTAL INVESTIGATION ON GGBS BASED SELF COMPACTING CONCRETE REINFORCED WITH SISAL AND BAMBOO FIBRES**

Self-Compacting Concrete (SCC) is becoming a popular choice in concrete industry due to ease of placement in congested reinforcements, reduced labour and equipment, no segregation character and smooth surface. Aside from these positive properties there are adverse characteristics, such as low cracking resistance, brittleness, low impact resistance and low tensile strength which can be considerably overcome by adding fibres to SCC. Addition of fibres to concrete can increase strength and can also reduce plastic shrinkage and drying shrinkage by arresting and delaying crack propagation. With the view of sustainable development, in this study sisal fibre and bamboo fibre (natural fibres) which are environmentally friendly, abundantly available, renewable, and economical and having low density is used to reinforce Self Compacting Concrete. This work investigates how the inclusion of sisal fiber and bamboo fibre of varying quantities in SCC affects the flowability and performance in hardened state. Sisal fibre is added at 0.25%, 0.35% and 0.45% by weight of cement and the optimum percentage of sisal fibre was obtained as 0.35%. To the mix with optimum percentage of sisal fibre, bamboo fibre is added at 0.1%, 0.2% and 0.3% by weight of cement and 0.2% was found the optimum percentage for bamboo fibre. The fresh and hardened properties of M40 equivalent GGBS based self-compacting concrete were compared and evaluated. Study on durability and crack behaviour for the specimen with optimum sisal and bamboo fibre is done and compared with the control mix. Results showed that performance of self-compacting concrete can be enhanced with the addition of sisal and bamboo fibres in terms of strength, durability and cracking behaviour.

Keywords: Self - Compacting Concrete, Sisal Fibre, bamboo fibre, flowability, strength properties

*Sameena V A*



## **EXPERIMENTAL INVESTIGATION ON HIGH STRENGTH CONCRETE**

This paper presents the results of an experimental investigation to establish M70 grade HSC following guidelines of IS 10262- 2019. This is done using PPC which is most common and locally available cement and with UFS. The PPC used contains 30% of flyash and after doing concrete mix design, UFC is replaced in 10%, 12% and 15%. Locally available coarse aggregates and manufactured sand were used. PCE based chemical admixture is used. Workability, compressive strength, tensile strength, water permeability measured. Test results revealed that with increase in UFS percentage, the compressive strength increased. The workability is also increased with increase in UFS percentage. The water permeability decreased with increase in UFS content. HSC with a compressive strength of 82 MPa (at 28 days age) could be produced with PPC and UFS. Since the total percentage of SCMs is high, the CO<sub>2</sub> emission will be less and can be treated as a green material. The high compressive strength can be advantageously used in compression members like columns and piles. Higher compressive strength of concrete results reduction in column size and increases available floor space.

Keywords: HSC, PCE, PPC, SCM & UFC

*Shyju M*

## **EXPERIMENTAL INVESTIGATION ON STRENGTH PARAMETERS OF CONCRETE MODIFIED WITH ALCCOFINE AND BUILDING MASONRY WASTE**

Demand for concrete as a construction material is increasing so as the production of cement. Increasing construction leads to utilization of various resources which causes harmful emissions and scarcity of resources on the environment. To produce environmental friendly concrete, the raw materials have to be replaced with some other materials which should not be creating any bad effect on environment. The use of industrial by products and C & D waste can reduce the problem. This work is to study the effect of Alccofine and building masonry waste on concrete. From previous studies, the addition of alccofine and building masonry waste improves the strength as compared to conventional concrete. It also reduces the consumption natural resources and also brings out a sustainable product.

Keywords: Alccofine, Building masonry waste, C&D

*Sreehari K R*

## **PREDICTION MODEL FOR CONSTRUCTION SITES SAFETY PERFORMANCE USING MULTIPLE REGRESSION ANALYSIS**

The construction sector is a labor-intensive industry. It creates jobs and helps people flourish all across the world. It's also well known for its dangerous working practices. In this situation, reducing the occurrence of accidents is critical. The present study was conducted to identify the factors that have a high influence on the safety performance of construction sites and to develop a prediction model for construction sites safety performance using multiple regression analysis. The research methods adopted here are literature review, questionnaire survey and data collection from field study. By reviewing the literature, several factors have been identified. The most influencing factors and elements for improving safety performance of construction sites are; Organization /contractors involvement, Safety policy, Safety training etc. These identified factors are used for questionnaire survey. The questionnaire data is further analyzed by reliability test and relative importance analysis. The results obtained from the questionnaire survey is used for multiple regression analysis and a model for predicting safety performance index is developed. The present study also suggests that all of the identified factors should be thoroughly investigated and studied further in order to reduce construction site accidents.

