Vol. No.01 Issue No. 08 Kochi January 2020

Rs:200/-

CONSTRUCTION CP PHILOSOPHY

BRIDGING SOULS OF QUALITY

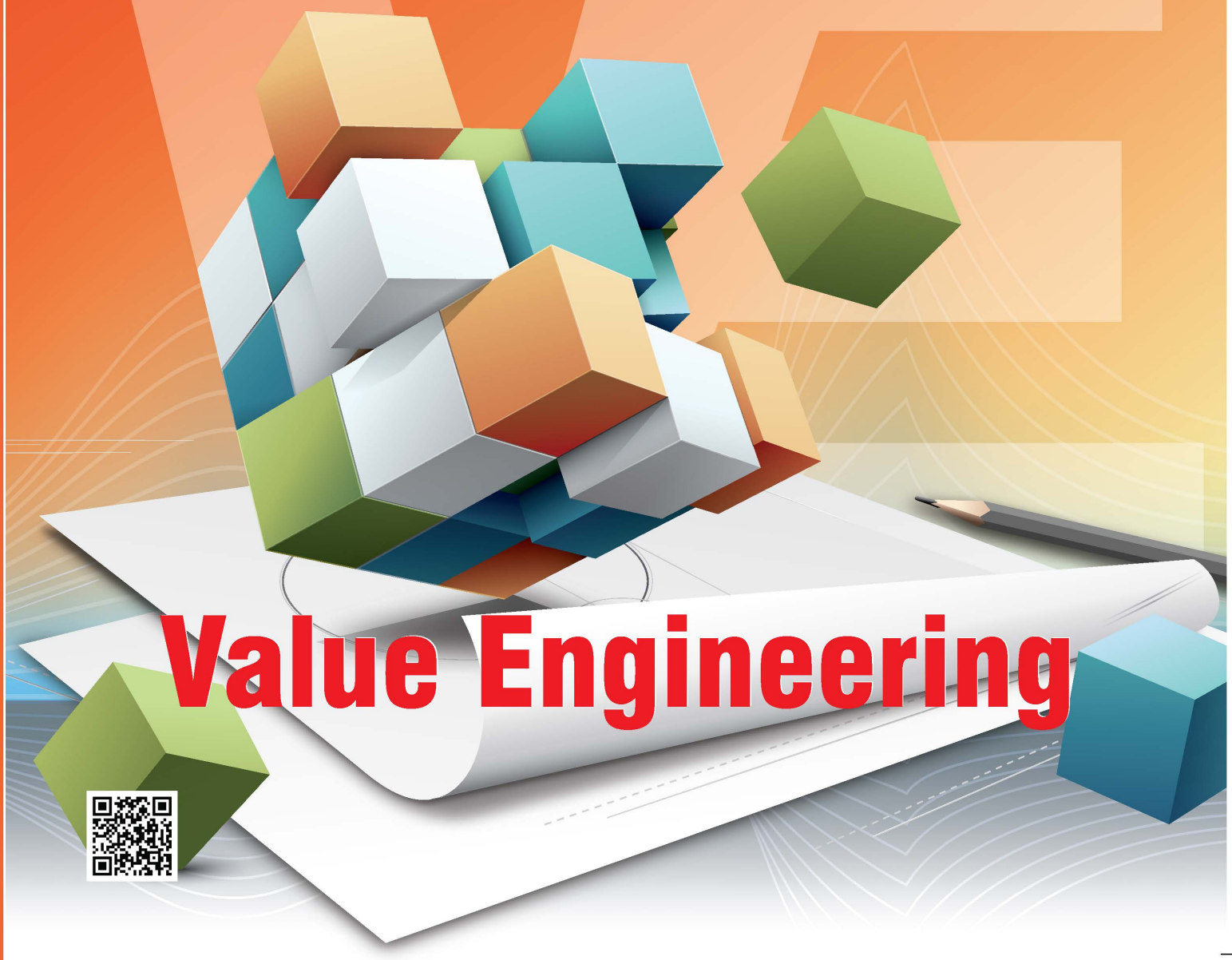
Value Engineering in perspective
Anita Lukose, Renne Hoekstra
Martyn Phillips, Naveen Kumar
Anil Kumar Mukhopadhyaya

Interview
Muthiah Kasi

Guest Column
A.N. Prakash

Special Focus
EXCON 2019

Miami Pedestrian Bridge collapse
Dr. N. Subramanian



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CONSTRUCTION PHILOSOPHY

Vol. No. 01 Issue No. 08 | Kochi | January 2020

Let optimal value be our goal

Engineering as a calling ranks at the very top of the professional value chain. Engineering is about lives being built upon solid structural foundations. No wonder, therefore, that anyone studying civilisations begin his/her quest by looking at the structures built by generations gone by. These structures derive their archaeological, architectural and historical significance from the engineering values they hold within them. Fortunately, today, we have an entire branch of engineering studies focused on value engineering. Although not an integral part of the curriculum everywhere, Value Engineering (VE) or Value Methodology (VM), as this branch of learning and engineering practice has come to be known, has given us great insights into the optimisation of values in every structural creation.

Value Engineering is not about cutting costs. It is more about bringing together insightful inputs from different corners so that the value of a project under execution gets optimised. Value Engineering, with its emphasis on team play and creativity, can make a big difference to the cost of projects, quantity of material used, efficiency of project management and sustained quality of the project throughout its lifespan. A lot of ideation can happen when a dedicated team brings to the table and project site creative insights. Thus, a project founded on principles of VE cannot but be of lasting value. In this issue of Construction Philosophy, we have focused on VE in a big way. We hope that our effort will help mainstream the concept of VE in India.

Together let us raise our voice for quality.

Nebu Abraham
Editor

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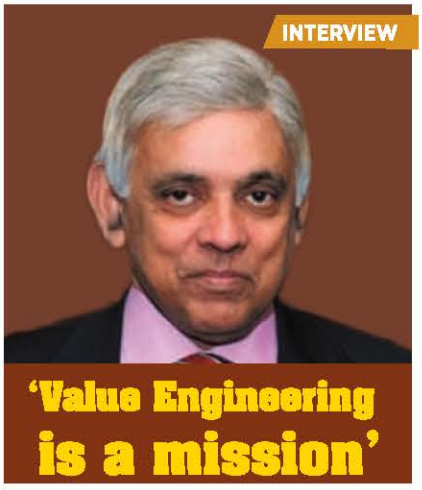
Join our author family : Send your articles to Editor@constructionphilosophy.com to get it published in our upcoming volumes



"Take up one idea. Make that one idea your life - think of it, dream of it, live on that idea,says **Muthiah Kasi**, pioneer of Value Engineering, shares the motto by which he lives in an exclusive interview.

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Construction Philosophy is owned, edited, printed and published by Nebu Abraham and printed at Sterling Print House Pvt. Ltd., Door No. 49/1849, Ponekkara-Cheranelloor Road, AIMS, Ponekkara PO, Cochin-682041, Kerala

Published at : Door No: 43/1920-D, Peringattu Buildings, Peringattu Road, Palarivattom, Kochi, Kerala, PIN 682 025
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Central nod for Kerala's semi-high-speed rail project

The Central government has approved Kerala's 531-km semi-high-speed railway line from Thiruvananthapuram to Kasaragod.

The project, which is expected to ensure fast end-to-end connectivity between the two destinations, reduce congestion in the State's road network and make travel hassle-free, is estimated to cost about Rs. 56,000 crore, including the cost of land acquisition. The project, titlted Silver Line, will have 10 stations.

A feasibility study report on the project, submitted by Paris based consultancy firm Systra recently, says that the project with dedicated railway lines to Thiruvananthapuram International Airport and Cochin International Airport is 'feasible and financially viable'. The semi high-speed trains will run at the speed of 130-180 km/h to cover the North-South corridor. Though the maximum speed for the rail line is proposed at 200 km/h, the trains will run at a maximum of 180 km/h. The new generation engineless semi high-speed train Vande Bharat Express (Train 18) has been proposed to ply on the corridor.

The project has been proposed through thinly populated areas to lessen displacement of people and would require only 1,200 hectares of land. The final location survey will be done as the land from Railways and the Cochin International Airport Limited (CIAL) is needed for laying the line and constructing the stations.

The report says that, initially, train sets with nine cars will be introduced and later it will be extended to 12 and 15 cars. The coaches will be made of aluminum under the 'Make in India' program.

The project would seek to tap solar energy. As much as 21% of road traffic is to be shifted to rail and economic savings have been worked out to be the equivalent of 1.8 lakh metric tonnes of carbon. The construction work on the project will begin in 2020. Work on the Detailed Project Report has been initiated.

Hoffmann Group appoints Manav Goel as India Director

To bolster its expansion plans for the country, Hoffmann Group has appointed Manav Goel as its India Director. A civil engineer and an IIM Kolkata graduate, he will be responsible for driving the group's sales and strategic business partnerships in India. He has been member of the Asia management team and board of directors for Halfen Moment Group, a Fortune 500 company and also India business head at Tyrolit India Superabrasives Tools, part of the world-renowned SWAROVSKI group, besides having leadership roles at Minean Habitat and Hilti. "India has always been a huge market for the company and we see immense growth potential for us here. At Hoffmann Group, we have the ability to support the manufacturing industry with our comprehensive portfolio and machining expertise of Germany," Goel said.

KEC International bags orders worth Rs 1,520 crore

KEC International, global infrastructure, engineering, procurement and construction (EPC) major with projects in 30 countries, has bagged orders worth Rs 1,520 crore across various business verticals. An order of Rs 964 crore was secured by its urban transport business for the construction of elevated viaduct along with 8 stations of the Delhi Metro Phase IV project. Two orders of Rs 391 crore was bagged by its transmission and distribution vertical for construction of 400 kV Transmission lines in Nepal. In the railways business, it has secured an order of Rs 165 crore for construction of road over bridges (ROBs) in western India.

Alstom achieves around 80% localization in India

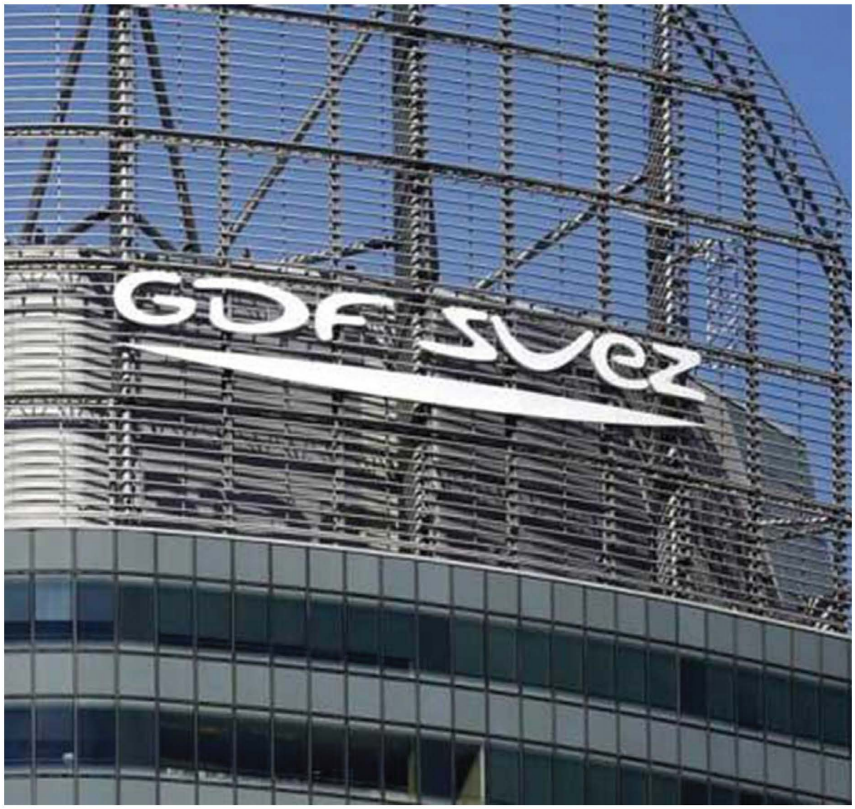
Alstom, the French rolling stock manufacturer, is planning to double its capacity from 240 to 480 train sets per annum and has achieved 75-80% localization at its manufacturing units in Sri City in Andhra Pradesh.

Alstom has begun manufacturing metro train sets for Mumbai Metro Rail Corporation (MMRC) at Sri City and begun supply to the Sydney Metro from this unit. Alstom counts Chennai, Kochi, Lucknow and Mumbai metros among its domestic customers. The company is also planning to introduce its electric bus to India which is already operational in Spain and France.

French firm Suez working on two water projects in India

France-based Suez SA is working on two water management projects worth 217 million euros (over Rs 1,700 crore) in New Delhi and Mangalore.

The waste water treatment plant, being set up in Okhla at a cost of 145 million euros, will be operational within three years. A 72 million euro water distribution project in Mangalore will also kick off within a month. The project, with a capacity of 564,000 m3 / day, was awarded to the company by the Delhi Jal Board, the governing body for water management.



Once the project becomes operational, the plant is expected to remove 41,200 kg of organic pollutant load per day and 61,600 kg solid load per day from the Yamuna. It is being implemented by the civic body of Mangalore and financed by Asian Development Bank. The project also includes extension, rehabilitation and operation of the drinking water distribution system which covers an area of 132 km, including 96,300 connections and a 2,148-km water distribution network. This 11.5-year contract, worth 72 million euros, will ensure a 24X7 water supply for the city and its 550,000 inhabitants.

In the initial three years, the company will design and lay down 1,388-km of drinking water network, design and construct a filter house, clear water sump and pumping stations. This will be followed by an eight-year period of operation and maintenance of the entire drinking water distribution system.

Action is better than compassion

Anindita Das grew up seeing the hardship of poor hill folk, especially the difficult times young girls had if they were intent on studying. She found that that family pressure often forced many girls drop out and get married and that the toilet facilities for girls in most schools were woefully inadequate.

She decided to make a difference in her little way. Teaming up with her friend Shoma Bakre, she launched Build A Toilet, a project to construction toilets for girls in high schools. So far they have built four toilets and are planning to build more. Being a Civil Engineer, she was able to ensure that the toilets had quality about them.

The toilets were built under the banner of Let's Do Some Good Foundation, formed by Das as a bridge between NGOs and corporates.

Anindita Das

Stories so far . . .

Within a short span of time in 2019 alone, we were able to carve a niche for ourselves among the ***Civil Engineering*** *fraternity. We had 'Metroman'* ***E. Sreedharan*** *on our cover in our inaugural issue. The subsequent issues had* ***P.G. Venkatram****, former Chief Executive, L&T Infra Engineering Limited, Er.* ***A.N. Prakash****, who is a byword for Construction Project Management in the country,* ***Chintana Herrin****, Senior Manager, Bentley Systems India Pvt. Ltd.,* ***Jagjit Avdeel****, Head of Gleeds Digital Services, Gleeds Consulting India Pvt. Ltd., Architects* ***Krishna Rao Jaisim*** *and* ***Padma Shri G. Shankar****, Architect* ***Sujata Kohli****, President, Indian Society of Landscape Architects, and* ***Century Real Estate Holdings*** *and* ***Sobha Limited*** *from the real estate side among others, gracing the cover and inside pages of*

Construction Philosophy

Anita Lukose

Nothing succeeds like

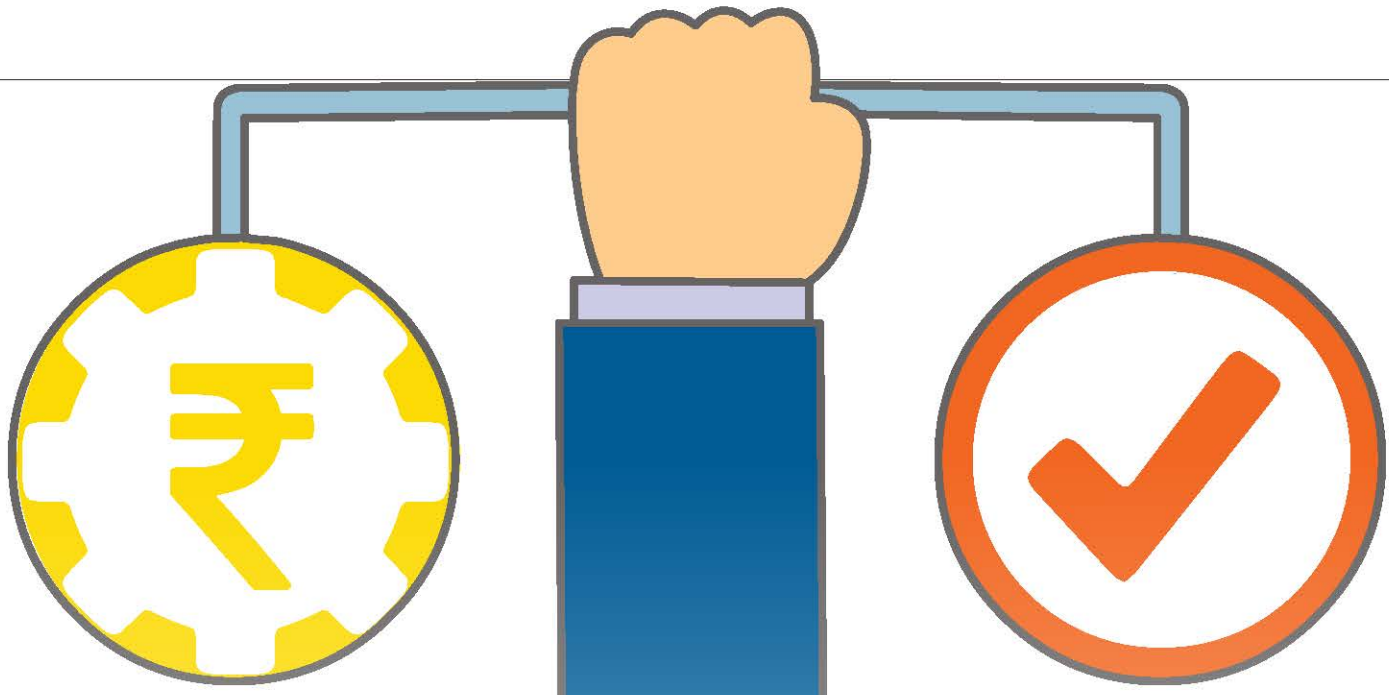
Gone are the days when organizations focused only on cost cutting and resource optimization for survival. This is the time for holistic thinking and innovations to grow in a competitive global economy. Value Methodology (or Value Engineering), pioneered by Lawrence D. Miles in the 1940s, can be a success mantra, reducing material wastage and satisfying stakeholder needs, writes Anita Lukose.

Value Engineering

The original flood control proposal for the Blue River Channel in the US was a massive, unattractive and expensive concrete structure in the middle of a national historic landmark. So, the US Army Corps of Engineers held a formal Value Engineering study. After rigorous review, including extensive flood modelling, the study team developed a more natural, aesthetically pleasing, and significantly less expensive approach. The result is river recreation, natural vegetation, ease of maintenance and 86% savings on construction costs. (SAVE International, 2013)

A quarter of a million cars each day, on a bridge designed for 75,000! When the much-needed Woodrow Wilson Bridge replacement, again in the US, was put out to bid, the one solitary response was 72% over budget! So, a formal Value Engineering study was held to bring the cost under control. By dividing the project into three separate contracts, attracting additional bidders and identifying $50 million in alternative savings, the bridge cost was lowered by $362 million. (SAVE International, 2015)

Value Engineers across the globe will have many such exciting experiences of identifying solutions, creating



innovations and enhancing project parameters to narrate. That is why, Lawrence D. Miles, father of Value Engineering (VE), described it as "a system to use when more than normal results are needed". VE helps to deliver a project that satisfies the needs and desires of the stakeholders within the constraints of the project.

Gone are the days when organizations focused only on cost cutting and resource optimization for survival. Today, it is time to think holistically and use Innovation as the key to grow and thrive in a global economy. Organizations look for path-breaking ideas to ensure market leadership and, thus, success. It is imperative to create a positive impact on the three different aspects of sustainability—economic, environmental and social—as the outcome of their business. Proper use of Value Methodology guides the VE team to generate sustainable solutions which check unwanted use of materials and reduce wastage, while satisfying stakeholder requirements.

History of VE

Value engineering (VE) was conceived in the 1940's by Lawrence D Miles while he was employed as a product engineer at General Electric. It was introduced in the construction industry by Alphonse J. Dell'Isola in the mid-1960's. VE clauses were first used in construction contracts by the Navy Facilities Engineering Command, followed by The Army Corps of Engineers. The clauses ensured that Value Engineering was a part of a contractor's deliverables. Thus began the Value revolution for America.

The basic objective of VE in construction is to achieve an optimum balance between cost, quality and reliability.

Later, VE incentive provisions with additional shares to the contractors were developed by the General Services Administration (GSA) and Public Building Services (PBS). This incentivised contractors to carry out efficient VE studies on projects. In 1968, VE became mandatory in design contracts. In the 1970's, the introduction of VE programmes in construction management (CM) services was pioneered by the Public Building Services. The basic objective of VE in construction is to achieve an optimum balance between cost, quality and reliability.

As it stands now, on US Federal contracts, VE is made a part of each Federal Government Contract. States have different types of statutes that includes either a VE clause or a provision for VE changes in their contracts. Some countries have also adopted versions of these proposals and incorporated the VECP (Value Engineering Change Proposal) process for their government contracts. VECP's enable the government and the contractor to work together to reduce programme cost and improve the performance of the product, project or service supplied. (The Value Methodology Memory Jogger, 2018)

The 'OMB CIRCULAR NO. A-131' provides guidance to support the sustained use of VE by Federal departments and agencies in the US to reduce programme and acquisition costs, improve performance, enhance quality and foster the use of Innovation. ASTM standards on building economics contains different useful

standards for performing Value Analysis especially 'E 1699-10' which details the 'Practise for Value Analysis (VA) of Buildings and Building Systems'.

What is value?

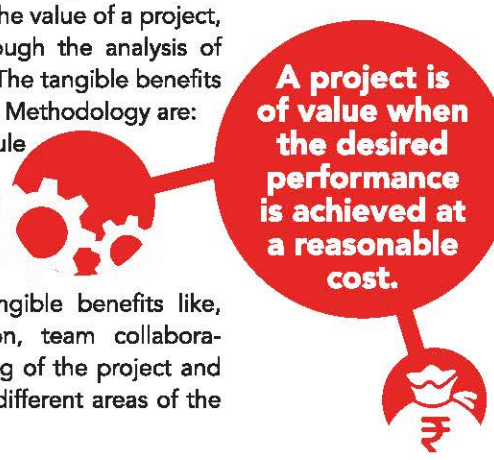
A project is of value when the desired performance is achieved at a reasonable cost. Value differs with person, time and space. This fact necessitates the requirement that value must be defined for a given set of parameters. The circumstances dictate value within the permissible resource allocation. Consider that a bottle of drinking water is available at Rs.15. A person working at a construction site, who is very thirsty, may buy a bottle of water at Rs.25. But he may not buy it for Rs. 500, which is beyond his capability.

What is Value Methodology?

A systematic process used by a multidisciplinary team to improve the value of a project, product, or process through the analysis of functions and resources. The tangible benefits associated with the Value Methodology are:

- Improve project Schedule
- Improvise Procedure
- Efficient use of material
- Resource optimisation
- Reduce Life Cycle cost

There are different intangible benefits like, enhanced communication, team collaboration, better understanding of the project and increased knowledge in different areas of the project.



The process:

(The Value Methodology Memory Jogger, 2018)

Value methodology is applied during the three stages of a value study: 1. Pre-Workshop, 2. Workshop (using the six phases VM Job Plan), and 3. Post-Workshop.

1. Pre-Workshop Phase:
   a. Gather information, identify team, determine and validate the scope, objec tives and deliverables
2. Workshop phase:
   a. Information Phase: Transform data to usable information and modify scope
   b. Function Analysis Phase: Develop function models and select functions for study
   c. Creative Phase: Create ideas by function
   d. Evaluation Phase: Select ideas for development
   e. Development Phase: Prepare final proposal
   f. Presentation Phase: Prepare and present report
3. Post-Workshop Phase: Implement changes, audit technical and financial benefits

Team Selection

Team selection is an important activity to ensure the success of a VE Study. VE team is a multi-disciplinary team consisting of professionals from different areas of the project. It is healthy to have a mixture of skill set and perspectives to generate questions and discussion. The probable team for a construction project can consist of Project Manager, Architect, Structural designer, Services designers, Owner/customer, Contractor, Quality inspector and Cost estimator. A study which requires more team members, the team is split into smaller teams to bring in effectiveness in discussion and analysis. A Certified Value Specialist (CVS) facilitates the Value study.

Function Analysis

Function is the heart of Value Engineering and is a mandatory requirement for all value engineering projects. Function Analysis helps the team to understand what must be accomplished in the project rather than how it is to be accomplished. "Function is what makes the product or service work or sell". Customers do not buy a product, but what the product does for them.

Function is defined by asking "What does it do?" Function is always defined as a combination of only two words, a verb and a noun. For example, to identify the function of a pen, we can ask, "What does a pen do?" A usual answer to this question is that it writes. But we know that we are the ones who write and not the pen. So, what does the pen do when we write? The pen makes marks on the paper. Thus, we identify the function of the pen as "Make Mark". When a customer buys a pen, he buys the function - make mark. That is why he is dissatisfied when the pen does not make marks on the paper.

Similarly, what is the function of a house?

Protect people? A house will not protect the inhabitants from everything, say, disease. But it protects them from natural elements. House is only one of the several methods of protecting people. A basic function of a house is to "Exclude Elements". The wall and roof perform this function. But one cannot survive if all the natural elements are excluded. To address this, we create windows to "Ventilate Space". We also need to get inside and go out of the house. To "Control Access" doors are provided and, in order to check entry of people, we create locks, the function of which is to "Restrict Entry". This understanding directs us to strategize and plan the available space for the best utilisation and satisfaction of the inhabitant. Some people like natural light, some want less sound from outside, some look for cross ventilation, some look for more area for storage and some are for easy maintenance of the building. Such needs, wants and desires captured as functions helps a value engineering team to prepare the logical representation of functions. This logic inspires the team to generate different alternatives. The best alternative based on the set criteria improves or creates value for the system under study.

Function analysis is very effective in perfecting the ideas and making it viable technically and commercially. Any system can be understood as a logical arrangement of functions. This understanding helps us to analyse, strategize and communicate what the system must do. Function analysis in Value Engineering makes it a methodology that can create awareness and clarity of the challenges or problems faced. The necessary functions can be retained, and the unnecessary ones can be deleted. The sell functions can be deliberated on. This in turn drives the value practitioners to formulate many creative options which are more viable in different areas of their concern.

VE team is a multi-disciplinary team consisting of professionals from different areas of the project.

Function-inspired change

Because of the heavy traffic and accidents that occur every day around the beltway in Washington, DC, officials determined the area needed a new hospital near the beltway. The value study team determined the basic function of the new hospital was to Expedite Response for medical treatment. A "function inspired change" came from one of the team members, who suggested adding a heliport-landing pad at an existing hospital located in downtown Washington, DC, and have a medical response team always available. This idea avoided construction of a new hospital and still met the basic function, Reduce Response. This excellent example of a function-inspired change was implemented, saving the owner a significant amount in life cycle cost. (Kirk, 2016)

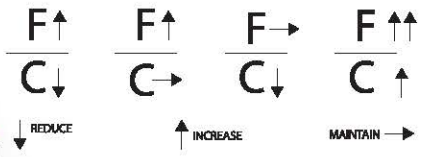
Function analysis is important because it alters the thought process of the user. Altering the thought process means changing the way one thinks about a project, product, or process. No longer focusing on the subject under study and what it is, team-thinking shifts to consider what it does, and how else to perform it. This change in mindset is powerful.

How to Increase Value?

In Value engineering, Value = Function / Cost

This helps one to think about different ways to improve Value by varying function and cost to increase the value of the ratio. Value increases by increasing function and reducing cost, increasing function and keeping the cost unchanged, keeping function unchanged and reducing the cost, etc.

To Increase Value



Importance of VE:

VE encompasses many methodologies and tools during a workshop rather than competing with them. Different methods like data collection, cost analysis, risk analysis that generates project information, creativity tools and various approaches for evaluation of generated ideas makes the VE workshop more effective. This gives organisations a great advantage of using different skills of its employees. As VE workshop is performed by a multi-disciplinary team, the project is studied from different perspectives and creates a holistic understanding among the participants. The discussions and the analysis are based on the team consensus. The creative alternatives are generated for the function identified rather than the components and elements of the project. Also, the function inspired changes are evaluated based on criteria identified for the best solution of the problem under study.

Value Engineering focuses on those value characteristics which are deemed most important from the customer point of view. Value Engineering is a powerful methodology for solving problems and/or reducing costs while maintaining or improving performance and quality requirements. A value study encourages proper collaboration among the team

'VE is yet to take firm roots in India'

Anju Asokan: **Value Engineering seems to be an idea that is in practice in bits and pieces, not understood in its totality or applied in our country. Isn't this the case?**

Anita Lukose:

In the construction industry in our country, it is not a policy that is practised, even though it appears in the tender documents. Those who prepare or review tender documents lack clarity on the methodology of VE. Many a times, VE is mistaken for some cost reduction ideas. Such ideas might actually bring down the value of projects and, thus, there is even the tendency to blame Value Engineering for poor quality of projects.

Why is VE not a branch of specialisation in India?

It is there as mechanical branches as electives and is mostly seen in PG theses. But many companies are giving this as a part of their induction training. It can be one methodology to bridge the gap between industry and academia. Indian Value Engineering Society (INVEST) conducts sessions at colleges to create awareness about VE among the students.

What are the key elements of VE?

One, a multi-disciplinary team which can perform a VE study under the guidance of a Certified Value Specialist (CVS); two, identified project, project details, study schedule, target for the study; and three, a firm commitment of resources and support by the executive management.

Is VE a dynamic branch where new ideas and elements are coming in? If so, what are they?

Initially, it was used to save money, reduce time, and improve quality, reliability and performance. Now, VE is also used for strategy and budget planning, cost control, design decisions, risk analysis and risk mitigation. It is a good methodology for decision making too. VE helps to realise savings not only in the initial project cost but also for the life cycle cost (LCC)

Does VE consider aspects of climate change and climate change impact mitigation?

When value engineering a project, climate change can be brought in as a key component of the value expected out of the study. Then the team can use the result of the study to strategize, design and implement the project.

and integration of the project design with respect to different disciplines. It helps the decision makers to take informed decisions. The VE team can also prepare matrices to help in deciding the features of a project according to the project strategy.

When to do VE?