**Keywords:** Reliability Analysis, Relative importance index, Multiple regression analysis, Safety performance of construction site

*Stephy Antony*

## **EXPERIMENTAL INVESTIGATION ON THE PROPERTIES OF CONCRETE SELF- CURED WITH PARAFFIN WAX**

Wax is a material being studied by engineers in concrete technology. Paraffin wax added to concrete is proved to be self- curing and it makes sure that the concrete is free from water evaporation and hence improves its water withholding capacity compared to usual concrete. Paraffin liquid is a hydrophobic substance so; it will attract water and absorb it thus reducing evaporation. As a result, more internal water will be available for hydration which reduces the need for external curing. But as per studies the strength of concrete self-cured with paraffin wax was less than conventional concrete. So the aim of the research is to prepare a concrete self-cured with paraffin wax that has sufficient strength and temperature resistance properties which can have wide application in water - scarce, tropical and elevated temperature situations. The experimental research work consists of comparing the properties of self-cured concrete with 0%, 0.5%, 1%, 1.5%, 2% paraffin wax and fly ash based concrete with 0%, 0.5%, 1%, 1.5%, 2% paraffin wax. The compressive strength, split tensile strength and flexural strength, are conducted for comparing the mixes. Comparing the result of these experimental studies, characteristics of the strength of paraffin wax added concrete can be determined. The optimum mixes are tested for temperature resistance at 50, 150 and 300 degree Celsius to analyze the performance of these concrete self-cured with paraffin wax at elevated temperatures.

Keywords: paraffin wax, compressive strength, split tensile strength, flexural strength, temperature resistance, fly ash, and self- cured concrete

*Swathy Krishna A K*

## PREDICTION MODEL FOR SCHEDULE, COST VARIANCE

Modelling of cost and schedule variance of a road will be helpful for members of the construction project team to understand the factors, which they must closely monitor to complete the project with the required performance. Questionnaire survey is done to find the most influencing factors affecting cost and schedule variance of road projects and RII is used to rank the factors. The most influencing factors on cost variance were identified such as Fluctuation of material price, poor planning, scheduling and monitoring, increasing labour salaries, Fluctuation of plant and machineries cost, project site location, Mistakes in the estimation of cost for the project, Design changes during construction, Poor site management at site, and slow decision process. And most influencing factors on schedule variance were identified as Weather conditions, Shortage in construction materials, Slowness of the owner decision making process, Poor site management and supervision by contractor, Construction methods, Ineffective planning & scheduling of project by contractor, Geological problems on site. Analysis is done to find out the factors which are highly correlated with the cost and schedule variance. An Artificial neural network model is developed to predict the schedule and cost variance in road construction projects. The trained network's performance is evaluated using mean square error and regression analysis.

Keywords: Artificial neural network, Modelling, Cost Variance

*Taneya Tom*

## INVESTIGATION ON STRENGTH OF RETROFITTED STRUCTURAL ELEMENT

Reinforced concrete is a composite material in which relatively low tensile strength and ductility of concrete are counteracted by inclusion of reinforcement having higher tensile strength or ductility. If loads acting on reinforced concrete beams are increased or if the strength of beam are reduced, the tensile stress in reinforcement and compressive stress in concrete increases, causing excessive cracking. Any technology or material has its limitation and to meet new requirements, new technologies have been invented. One such technique is retrofitting-the process of restoring the strength of a structure to its original condition. There are many techniques used for retrofitting purpose like jacketing, sealing, stitching, overlaying, FRP wrapping etc. This paper presents the study on the behaviour of concrete retrofitted with carbon fabric and basalt fabric. Interest is warranted due to the advantages of this method compared to others, include low environmental impact and low cost and support their potential across a wide range of applications without changing much aesthetics of the structure. Much effort has gone into increasing their mechanical performance to extend the capabilities and applications of this group of materials maintain its durability characteristics. This project aims to investigate on the behavior of retrofitted structural element with single wrapping of fabric and details of achievements made with them. From the review conducted it was evident that the load carrying capacity of specimen had increased significantly after retrofitting.

Keywords: Retrofitting, Fibre reinforced polymer

*Uthara K S*

## APPLICATION OF LEAN PRINCIPLES IN MULTISTOREYED BUILDING CONSTRUCTION

The construction process involves value added activities and non-value-added activities (NVA). NVA are those which do not add any value during the construction process. There are many non-value-added activities like waiting times, reworking, transporting and handling superfluous materials, and a variety of other non-value-added tasks in the construction industry, which causes loss of quality & profits in qualitative and quantitative terms to construction sector. Many projects management approaches have tried to improve performance in construction industry, lean construction is one of them. There are several Lean strategies that may be used to find waste in construction projects, but the most significant lean application objective is to find non-value-added activities on construction projects, which is possible using a number of lean tools. This project aims to identify key issues in the construction industry that lead to non-value-added activities based on seven lean wastes, as well as to assess labor inefficiency caused by the seven lean wastes that have been identified and measured through direct observations using the work sampling method. This project provides the ideas about the factors that leads to the non-value-added activities, and finally develops a work sampling tool mobile application using Kodular software to easily generate the monitoring time, pausing time, setup time and the amount of time spent by labour on different wasteful activities in a direct graphical format.

Keywords: Non- value-added activities, Lean principles, Lean construction. Work Sampling Tool

*Yedulakshmi Nair*

## UPCOMING EVENTS

3<sup>rd</sup> International Conference on

# INNOVATIVE TRENDS IN ENGINEERING FOR SUSTAINABILITY (ICITES-2023)

Theme : **SUSTAINABLE BUILT ENVIRONMENT**

11<sup>th</sup> April 2023 – 13<sup>th</sup> April 2023

(HYBRID MODE)

KTU sponsored 5 Days Faculty Development Program (FDP)  
on

## “EMERGING TRENDS IN ENERGY EFFICIENT BUILDING CONSTRUCTION”

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