VE should be initiated at an early stage in a project as it facilitates implementation of the VE recommendations without delaying the progress of the project. But VE study can be initiated for a project at any stage, and the project objective varies depending on the strategy of the study. (Kasi, 2017)

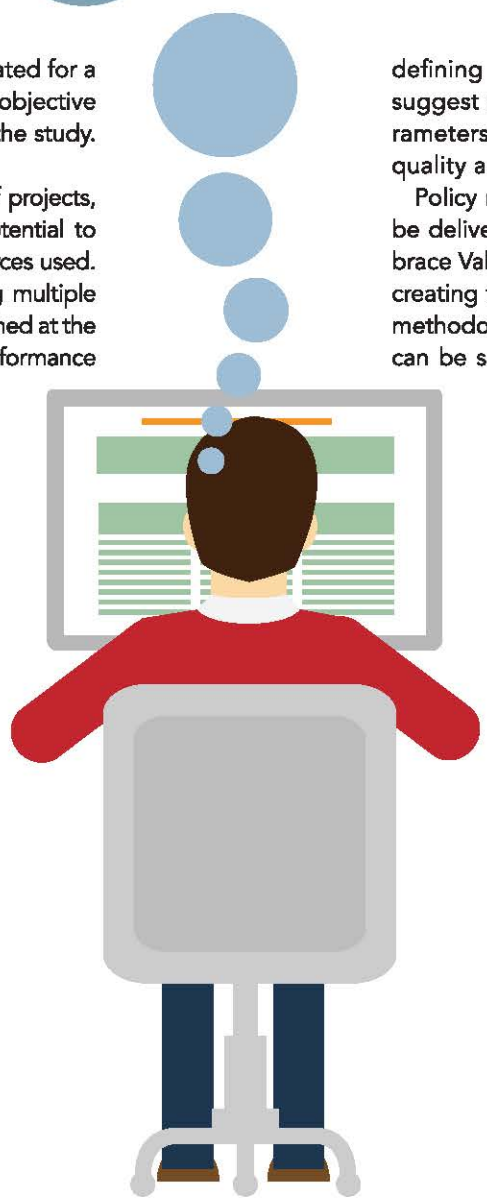
VE can be performed in any type of projects, but is suggested for projects with potential to create changes which justify the resources used. Value Study can be performed during multiple stages of the project. When it is performed at the conceptual level to establish the performance measures and to ensure the dependability of the solution, it is called Value Planning. Value Engineering is performed during the design and planning stage of the project. Value Analysis ensures the value of an implemented project. (Kasi, 2017)

Where are the VE experts?

VE is promoted globally by SAVE International (Society of American Value Engineers). INVEST (Indian Value Engineering Society) is affiliated to SAVE International. INVEST conducts VE workshops and certification programmes.

VE, with its evident advantages, namely systematic methodology, function analysis and the possibility to apply different tools within the methodology, can stimulate the team to bigger results. But it becomes a concern when VE studies are often looked at as a method for problem solving or even cost cutting. Teams rarely see a study as an opportunity to address a higher goal. Many a times, the immediate problems or the symptoms of problems are addressed.

Function analysis is important because it alters the thought process of the user. Altering the thought process means changing the way one thinks about a project, product, or process.



Value Engineering helps to deliver a project to the client that satisfies the needs and desires of the stakeholders within the constraints of the project. It improves the performance during the total life cycle of the project. Value Engineering team well versed with defining and improving function is able to suggest alternatives which enhances the parameters of the project especially cost, time, quality and reliability.

Policy makers, who understand the value to be delivered through the project, should embrace Value Engineering. It can be initiated by creating the right kind of awareness about the methodology, assured by making VE policy and can be sustained through VE incentive clauses. Academia should include VE in their curriculum. This enhances the understanding of students and helps them to become more employable.

VE has been successfully used by the different governments and organisations globally. Value Methodology and other value enhancing tools help governments and organizations to enhance their performance and deliver value. Indian construction industry can gain much from structured Value Methodology.

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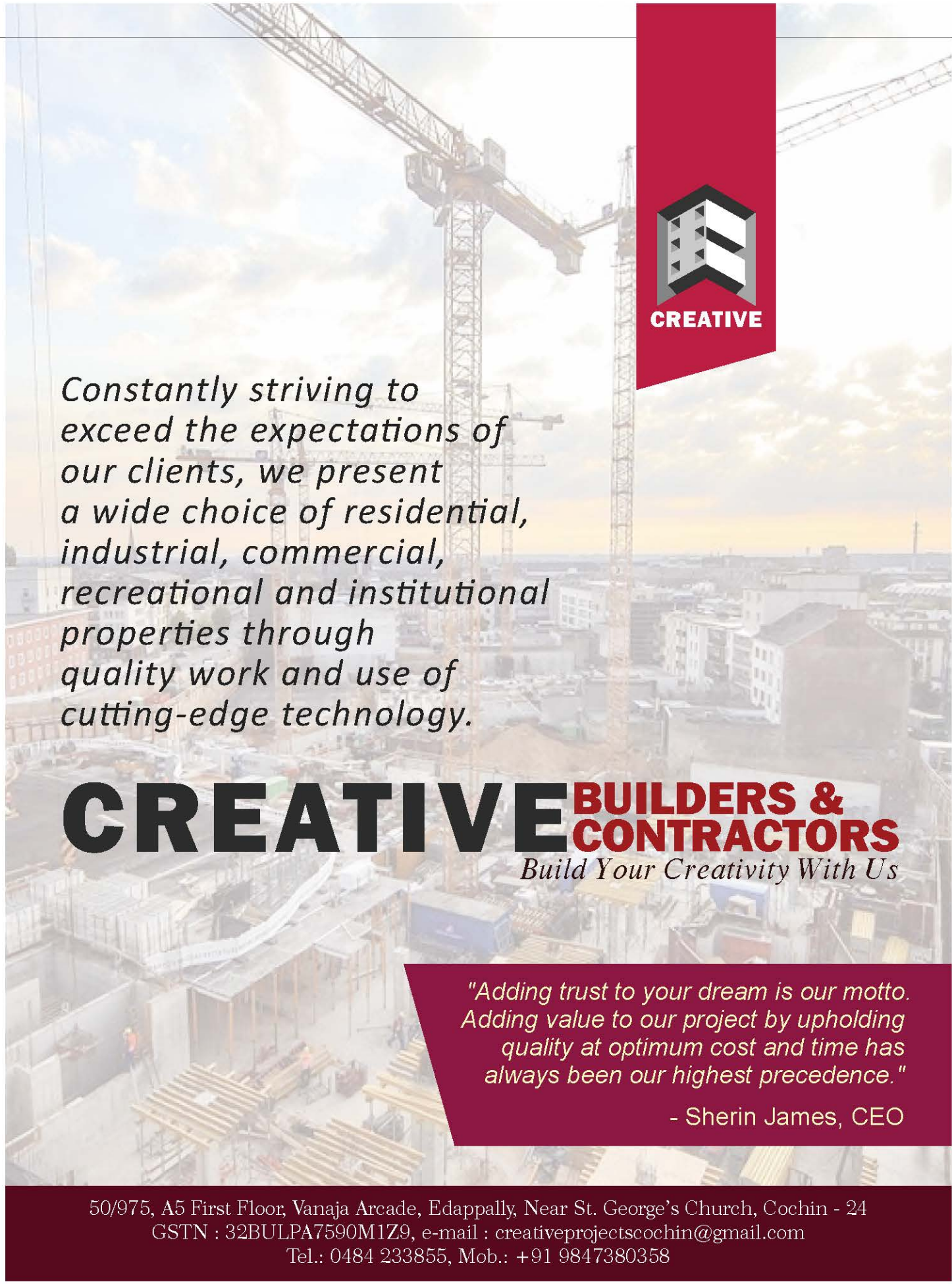
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VE is a mission

Muthiah Kasi

Excerpts from an exclusive interview granted to Elizabeth Pranitha Joseph and Anju Asokan

Your name is synonymous with Value Engineering. What is the secret?

Swami Vivekananda once said, 'Take up one idea. Make that one idea your life - think of it, dream of it, live on that idea." And it is exactly what I did. I live with it. For every project that I take up, I insist that they keep VE as a mandatory option, which will go through an approval process. It was difficult initially as they found that they needed to spend time on it. But eventually they benefitted from it and VE has now become a routine. For me and for the construction industry.

On the face of it, VE looks like it is all about cost reduction...

VE, most of the time, is cost utilization. In one project, for example, we could reduce the cost by 20% after observing the principles of VE closely, and the government agency concerned was shocked to see it. We are often asked whether VE is all about cost reduction. It is not. If you want to cut costs, hire a cost estimator. What we do is to improve the performance of services that the public want

If you want only to save money, even the best of value engineering would give you nothing. We all have seen projects with lower cost ending up with high maintenance expenditure later and projects with appropriate costs ending up with lighter maintenance bills. So, the question is simple: "Do you want to spend money now or later?"

What is the best way to spread awareness about Value Engineering?

I think the best way is to have one 'champion project' that becomes a case study for the industry and practitioners. But that's a struggle. It's like asking fresh graduates about their work experience.

Is Value Engineering related to sustainability?

A major problem we confronted in one project was getting a 180-feet girder to rest on a column. We eliminated all girders and made a bracket that supported the load and that, in turn, led to an innovative design. We were able to save more than 4000 cum concrete. Cost reduction impacts sustainability, while Value Engineering enhances it.

What is the competition for VE in the global Industry?

When it comes to VE in construction, there is no global competition. Competition exists only in cases where someone opts for VE. If one does a good balancing and comes up with a substantial cost-saving, then everybody will follow it.

How should we approach VE in construction industry?

In VE you have to look at the balance. It means consumers want a function for which they give you a cost, but if you do cost reduction, the performance is low. But they don't realise it. In construction, as time goes by, they spend money to attract stakeholders and cut the cost on dependability.

People should be aware of VE, but the project should be showcased not on its terms alone, but by addressing the customers' needs and desires. Con-

sumers should be educated not in Value Engineering terms, but by showcasing projects that subscribe to VE principles and address their needs and desires. In India, we can see that it would take a long time to do that. But if they get it, they will stick with it.

Is VE different for different sectors?

It is absolutely the same. As I said, all stakeholders change—consumers change, practitioners change, but the needs, the desires and the constraints never change. The process is the same. If you have something in mind, Value Engineering asks you certain questions like "What is it?", "What does it do?", "What does it cost?", "What should you do?", "What should it cost?","Will it do?","Will it perform?","Will it be acceptable?", "Can I sell that idea?", "What is that process?", etc. All these are basic questions asked in any field. Answering these questions is Value Engineering.

Don't you think it is time engineering curriculum incorporated VE?

Absolutely. If colleges are convinced, they can teach this very efficiently and that will ensure that students know what VE is all about. I have been teaching a one-year course on VE in Illinois for the past eight years. It is very popular and is attended by Masters and PhD scholars from different fields. I often think a lot about putting the course together because they are from different fields and I want them to learn the techniques the way I am convinced. Normally, my classes are recommended by many professors towards the end of their final semesters. After 50 years Value Engineering, it is slowly getting into the education field in the US.

Why did you chose VE as a career and a passion?

It was an accident! I was a typical project manager. All I could see was black and white. I never went beyond the boundary. Then I took a course on Value Engineering. I joined the class and challenged the speaker saying that I don't agree with him. We had a long discussion and I realized that it was good.

Later, our company went through a financial crisis and was about to go bankrupt. I was the CEO then. I realised that if I want to compete with other companies, I have to be different. So, I moved into this and voluntarily gave the client a sample without charging him. A few agencies came to know about it and afterwards everyone adopted it. And we have gone up from four divisions to 29 divisions now and that's basically because of VE.

VE is yet to be given priority in a project. Why?

It's basically ego. And it is not easy to convince people. Most people think they can do the Value Engineering, they can do the balance and so they don't need you. If you want do cost reduction you really have to educate them. First do the sample, demonstrate and then take it up. ●

Muthiah Kasi A, internationally renowned contributor in the field of Value Engineering (VE) and Life Cycle Cost Analysis, and Chairman of the Board at the Chicago based Alfred Benesch & Company, is a structural Engineer who specialises in bridge design. He has more than 43 years of experience as a Project Manager and Project Engineer on highways, bridges and building projects and has authored and co-authored several publications for ASCE, CRSI, NIST, and ASTM. He is currently the re-certification Director for SAVE international and Sub-committe chairman for ASTM E06.81-Building Economics. mkasi@benesch.com

Integrate VE into

Value engineering is not about cutting corners, but about adding benefits and values to every construction project. For this to happen, VE should be integrated into project planning, says Renne Hoekstra. Excerpts from an exclusive interview given to Elizabeth Pranitha Joseph.

Isn't every Engineer concerned about deriving optimum value from a project? Then how can we differentiate between the calling of an ordinary engineer and a value engineer?

Most of the time, what happens when an Engineer's design contract is negotiated is that there will not be any room for him to optimize the design. Or, they are told by the owner "This is what I want". When that happens, that is what they give them even if it is not (the) optimal project. When we come in with our subject experts to conduct a value engineering workshop, we are not put in the same box that the design engineer is put since the owner asks the designer to stay within the scope of the project he/she sees it. In value engineering, we don't have to be in that scope box. We get to say, "Why are you doing that?" or "Have you considered this?" or "How else can we achieve the functions?" or "Why are you even doing that function?" So, we have the opportunity to get out of the box.

At which stage of a project should we adopt VE?

There is a wonderful opportunity if you do a value planning study. Value planning would help you decide the scope of a project, so that you can establish an appropriate scope and budget and we don't get to the end and realize that we don't have enough money. So, if an organization wants to do value engineering later on, what we really are looking for is potential fatal flaws where there might be a bust in the design that might create a problem in construction, but we look at constructability elements. So we would look at plans and specifications and help them ensure that they are constructible. We look at different things. So the best time to do value engineering is at the 15% stage. When you get to 15%—and not more than 30% is your optimum—and if you did it at 15, you would actually have the opportunity to design value into the design.

Does VE foster creativity or curb it by merely focusing on resources and time constraints?

No, it is not just about cost, and that is our challenge. Normally what happens when you just cut cost is you negatively impact performance or function of whatever it is. Performance could be defined as quality, impactful schedule, operability, maintainability… So, there

project planning

Renne Hoekstra

are other things that are required for a project to be successful. That is why, during a value study, it is important for us in the information phase to understand from a client as to how must this project perform and what defines success for the project. We use those in our evaluation phase because the definition of 'value' is performance or function over resources, which could be cost or schedule. So you don't want to just do cost cutting because the project is going to suffer. VE helps us to not just focus on capital, but also on life cycle and how does it all relate to performance or function.

Isn't it difficult to educate the customers when they are least bothered about VE?

We have the same struggles throughout the United States. Although we have federal requirements for doing value engineering, that doesn't mean that they want to do it. It has been such a struggle and I don't understand it. I'm bringing you a process that helps to improve the value of your project, which means you may save money, time, and, in construction, time is money and you will not negatively impact how your facility performs once it's completed. I think India is running into the same issue as they can't see the value. So what we need to focus is on the benefits. We always want to provide a benefit.

Why is it that VE has not received the importance it deserves in our construction priorities, especially in the case of public infrastructure projects?

I wish I could answer that question. I have been trying to find an answer. Many of us in the US and many of our project managers for the government, when they get their employee evaluations, one of their evaluations is, "Did you meet schedule?" So if I make you stop at 30% and do value engineering and then if we identify some wonderful value engineering opportunities, you will have to go back and redesign, which would affect the schedule. So many of the project managers don't like or want this. So we have several organizations that are promoting innovation and value engineering. What they ask the project managers is, "Did you do a value engineering study?"

If we determine that there are really some valuable opportunities that we want to integrate, we reset the schedule from that point and not make you stick to the original schedule, so that it doesn't negatively impact their performance.

Shouldn't every project, be it private or public, be subjected to due diligence by a VE professional so that precious resources and time are saved?

Usually, there is not enough money in the budget. When a contract is awarded, with it comes the scope of work from the client who states their demands. So the designers often do not get a chance to go outside that box. Although they would like to think that they're doing value engineering, I would tell you that, at least in the US, they are not, because there is no scope. Which means there is no fee associated with them looking at other ways to approach things.

For example, let us talk about a drainage project. If I'm the design engineer and you give me the parameters, say, drainage structure for a two-year storm. I design a culvert pipe that will meet your requirement. I would spend 30% of the fee and I will take it to you and I will say 'Okay, here is your design' and the owner will say 'Yeah, I don't want a pipe. I want a box culvert!' But this is cheaper. And you are still getting the same function if I do a pipe. But the owner says, 'No, I want a box culvert'. That is the challenge!

Our owners are their worst enemies. They don't understand that they are not allowing engineers to be designers. Those are some of the challenges we've seen in the US over the years and I don't know if it is any different here in India.

Often clients change their mind on the design even after adopting VE. How is it going to be practical? Do we have to redesign and carry out VE again?

If you have integrated the clients into the process, then that could potentially be a part of one of the ideas instead of waiting until later. I can't imagine that a client would spend all this money and design, do value engineering and then make a different decision. Remember that the value engineering team does not make decisions. We bring all of the ideas. We do an entire evaluation process to get to the development of what we think are viable and implementable solutions. We do not make decisions. The client would still make those decisions. They would have already spent too much money. So again, integrating and understanding what are their needs, what functions and what performance measures are important needs to be done in the beginning and not later.

Have you had similar experience before?

I have had one instance where the project was already 70% designed. It was a waste water treatment plant. And the reason they did it was that the client had not integrated a key financial partner in the beginning to pick and select the design team and they felt they needed to have an outside team look at it so they can prove to this funding partner that they had made the right decisions. Right now in our country, and I don't know about in India, we actually have other types of delivery methods for project. We have CMGC (Construction Manager General Contractor) system, which integrates the contractor with the design and the owner. So now you're actually getting their input during the design phase. So that is also helping. So, some of these new delivery methods are getting integrated with value engineering.

How big a role would VE play in the construction industry in the coming decades?

Well, if you are talking about my goal, I would like to actually improve the knowledge of what value engineering is and get it to be more of a household term. I would really like to see it grow. But again, we have to continue to educate and a part of that, in the US, is ensuring that the government understands the importance of VE. I think that if we continue to train organizations on the importance of VE, then they will want to do more. Then it can become more of a career for the universities to start looking at and teaching.

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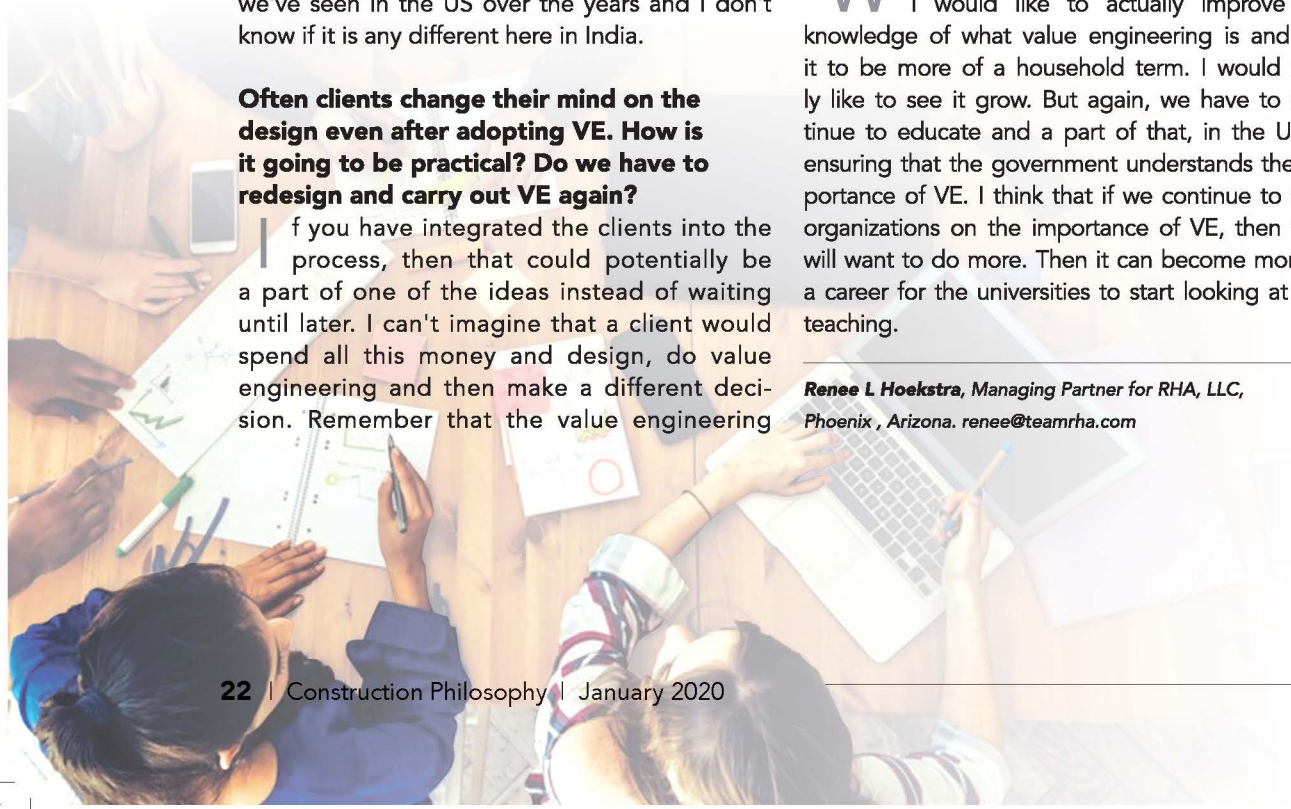


Abraham P. Lukose

VE in public service delivery

As shown by a waste management system developed for Bengaluru, Value Engineering or Value Methodology can contribute substantially to the development of a city's public service, says Abraham P. Lukose.

Everything around us can be thought of as systems, made up of smaller parts which work together to make bigger systems. For example, a cup is made up of its body and its handle but the cup is part of a coffee table, which is part of a room, which may be part of a house and so on. These systems exist because they serve functions that satisfy the needs, wants and desires of the stakeholders involved.

Similar to the cup, entire cities can be thought of as systems and the citizens its stakeholders. Early humans required only food, clothing and shelter and lived in caves, but modern society has evolved to demand a lot more from cities than just bare necessities. This includes housing, transport, electricity, piped water, safety and culture.

The value of a city's public service system is based on how well the requirements of its people are met, and is only good as long as its services are satisfactory for its citizens. Value Engineering (VE) is an attempt to increase the value of a system.

Public Service Organizations and Innovation

A report in the International Journal of Innovation Science shows the relationship between value creation and innovativeness. The Value Creation curve, (Figure 1) is a non-linear pattern that appears to characterize the relationship between innovativeness and value creation (Stauffer, 2016a). It is defined as the increase in value creation that occurs as the Innovation Index [of entrepreneur or venture] increases.

In other words, innovation in a public service context intends to achieve two things:

- Increase the responsiveness of services to local and individual needs (Mulgan & Albury, 2003);
- Keep up with public needs and expectations (Mulgan & Albury, 2003)

There are 2 prerequisites for value creation:

- **The intent to innovate:** Shown as support from senior management, a comprehensive policy statement and defining accountability for innovation practices.
- **An approach to innovation:** This is a management practice by which organizations retain its competitive advantage, increase profitability, and generate visible improvements to the top and bottom line.

Value Engineering as described by the Society of American Value Engineers (SAVE International) addresses these prerequisites by the following:

- To develop the intent to innovate within the organization, a **Value Policy Statement (VPS)** needs to be accepted by organization's senior management. The VPS is a visible record of VE acceptance and signifies acceptance, endorsement and encouragement and defines the rela-

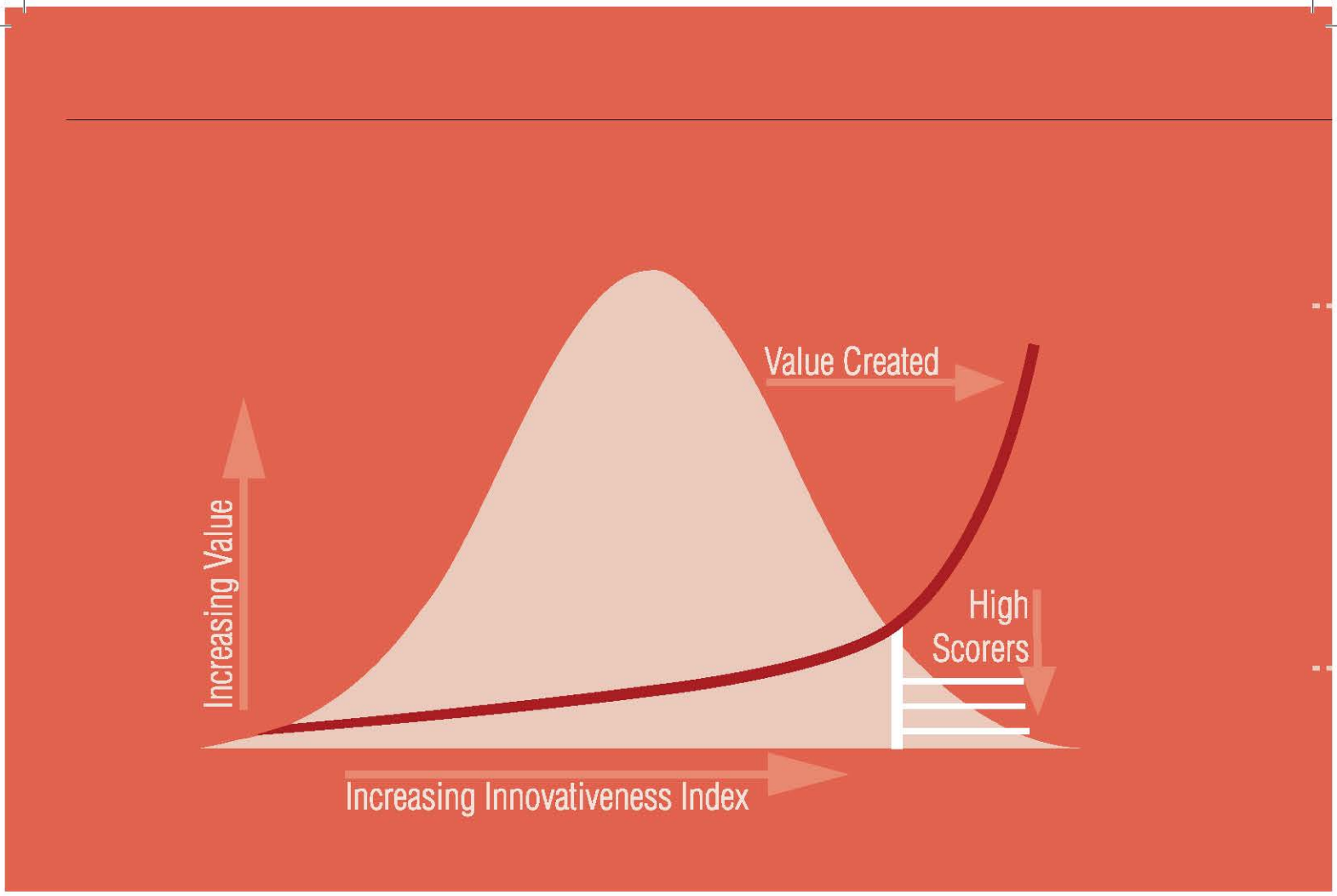


Figure 1: Value Creation Curve (Stauffer, Climbing Innovation's Value Creation Curve, 2016b)

tionships with other departments.

The approach to innovation referred to as **Value Methodology (VM)** is a systematic process used by a multidisciplinary team to improve the value of a project, process or product through the analysis of its functions. VM leads to innovation and improves creative ability. (Lukose, 2013).

Value Engineering and Public Service Organizations

Public Service Organizations looking to improve value for their stakeholders will find VM an ideal tool because of the following attributes of the methodology:

Stakeholder inclusiveness: Necessary because of the pluralistic nature of today's cities

Systems orientation: Necessary to incorporate the context of the public service

Structured application: Simplifies implementation and increases acceptance in the orga nization

Function orientation: Very useful to simplify and understand complex systems

Proven methodology: Reliable approach to value creation.

Additionally, VM is a process to:

Improve the performance of a system

Identify and reduce unnecessary resources

Drive team consensus

Offer alternatives while assuring that quality, reliability, and other critical factors meet or exceed customer expectations.

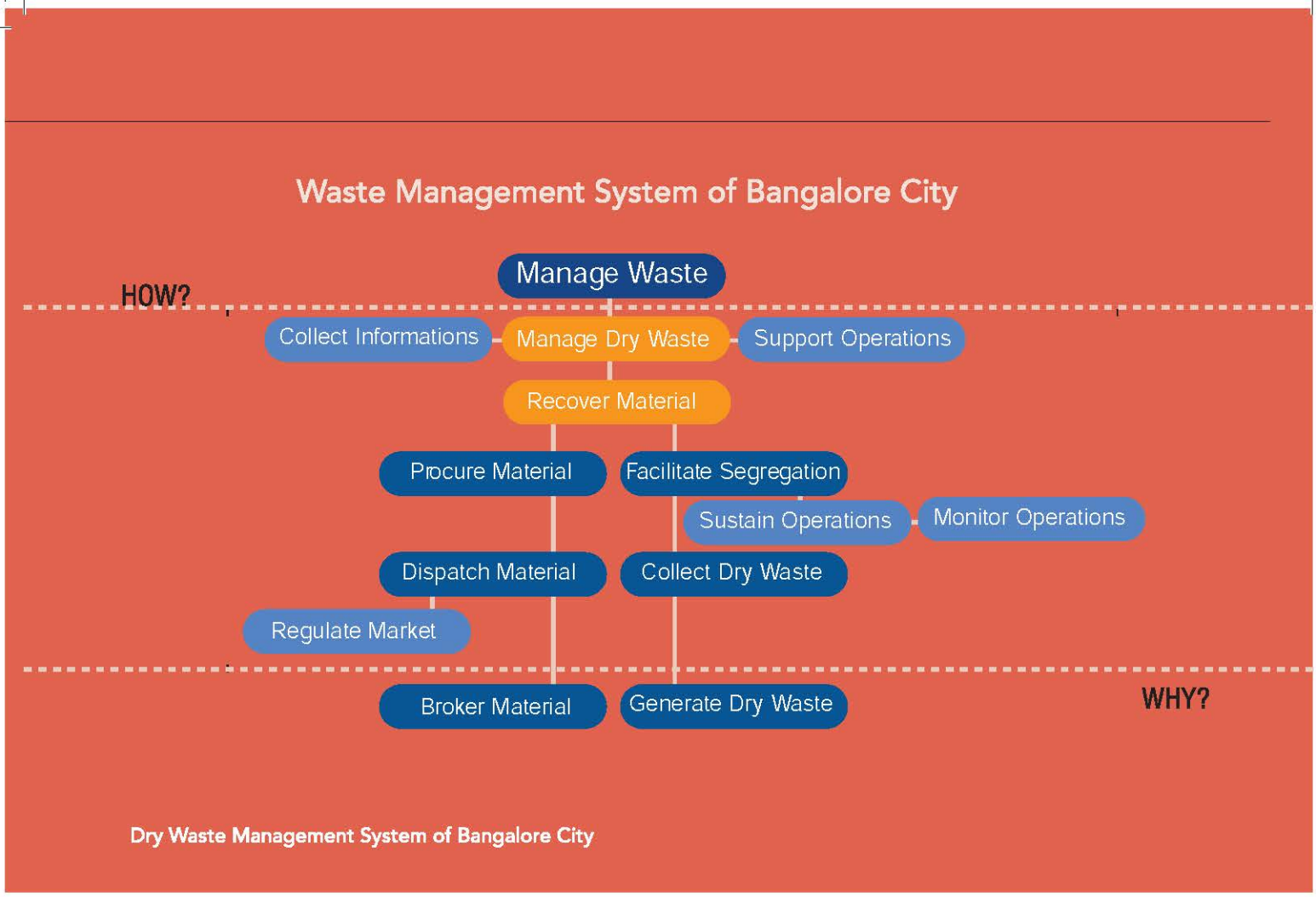
There are a series of specific steps or phases, as they are called, which are used to analyze the product or system in order to develop alternatives. One of the steps is the Function Analysis Phase which moves the focus away from the expected solution and places the focus on the required performance or need.

Out of the two techniques that can be used for the Function Analysis Phase, is the Function Analysis System Technique, also known as FAST. It is an analytical, diagramming tool used to identify and analyze functions with intuitive logic to stimulate creative and innovative thinking with the primary objective of improving the value of a given project, product or process as defined by SAVE International & Miles Value Foundation.

FAST diagrams provide a platform for stakeholders to ask two questions:

How is the function being satisfied now?

Is there a better way to satisfy this function?



Dry Waste Management System of Bangalore City

How VM recently enabled the analysis of the Waste Management System of Bangalore, is explained by means of FAST (see Fig.)

In the above figure, take for example the function Collect Dry Waste. It raises some pertinent questions namely:

How is dry waste being collected now?

Is there a better way to perform this function? (If it is currently being performed by push carts, can we look at the option of using vehicles, and so on)

By breaking down the entire Waste Management System into independent functions, the team at ATINA Systems was able to offer a clearer understanding of the system to the participants, providing decision makers the opportunity to improve the system. Similarly, FAST can be used in any public sector organization to show the logical relationship between different functions.

It is important for governments to adopt Value Engineering primarily because it helps understand the needs, wants and desires of its citizens and secondly, because it helps create value for its citizens. ●

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Anil Kumar Mukhopadhyaya

We've not missed the VE bus

The construction sector, which embraces real estate, highways, bridges,dams, airports and many others, can look forward to far more effective use of scarce resources if the principles of Value Engineering are adopted, says Anil Kumar Mukopadhyaya.

Lawrence Delos Miles did not just wake up one day and come up with his ubiquitous, function based thinking now known as Value Engineering. It came about primarily in response to a shortage of raw materials after World War II. Unable to fulfil orders, Miles, who was in charge of procurement at General Electric (GE), began looking at alternative materials that could perform the same function. He often found better ones than the original.

The concept, became so popular that it was made standard practice and Miles is known as the Father of Value Engineering, which is also widely referred to as Value Analysis, Value Methodology and Value Management. It proved exceptionally useful when GE moved into consumer goods and it became necessary to find better ways to compete in the market in terms of both cost and quality for the survival of the company.

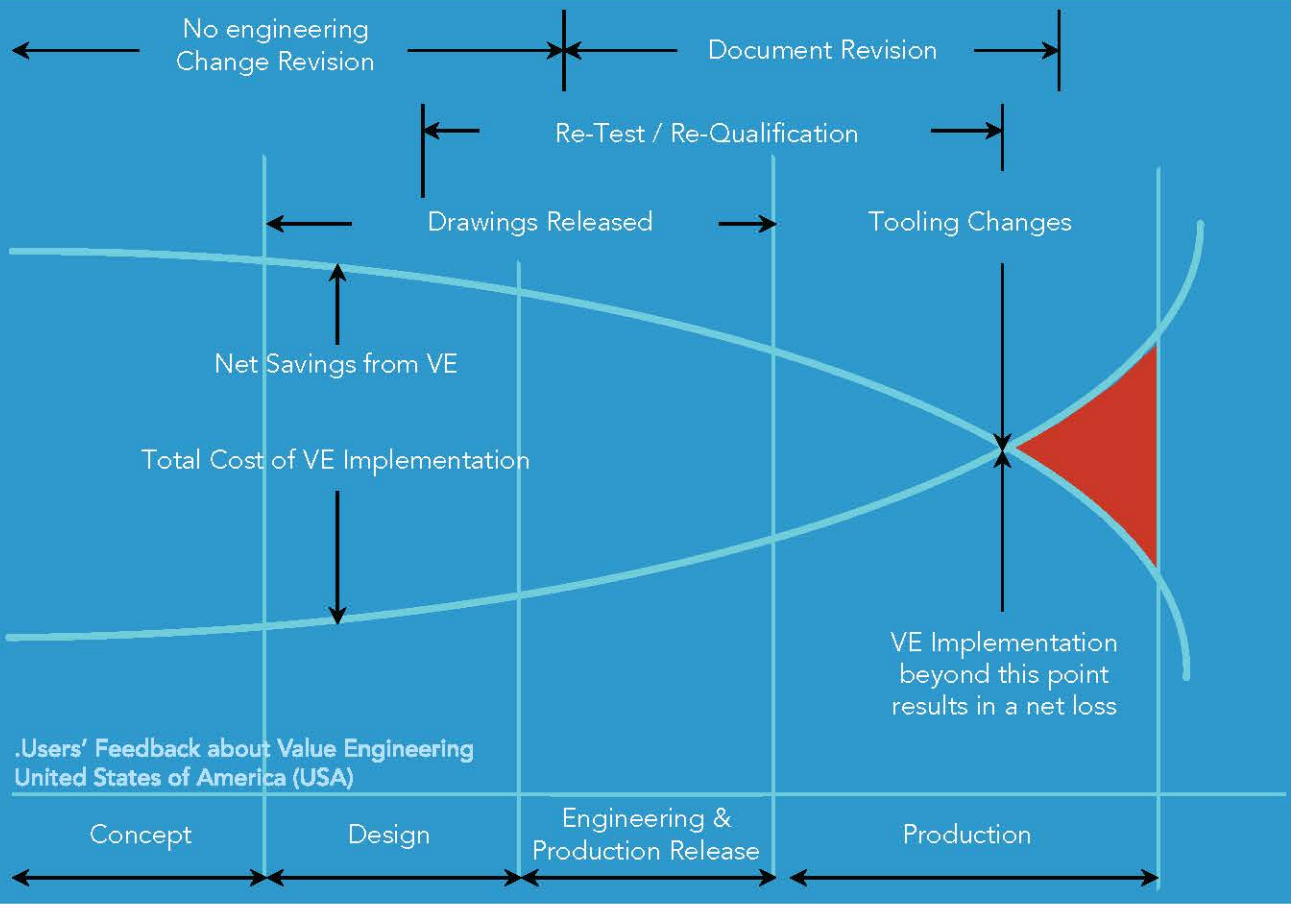
Miles defined Value Analysis as "an approach to locate, identify, remove or eliminate unnecessary cost" and Value Engineering as "The systematic application of recognized techniques which identify the functions of the product, service, project or system, establish the worth of those functions, and provide the necessary functions to meet the required performance at the lowest overall cost".

Miles wanted all this to be accomplished without compromising on the quality, safety, life, reliability and dependability of the product or project. It is common belief that to reduce the cost of a product, one must compromise on quality. However, Miles' methodology proved that 'quality often increased as a result of developing alternatives for the accomplishment of the use and aesthetic functions'. The techniques of Value Engineering began to be adopted outside GE and eventually all around the globe, saving its benefactors billions in dollars.

Techniques

A product exists because it accomplishes a certain function or group of functions. The focus of all Value Analysis and Engineering is therefore on functions. Miles believed that quality compromises become necessary when simple, practical and low cost ways of accomplishing the functions the customer needs are not learnt, developed or specified. Thus, Value Engineering requires an organized creative approach that involves three basic steps:

Identifying the function which can usually be described in a two-word definition using an Active



Verb and A Measurable Noun like support handle, provide light, etc.

Evaluating the function by comparing it with other ingeniously created alternatives, which would accomplish the function.

Developing alternatives with the main focus on function and not merely on material, part or device.

Though VE employs some special techniques, it follows a step by step approach and has six phases for Value Study. These phases are:

Information Phase: where all the pertinent aspects of the project are thoroughly studied.

Function Analysis Phase: where all the individual elements are analyzed, the main elements that consume the highest cost are shortlisted and the total budget is calculated.

Creative Phase: where the alternative materials to be substituted are fixed into the conventional construction.

Evaluation Phase: where the ideas generated during the Creative Phase are screened and evaluated by a team.

Development Phase: where the best alternative is developed further through sketches, cost estimates, validation of test data and description of the process of implementation.

Presentation Phase: where the VE team presents their findings to the decision makers, and endeavors to convince them why their suggested alternatives should be implemented.

In all of this, there are Four Pillars that VE rests on:

Multi-Disciplinary Team
Step-by-Step Approach
wFunction Orientation
Creativity / Innovation

Value Engineering in Construction

Though VE was conceived for GE with products, the economic impact went beyond product design and manufacturing to construction and services. In fact the techniques when understood thoroughly and used properly could be a problem solver in any area. "Construction in the 1970s is a 100 billion dollar industry," wrote Miles, in his book ***Techniques of value analysis and engineering,*** "reducing the amount of unnecessary costs, i.e., costs that do not bring either use or aesthetic functions to the user, provides enormous opportunity for benefits to the architect, engineer, contractor, owner and society". Miles raised questions regarding the construction industry and said that it was bound by obsolete

SUMMARY OF PAST VALUE ENGINEERING SAVINGS **Federal Aid Highway Program**

	FY2003	FY2002	FY2001	FY2000
No of VE studies	344	377	377	388
Cost of VE studies Plus Administrative cost	8.5 Mill $	9.02 Mill $	7.29 Mill $	7.78 Mil $
Estimated Construction Cost of projects studied	19,241Mill $	20007 Mill $	18,882 Mill $	16,240 Mill $
Total No. Recommendations	2144	2344	2013	2017
Total value of Recommendations	3163 Mill $	3050 Mill $	2375 Mill $	3483 Mill $
No of approved Recommendations	914	969	1017	1057
Value of Approved Recommendations	1,016 Mill $	1043 Mill $	685 Mill $	1,128 Mill $
Return of Investment	120:1	116:1	119:1	145:1

FEDERAL DEPARTMENT OR AGENCY DOLLARS

Agency	VE Savings ($)
Defense Department	734,385,000
Department of transportation	686,373,874
General Service Administration	109,608,453
Army Corps of Engineers	59,554,000
Department of the interior	22,427,840
Department of Agriculture	8,764,155
Justice Department	5,990,387
Veterans Affairs	2,270,800
Health and Human Services	1,884,454
Agency for International Department	800,000
State Department	91,721
Total	1,632,150,694

SAVAD BY VALUE ENGINEERING FY 95

codes that had remained unchanged through 30 years despite enormously changed conditions. His observations are just as relevant today as they were when VE was introduced in 1947.

The flaws he identified were as follows:

Obsolete design details are repeated from job to job. This is especially true when the design is very old and is a problem we find in the Railway Industry because this is one of the oldest Industries.

Materials that bring no user functions (either use or aesthetic) are often used. This is not only in construction but in almost all manufacturing products. The reasons for this is poor value of the product because decision is based on old concepts.

New functional materials are not being used. No designer wants to put himself in personal loss. If, by any chance it fails because of any other reason, management will be interested to find a scapegoat.

Practices from the past are incorporated into the design, contracting and construction. This is the result of habitual thinking.

Most construction jobs involve three businesses: architects and engineers, contractors and owners. Each of these can, and very often work contrary to each other.

The construction sector, which embraces real estate, highways, bridges, dams, airports and many others, is an important component of the Indian economy. If the principles of Value Engineering are applied to these different sectors, it would certainly result in far more effective use of scarce resources. We have not missed the VE bus. The journey has just begun.

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Martyn Phillips

VE, risk management key to project development

'Value methodology' has been practiced for over 50 years, but has only recently started to be used in architectural, building and civil engineering projects. The benefits of the process include early and continued stakeholder consultation, team alignment and culture change, a managed risk approach, consideration of whole-life impacts and integrated service delivery. This is the first part of a three-part series.

Today, more than ever, there are many variables and viewpoints in any project, large or small. Often there are different stakeholder interpretations of what is required, time-scales, and standards. Value methodology provides a basic framework and a tool set that, when properly applied, addresses issues of potential misunderstanding and misalignment at the start of a project and, in many cases, results in significant reductions in the whole-life costs of the final project.

There are many definitions and interpretations of value-related approach. The term 'value and risk management' is used here to signify a holistic approach that is applied at specific stages throughout the life of a programme or project. Depending on project scale, complexity, and the stage of development, the techniques for addressing different aspects of any particular project may vary. It is implicit here that, through the proper use of this modified value methodology, economic assessment, risk and uncertainty are addressed appropriately. Application of the value and risk management approach 'fast tracks' a common understanding of all of the requirements through an analytical and consultative approach, thus deriving consensus on key recommendations.

The value and risk management approach is a natural companion to good programme and project management for complex or sensitive issue areas and for encouraging continuous improvement. It provides a vehicle for transforming the way organisations and individuals approach project planning and development. The methodology encompasses techniques to address the interrelated aspects of

- stakeholder issues and concerns
- stakeholder values
- project functionality
- operations and maintenance requirements
- costs and (capital and whole life)
- implementation schedules
- implementation obstacles
- potential project risks.

There are two contrasting applications.

Strategic choice—through strategic focusing, formulation of clear, unambiguous, strategic direction to enable approvals, funding and subsequent orientation of the development/implementation team. To build consensus on the way forward through complete gathering of the many and various stakeholder views, strategic focusing is, of necessity, an iterative process.

Value enhancement—through value engineering—continuing value improvement for finessing to optimum quality, functionality and cost parameters.

Need for project improvement

Construction projects have acquired a reputation for confrontation between the contracting parties and, in some cases, the public, resulting in

- major claims and over expenditure
- delays and service disruption
- poor overall value for money
- stakeholder discontent.

The causes of these problems can often be traced to misalignment of stakeholder expectations from the outset. The typical development of a project is shown in Fig. 1. It is clear that a project is developed over time, with input from a number of different parties. It is this multiplicity of inputs at different stages that leads to the problems identified above. To avoid such problems, there is a need for a routine, proactive methodology that will 'get it right, first time'. There must be absolute clarity of context, needs, objectives and communications.

Value methodology, as we know it today, evolved in the US in the late 1940s. Its roots lie in the manufacturing sector where it originated in General Electric and was known as 'value analysis'. In 1954, value methodology was introduced into the US Department of Defense, Bureau of Ships, in which the term 'value analysis' was changed to 'value engineering'. Value engineering spread to many US federal and local government agencies. It should be noted that value methodology is much more than a cost reduction technique.

Some related terms include:

- value analysis

value engineering
value management
value control
value improvement
value planning.

Value methodology is now used formally in several other countries throughout the world. These include Australia, Canada, France, Germany, China/Hong Kong, Hungary, India, Korea, Japan, New Zealand, Saudi Arabia, Taiwan, the United Kingdom and the United Arab Emirates. In Australia, Europe and Hong Kong particularly, the application of value methodology is known as value management.

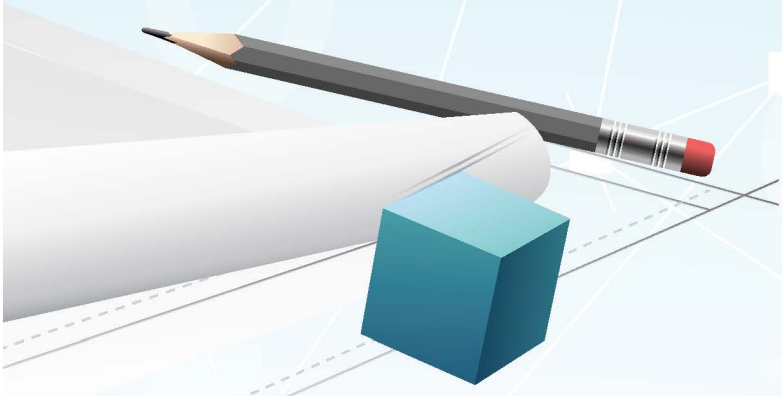
There is now a European/British Standard on Value Management, BS EN 12973: 2000 and an explanatory document, PD 6663: Guidelines to BS EN 12973, Value Management—Practical Guidance to its use and intent. The original and predominant value society is SAVE International (formerly the Society of American Value Engineers).

There is no universal agreement on the various terminologies which are often used interchangeably and at other times each term may have a vastly different focus for different people. Suffice it to say that the definitions tend to fall into two categories

'big picture', broad-based management thinking to evolve a project from the outset, i.e. strategic choice

Sharply focused, function-based, analytical thinking for improvement to serve a specific end-user purpose, i.e. value enhancement.

Value methodology is complementary to the process of project management and aids in cutting across bureaucratic boundaries and managing the 'grey areas'. It is being used more and more by 'learning organisations' throughout the world for concept identification and project development.



Perceptions of value and risk

Value is determined not by the producer or promoter, but in concert with the customer/user. Nor is value related solely to money, as value criteria may include, for example, aesthetics, ease of operation and maintenance, environmental friendliness, and provision for longer-term needs. Clients are really seeking to buy performance, not just traditionally practiced project development activities.

Good project performance includes satisfying a range of stakeholders who may have differing views, values and thresholds of tolerance for perceived risk. Fig. 2 illustrates a wide variety of stakeholders and aspects to be considered. The key to success is to provide a holistic framework, complete with a tool set, for addressing needs identification, conceptualization, development, implementation and optimization, while involving the appropriate stakeholders (and seeking to understand their values).

Risk and uncertainty are present in quite different forms for various levels of project authority and implementation personnel. Risk may be stated as any potentially detrimental occurrence to a project in terms of cost, schedule, safety, quality, reliability stakeholder disruption, and so on. At a higher level, risk may be related to, say, failure to protect public health or economic failure of a region. Fig. 3 illustrates some of the more generic project risks typically considered.

Through its logical process and multi-stakeholder representation, a value and risk management workshop is an ideal forum to identify and categorise project risks and uncertainties. Assessment of the risks may be made quantitatively, qualitatively or pragmatically. The synergy of the value and risk management team invariably leads to an innovative and practical risk management plan.

While neglect to identify a risk can be expensive, so can unnecessary allowance to avoid each and every possible may be foreseen. Further, once identified, risk may be examined creatively and turned into a scheduling or economic opportunity. A balanced approach is advocated when specifying methods to evaluate risks. In line with varying stakeholder values, the degree of risk accorded to a project party is dependent on the level of comfort for carrying that risk. Risk transfer is a common practice, but may incur significant unnecessary costs if not properly evaluated.

Martyn Phillip *Director, Team Focus Global Project Solutions, Canada*

Naveen Kumar

INVEST can show the way in VE

Indian Value Engineering Society (INVEST), a premier society devoted to advancing and promoting the Value Methodology, can serve the governments at the Centre and in the States through dissemination of specialised knowledge on VM/VE to professionals and executing special assignments through value practitioners, duly certified by SAVE International, writes Naveen Kumar.

Anyone visiting an Indian city or town would find a sea of humanity jostling to reach offices, homes, schools, colleges or diverse other destinations, all the time wishing "How can I get there faster, smarter, safer and happier?". What they actually talk about is the infrastructure that would take them to their destinations quickly and safely. The search is for quality, affordability, safety of travel.

Infrastructure is key driver of any economy. In 2018, India ranked 44th among 167 countries in World Bank's Logistics Performance Index (LPI). According to India Brand Equity Foundation (IBEF), the country needs an investment of $50 trillion ($778 million) by 2022 to lift itself from this low rank. Not surprisingly, the Government of India has already begun investing heavily in the sector.

In this context, one needs to look at challenges that the Indian infrastructure faces. Fortunately, these challenges are not exclusive to India. Similar challenges have been faced by other countries and some of the solutions can be adopted in India.

There are three key challenges before Indian infrastructure:

1. **Contract enforcement:** Critical contracts like Power Purchase Agreements (PPAs), road/airport/metro contracts need to be clinched to attract required capital.
2. **Ease of access to inputs at lower costs:** Inputs need to be available at appropriate prices for sustainable infrastructure development. This covers a wide swathe of issues from land acquisition to availability of construction material to design solutions to spectrum prices.
3. **Pricing:** Every infrastructure service should be rightly priced so that they justify the execution costs and user capabilities. Tolls on roads, electricity tariffs and airport user charges are often subsidised, which proves a drain in public money (read taxpayers' money).

A close look at these three challenges would reveal the inextricable linkages between 'Cost' and 'Price' and 'Sus-

tainable quality' and 'Value' as being two key aspects of a sustainable infrastructure development in India, as was the case years ago in many of the then developing and now developed countries. This is where the globally practiced Value Methodology (VM)/Value Engineering (VE) in its most basic, but extremely effective way, helps us address the fundamental issues of 'cost-quality-value'.

The use of Value Engineering as a decision-making tool lies at the core of investment strategies of both public and private sector organisations in many countries. In the USA, the government has a policy of providing incentives to encourage contractors to submit proposals that identify ways the government can save costs. All fixed-price construction contracts of over $100,000 outlay are to provide for VE. Participation by the construction contractor is normally voluntary. If the Government accepts a value engineering proposal, a construction contractor is entitled to a share of up to fifty-five per cent of the savings under his contract.

In the U.K., value engineering is a rule of thumb in all national and local public procurement actions. Value engineering is undertaken at the project identification stage for infrastructure projects. Thanks to the universal applicability of value methodology tools, the British Government has also mandated its adoption in other aspects of governance, including the determination of policies and standards. Potential savings from value engineering set as targets for each government department/agency and audited as part of an overall budgeting system of governance.

The Hong Kong Administration has issued a circular stating the requirements and guidelines for application of value methodology to its Public Works Programme (PWP). VM studies should be considered for every major project with cost exceeding $200 million. In Japan and South Korea as well, government policy was established to compel value engineering studies by implementing agencies prior to their procurement actions.

Benefits of value engineering

Value engineering studies have resulted in quantifiable benefits in the form of cost savings. For example:

- Value engineering studies conducted for projects included in the US Federal Highway Administration's Federal Aid Highway Program saved the agency an average of US$1.8 billion dollars a year – or between 5.4 and 10.1% of projects' estimated construction costs – between 2003 and 2007
- Value engineering change proposals—value engineering completed during the construction phase – submitted to the US State Departments of Transportation (DOTs) saved the DOTs US$61 million in 2002
- Value engineering studies conducted for the US Department of Defence resulted in savings of over US$25 billion between 1983 and 2002
- In the UK, savings from value methodology initiatives are pre-targeted and cast in performance contracts of government departments. In 2004, a total of £23 billion in VM savings were generated. This emboldened the government in 2007 to set a higher goal of not less than 3 per cent of all public service expenditures or an equivalent of £30 billion, to be created by year 2010-2011.
- In Japan, the Ministry of Land, Infrastructure and Transportation in 2003 found that a value engineering-type inspection of the designs of public work projects done prior to their construction could lead to a 10% cost savings. A localized 2005 value engineering study done on several road projects in the Oita Prefecture yielded an average savings of 31%
- In the South Korea toll-way project, a value engineering study revealed that the cost of the project could be reduced by as much as 50 per cent without compromising on the project's benefits and functionality.

Conclusion

Infrastructure is no longer a staid industry devoid of innovation. New technologies and ideas are flourishing. Integrating these innovations, which could change the way infrastructure is designed, developed and delivered, requires aligning stakeholders, implementing effective strategies and creating fertile enabling environments.

It is generally recognised that the public sector investment provides the bulk of infrastructure in developing countries. Public investment effectiveness and efficiency are not always assured, there should be a strong focus on managing the total project costs over the life of each project and this can be achieved through appropriate institutions and integrating value engineering into policies.

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Dr. N. Subramanian

How did Miami Pedestrian Bridge collapse?

On March 15, 2018, a pedestrian concrete truss bridge in Miami, Florida, USA collapsed during construction. The failure of this bridge caused several casualties and raised serious concerns about the design and construction of the bridge, in addition to the use of accelerated bridge construction (ABC) technique.

A partially constructed 53 m long, 862 tonne Florida International University (FIU) pedestrian bridge collapsed on March 15, 2018, at about 1:46 p.m. This bridge, crossing an eight-lane roadway in the city of Miami, in Miami-Dade County, Florida, fell from a height of about 5.64 m on to SW 8th Street (US Route 41), crushing eight vehicles, killing one bridge worker and five vehicle occupants. In addition, another employee was permanently disabled; four more bridge workers and five other people were also injured (see Fig.1).

The collapsed bridge was a single concrete truss spanning 53 m and placed over its piers just five days prior to the collapse. Work on the adjoining span of this truss over an adjacent canal (to make it a continuous bridge of span 88m after completion), access ramps, and faux cable-stay tower had not yet commenced (see Fig. 2). The concrete bridge was first cast at a nearby off-site location as per the Accelerated Bridge Construction (ABC) technique and then transported to its final location. ABC was chosen for this project as it provides minimal traffic disruption.

Structural details

As shown in Fig. 2, this two-span pedestrian bridge was designed by FIGG as a continuous, two-span single truss concrete bridge with a main span of 53 m (cast at an off-site location) and a back span of 29.26 m (to be cast in-situ), and scheduled to be constructed in 8 stages (Ayub, 2019). This bridge had 9.65 m wide bottom deck and a 4.88 m wide canopy. Architecturally, the structure was made to appear like a cable stayed bridge with a central pylon.

The cross section of this single plane central, open truss, comprised of narrower top chord that served as a canopy over the wider bottom chord, which was considered as the walkway (see Figs. 3 and 4). The height between the deck and the canopy was 4.55 m. The overall height was 5.49 m. The pylon was 33.22 m tall with inclined steel pipes connected to the top nodal points of the truss canopies of the main and back spans. The connection points were located in a concrete pad called blisters. The use of concrete trusses in bridges is rather uncommon because it requires pre-stressing of truss members carrying tension, as concrete is weak in tension.

The concrete deck had two-way post-tensioning tendons. The concrete truss members including the canopy were pre-stressed with high-strength steel cable and bars. The construction of the entire bridge was scheduled to be finished by early 2019. Hence to reduce the time, it was built using the Accelerated Bridge Construction (ABC) technique. The main span bridge superstructure, including deck and canopy, were precast near the actual site, but in a direction perpendicular to the axis of the bridge.

Fig.1 Collapsed FIU-Sweetwater University City pedestrian bridge

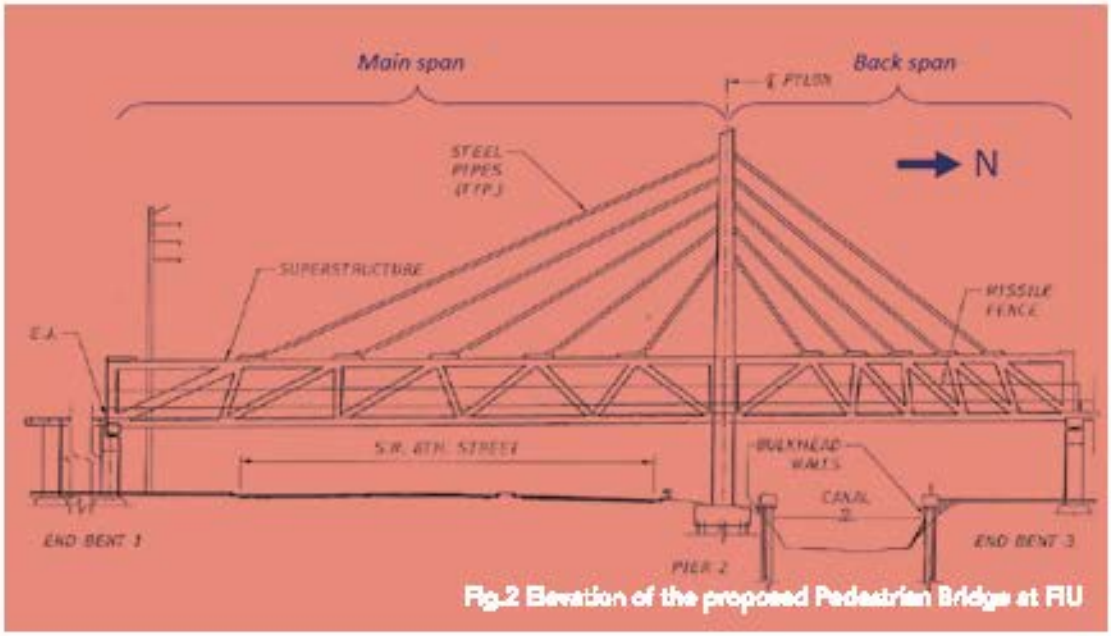

Fig.2 Elevation of the proposed Pedestrian Bridge at FIU

During construction, the concrete deck, trusses, and canopy were cast separately and in a sequence, i.e., the deck and diaphragm concrete were cast first, then the truss and the canopy. Because the concrete batches were cast at different times, construction joints or cold joints were left at the interface between the truss members and the slabs. Finally the blisters over the canopy were concreted to provide connection to the future sloping steel pipes.

After all the PT tendons (12 longitudinal strands and 65 transverse tendons in the deck and four in the canopy) and PT bars in the diagonals were post-tensioned, the main span was moved to the final location. It was transported, rotated by 90o, and placed on the bridge piers by two transporters on March 10, 2018 (see Figs 3 and 4). On March 15, 2018, 5 days after the relocation, the main span of the bridge collapsed onto US Route 41.

Diaphragm II experienced a blow-out of concrete at the junction of diagonal 11 and column 12 creating a hole. As a result, column 12 lost support over the pylon and failed with the top tilting approximately 80 degrees towards the south, as shown in Fig.1 (see also Fig. 5). The base of column 12 shifted a few feet towards the north but remained on the top of the pylon. The collapse of the canopy, diagonal 11 and the deck soon followed.

Probable causes

After the bridge collapsed, the Federal Highway Administration (FHWA) collaborated with the NTSB to test and evaluate the construction materials collected from the collapse site, including

Fig. 3 Main span of the Pedestrian Bridge at FIU before, during, and after transportation

samples of concrete, steel bars, and one of the post-tensioning rods. NTSB identified that a combination of the following factors caused the bridge to collapse: design errors, inadequate peer review of the bridge design, poor engineering judgment, and response to the cracking that occurred in the joint region which led to eventual failure, and lack of redundancy in the bridge design. NTSB concluded that the failure of the nodal region of truss members 11 and 12 triggered the bridge to collapse.

These investigations resulted in several findings including the following (see NTSB, 2019):

Concrete and steel materials used in the construction of the bridge were not defective and the hydraulic jack used to post-tension the steel rods in member 11 was operating as expected at the time of the collapse. The samples of concrete taken for testing showed satisfactory strength at or above 58.6 MPa.

FIGG Bridge Engineers (FIGG) and the Engineer of Record (EOR), failed to recognize that the bridge was in danger of collapsing when they inspected it hours before the collapse. The concrete truss had developed numerous wide and deep structural cracks jeopardizing the integrity of the bridge. The EOR did not issue instructions for shoring the bridge at appropriate locations and closure of the SW 8th Street. At the time of collapse, the post-tensioning bars were being re-tensioned at the specific instructions of the EOR.

The bridge had structural design deficiencies that contributed to the collapse during construction stage III. FIGG Bridge Engineers made significant design errors in the determination of loads, leading to a severe underestimation of the demands placed on critical portions of the pedestrian bridge; and significantly overestimated the capacity of the member 1/2 and 11/12 in the nodal regions. The cracks on the bridge occurred due to deficient structural design. FIGG Bridge Engineers should have considered all critical construction stages when designing the bridge and correctly determined the governing interface shear demands. But according to FIGG Bridge Engineers Inc., the construction joint between the deck and truss members 11/12 was not roughened by the contractors as required by standard construction specifications and hence is the main cause of failure.

M/s Louis Berger was not qualified by the Florida Department of Transportation to conduct an independent peer review and failed to perform an adequate review of the FIGG Bridge Engineer's design. M/s Louis Berger were of the opinion that they were contracted to do the final check only and not the design check at intermediate stages.

Despite the admissions and the knowledge that the cracks were growing in size, EOR stated more than once that the cracks did not present any safety concern.

The evaluation of the cracks by EOR, and his recommendation to re-tension the post-tensioning bars of diagonal 11, were not included in the original design and therefore should have been subjected to peer review.

The member 11/12 nodal region contained non-structural voids (four hollow vertical pipe sleeves and the horizontal drain pipe) within the

concrete and this might have resulted in overstress and the subsequent collapse of the main span.

Cao et al., 2020 considered four important construction stages (pre-stressing, transportation, relocation, and re-tensioning) in their computer re-analysis of the bridge and found that the horizontal component of the re-tensioning force overcame the resistance of the joint and caused it to slide with respect to the deck. As the sliding progressed, dowel action between the deck and joint became fully mobilized, crushing and damaging concrete locally within the joint and the deck. This damage (of the cold joint, adjacent joint and deck concrete) produced more sliding leading to the ultimate collapse of the entire bridge.

Conclusions

The collapse of the Florida International University (FIU) pedestrian bridge on March 15, 2018, which claimed six lives and injured 10 people, could have been avoided. The failure is attributed mainly due to errors of the designer, who failed to consider the loading and conditions of the truss bridge during the construction stage III, which resulted in simply supported condition, instead of the final continuous bridge. Moreover, the contractor did not roughen the cold joint as specified in standards, thus reducing the shear-friction capacity of the joint. In addition, though several cracks were found during construction and erection, which kept on increasing in size, all the people involved in the project neglected them and considered that they were not catastrophic.

This article is based on the report of the U.S Department of Labor (Ayub, 2019) and the illustrations used in this paper are from the references cited. ●

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Mitya Moitra

Plan well, reduce risk with Data Analytics

Digitisation is playing a major role in all sectors including construction. Data Analytics can help improve asset investment planning, reduce project life-cycle cost, optimise budget planning and reduce risk

December 5, 1990: A loud noise that sounded like a gunshot. And within seconds, the Magnolia bridge on the west coast of America "folded like a deck of cards," pushing 64 persons and 32 vehicles into the river, killing 46.

How did it happen? What led to this tragedy? Naturally, the party in power faced mudslinging for approving the construction of a bridge that had significantly higher composition of sand than cement. This incident happened at a time when digitization was unheard of, and construction decisions were not backed by data.

But now, almost three decades later, when the world is going through a digital disruption, Arcadis has done a case study on the Magnolia bridge. And it has successfully designed an analytics strategy to maintain built assets like bridges, pavements, highways, buildings.

So, what are the key areas that construction companies need to consider? To allay fear of any mishap that arise because of engineering failures resulting in loss of time, material, labour and in some cases, loss of life? Let's have a look!

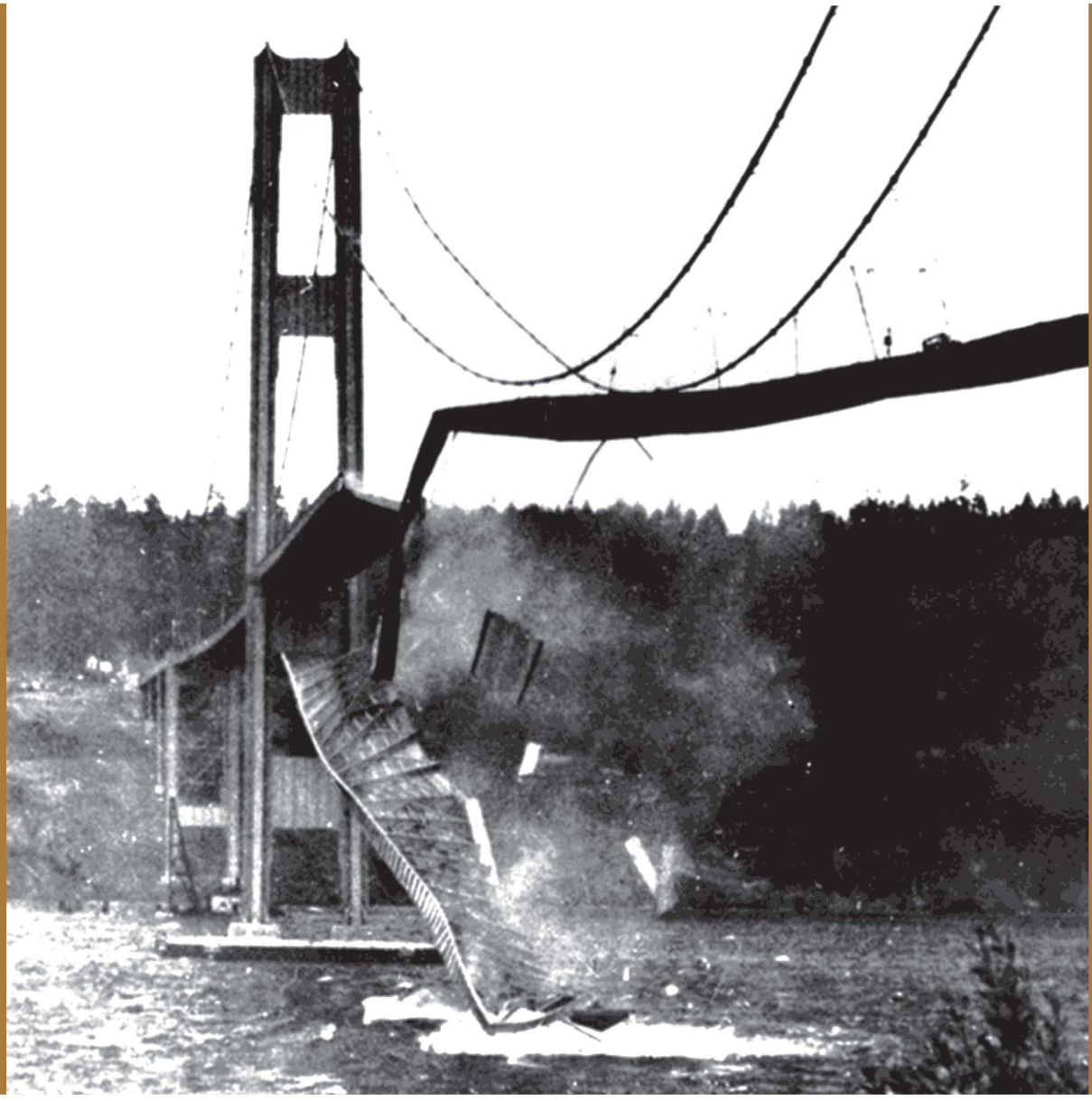
What are the types of assets?

The adage "The whole is greater than the sum of its parts," is true in the case of asset types, i.e. The Sum of the Parts is Greater than the Whole. The design of Magnolia bridge treated it as one asset. However, this approach discounted the fact that different parts of the asset are made for different purposes and should not be treated in the same way.

Bridges, for example, are at a different hierarchy, level of complexity and size as compared to its components which comprise various types of stones, iron, steel parts. These parts have different dimensions, malleability, tenacity and effectively serve a specific purpose for the whole asset type.

What is asset health?

Assessment of asset health requires us to look at an asset with a holistic view rather than tracking a



few metrics which might be direct pain points from an operational side of things. These measures can be grouped into:

Asset data: This would subset into attributes including age of the asset, material composition and warranty period. The age and remaining asset life are key metrics to help us understand percentage investment in asset maintenance and effective cost deterioration.

Operations data: This alludes to sensors, temperature and energy consumption data which is valuable to calibrate metrics and ensure that they are below the threshold levels. For example, in the case of bridges near water pipes, this data is critical to keep in check emergency situations like pipe bursts.

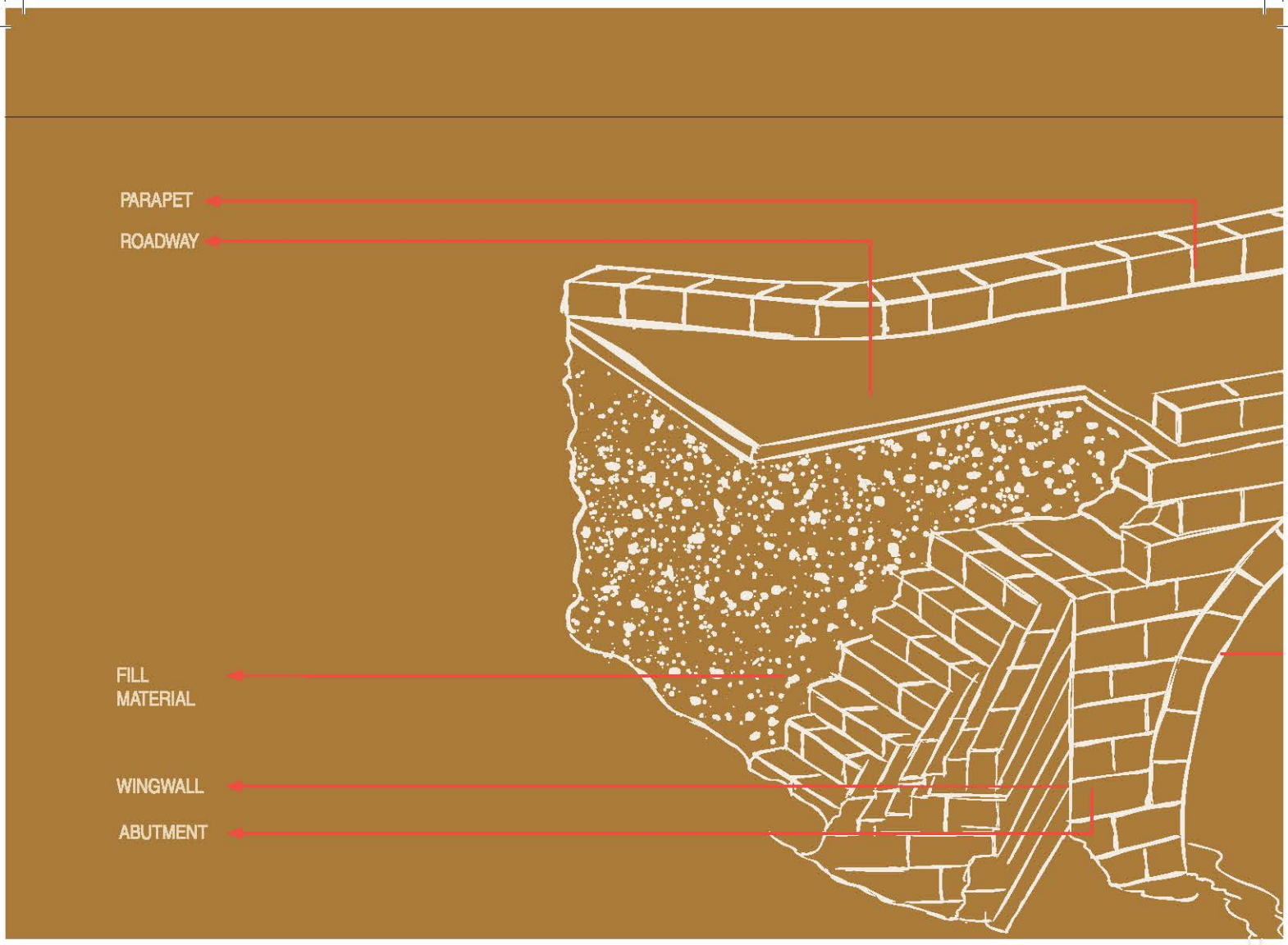
Interactions data: Data should span structured as well as unstructured fields in order to accurately track sentiment. Such data attributes include maintenance and failure logs, which will be useful to analyse key words and text fields for asset data that will help us understand the definition of failure of an asset. This is crucial to catapult maintenance efforts in the right direction.

Environment data: This will pull in weather as well as location data which will determine the maintenance strategy by region. Different geographies require different types of maintenance efforts due to change in temperature, soil composition and altitude.

The Magnolia bridge design lacked a 360-degree view of data and was a product of the gut feeling of engineers and over-confident project managers who were trying to meet unrealistic timelines to win a tender for another bridge construction project.

A spatial view of objects

Everything is interconnected. Construction of assets should be in congruence with the purpose of why they exist.



The west coast at the time of the Magnolia bridge mishap was a product of uneven spatial development. Construction in the financial hubs was not matched by adequate housing and infrastructure provision, especially transport.

Investment in housing infrastructure should be on a high priority to accommodate an ever-increasing population, as well as an influx of people due to urban life and job creation with increase in employment rates. Main bridges and other major structures should be built at an optimum distance from town centres and supermarkets to channelize transport.

Using resilience stress testing measures, the government also needs to ensure that systems can cope with threats, especially those intensified by the increased interdependence of infrastructure systems.

What type of problems occur in asset maintenance?

The type of maintenance applicable to an asset type ranges from reactive, proactive, predictive and preventative. This results in job types that are suitable for work needed for the asset, e.g. inspection, cleaning, rewiring, repainting, repairing, replacing, etc.

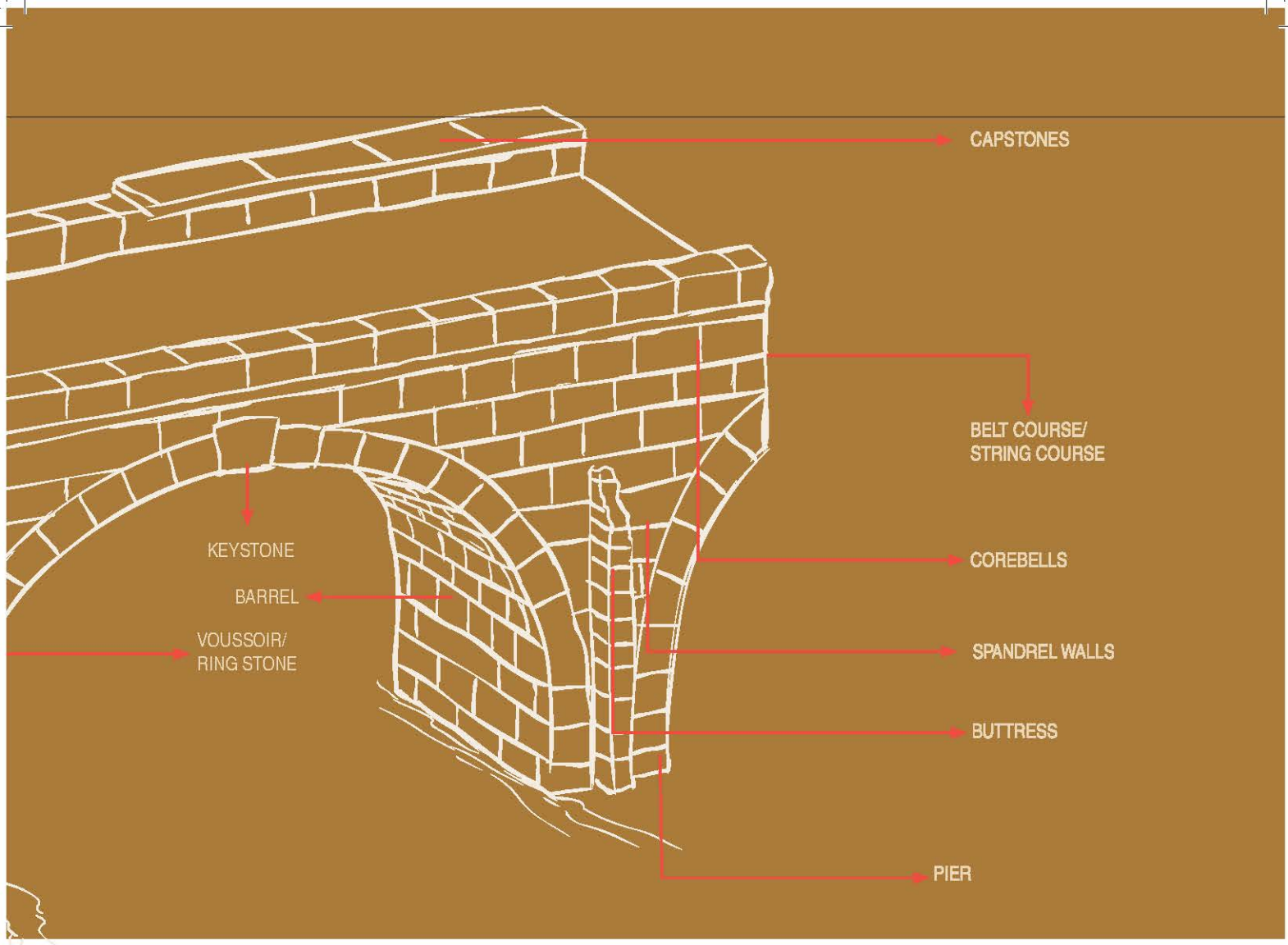
Sometimes the replacement or refurbishment cost is too expensive to be afforded with the budget, in which case the company will need to go in for the next best cost-cutting option.

Mitigating risk

Asset risk is measured against probability of failure (PoF) and consequence of failure (CoF), risk being the product of the two. Having a high PoF is not necessarily a big problem if the CoF is small. Also, run-to-failure is a valid asset maintenance approach for low CoF components. In order to mitigate risk, we want to reduce either the PoF or CoFto optimise investment.

How to deal with failure?

Failure might occur on one asset type, but its effect is triple. The nature of materials used in bridge construction changes over time. This can take us to the zone of 'known unknowns', where there is at least an awareness of metrics that could



change, and 'unknown unknown' which can amplify the effect of failure. It is important to ask specific questions such as:

What is the useful life at which the asset type exceeds 80% PoF?

What is the minimum number of repairs needed until the condition of the asset degrades?

Asset investment planning

We should look at different investment scenarios in order to optimize costs and minimize risk.

If money were unlimited, there would be nothing to optimise. Optimisation only becomes important because in the real world we have finite resources and other constraints that prevent us from always doing the 'best' thing.

Engineers focus on very specific issues and what the best solution would be for that specific component on that specific bridge and 'miss the wood for the trees.' By delivering a cheaper but good enough intervention, more work can be delivered which might enable a better overall outcome across all assets.

Data Analytics

"Progress is impossible without change, and those who cannot change their minds cannot change anything".

Bridges have collapsed. It can happen in the future too, but the same mistakes should not be repeated. If an asset is about to fail, we need to provide warnings of failure 30 hours before they occur rather than before 30 minutes.

Data Analytics is leading the way to improve asset investment planning, reducing project life-cycle costs of built assets and estimating the best way to optimise budget planning and risk maintenance.

The construction industry is a laggard vis-à-vis digitization, though education and healthcare are in a similar category. These industries too can capitalise on the proliferation of data and add value to mankind with breakthrough research work and case-studies which can be implemented and productionised.

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Cement that bends

Work wonders with Engineered Cementitious Composite

The fast growing construction industry requires new materials that can keep up with the pace with new trends in construction. Engineering cementitious composite is one such material that has superior properties than conventional concrete. Read more to know more.

Concrete, being one of the most popular artificial materials on earth, needs no introduction. It is composed of coarse aggregate bonded together with fluid cement which hardens over time. The constituents of conventional concrete are cement, coarse aggregates, fine aggregates, and water.

Concrete has a number of advantages: its ability to take large compressive forces, its long life and relatively lesser cost of maintenance add to the economic benefits. Concrete is economical if the ingredients are readily available. Other advantages are it can be moulded into any shape and has strong fire safety features.

Like every other material, concrete too has disadvantages, one of which being its disability to take tensile strength. It has low ductility, low strength to weight ratio and is susceptible to cracking. Though concrete has been in use in spite of these disadvantages, the lack of bendability became a pushing factor in developing new types of concrete. One such concrete is Engineered Cementitious Composite (ECC).

What is ECC?

Engineered cementitious composite (ECC) is also known as bendable concrete. The constituents of bendable concrete are cement, fine aggregate, water and specially selected short random fibers, usually polymer fibers. Unlike regular concrete, ECC has a strain capacity in the range of 3–7%, compared to 0.01% for ordinary Portland cement (OPC) concrete. ECC therefore acts more like a ductile metal than a brittle glass (as does OPC concrete).This concrete thus erases one of the major disadvantages of conventional concrete, i.e., low ductility.

Engineered Cementitious Composites (ECC) has been under development at the University of Michigan's (U-M) Advanced Civil Engineering Materials Research Laboratory (ACE MRL) since 1992. ECC was invented by Dr. Victor C. Li, director of

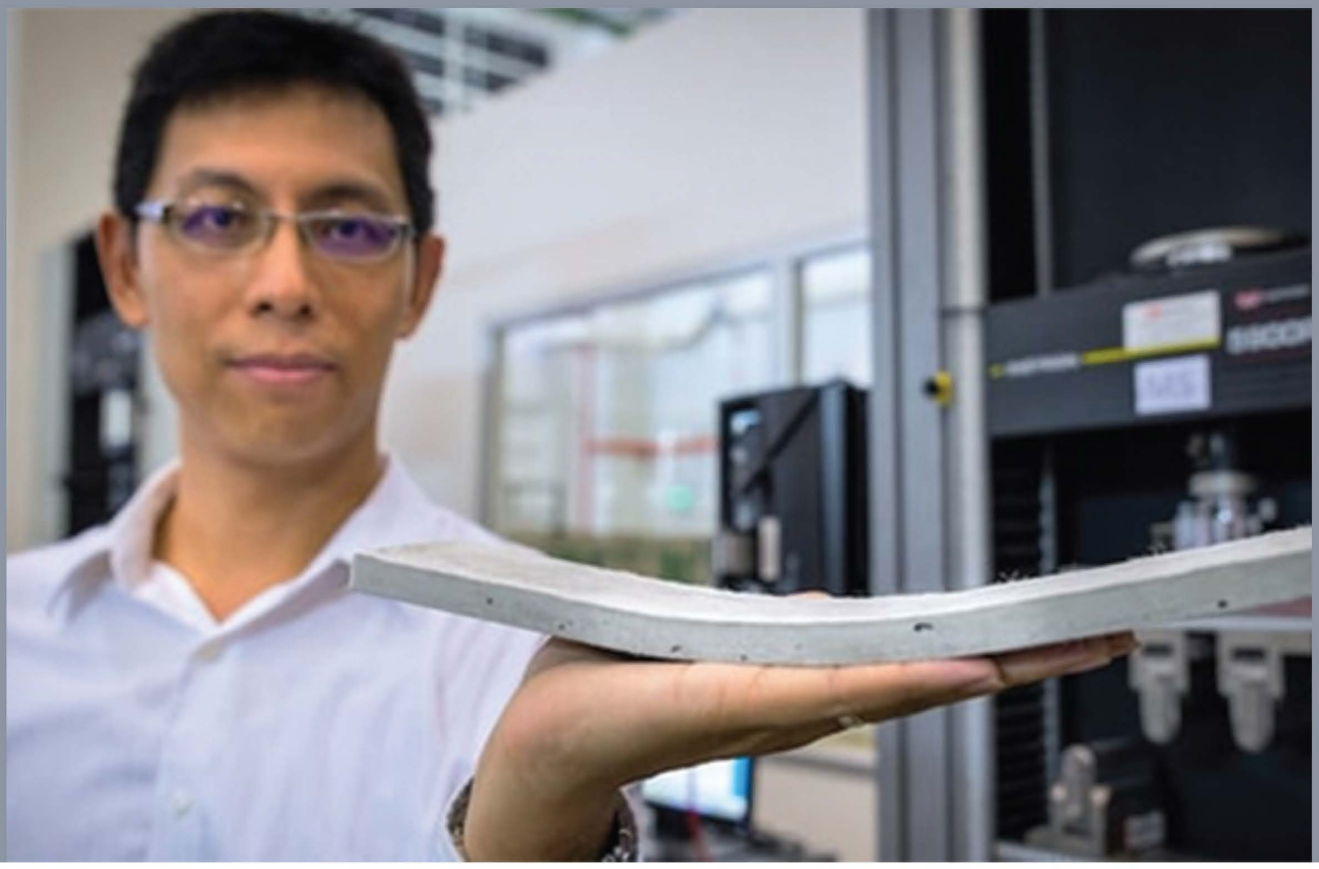


Figure 1:Bendable concrete

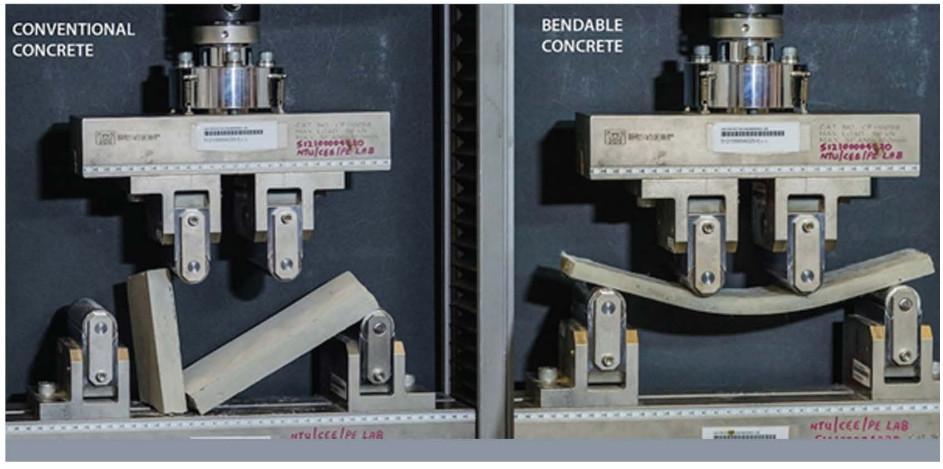


Figure 2:Bendable concrete

ACE. The material constituent of ECC is similar to that of fiber reinforced concrete (FRC), i.e., water, cement, sand, fiber, and some common chemical additives. ECC is prepared by applying principles of microstructure tailoring to precisely control the interaction between the different materials that make up ECC.

Microstructure tailoring is the process of predicting the properties and characteristics of combinations of materials based on known properties of the individual materials before combining them. ECC is thus a carefully engi-

neered system. Every component is specifically designed to work with the others to achieve desired performance characteristics. ECC exhibits higher performance characteristics in terms of flexibility, fatigue resistance, very low fluid permeability, and compressive strength similar to that of high strength concrete.

Bendable concrete belongs to the group of HPFRC (High Performance Fiber Reinforced Cement Composite) because of the very high plasticity of the material. ECC has a strain capacity in the range of 3–7%, compared to 0.01% for Ordinary Portland Cement (OPC) concrete. Hence it acts more like a ductile metal than a brittle glass (as does OPC concrete). Tensile properties superior to other fiber reinforced composites, ease of processing when compared to the conventional cement, the use of only a small volume fraction of fibers (~ 2%), tight crack width, and a lack of anisotropically weak planes, makes ECC unique.

These properties are largely due to the interaction between the fibers and cementing matrix, which can be custom-tailored through micromechanics design. The fibers in ECC create many microcracks with a very specific width, rather than a few very large cracks (as in conventional concrete.) This allows ECC to deform without catastrophic failure.

Due to the microcracking behaviour, ECC

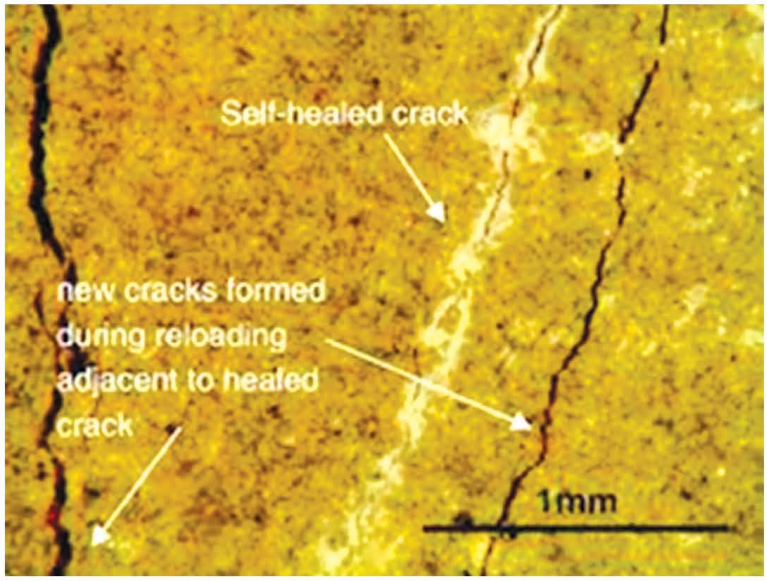
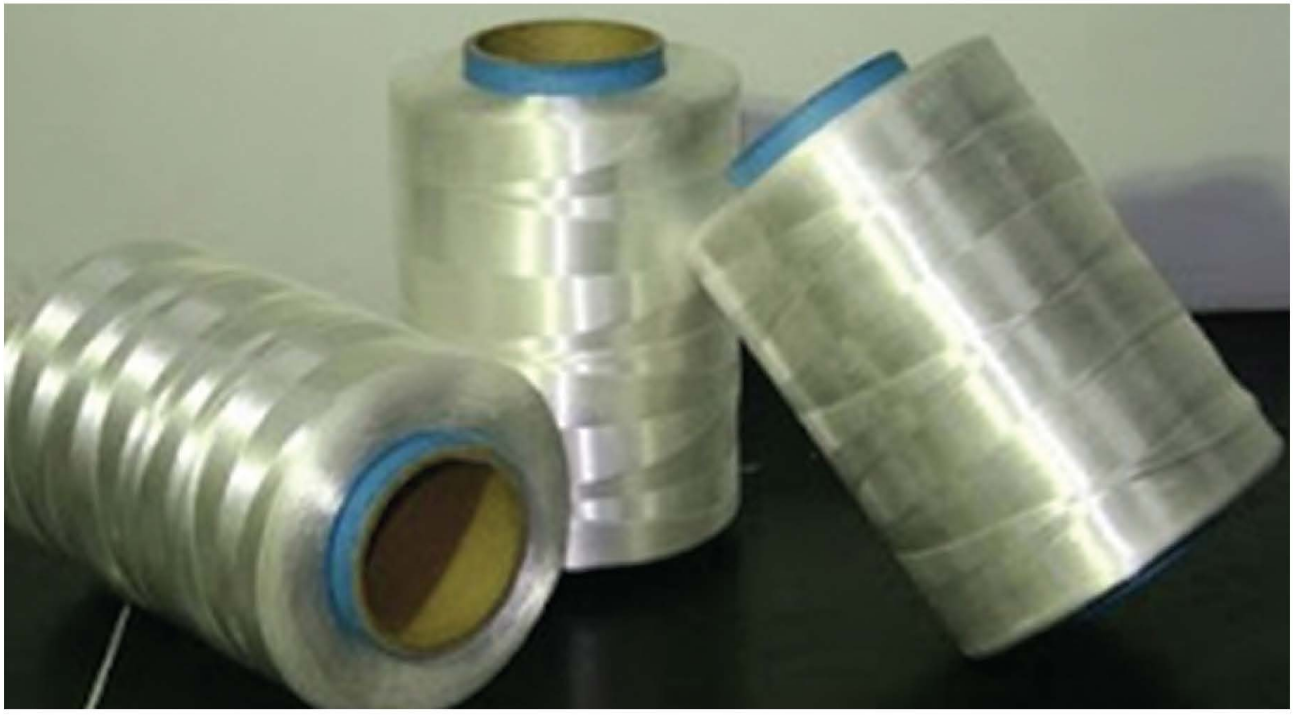


Figure 3: Self healing of cracks

Figure 4: polyethylene fibre

exhibits superior corrosion resistance and self-healing. The corrosion resistance is exhibited because the cracks developed in ECC are so small that the aggressive medium cannot penetrate and attack the reinforcing steel. On coming in contact with water the exposed unreacted cement particles in the cracks hydrate to form products that expand and fill the cracks thereby preventing transport of fluids and regaining the mechanical properties.

These products appear as a white 'scar' material filling in the crack. Though this phe-



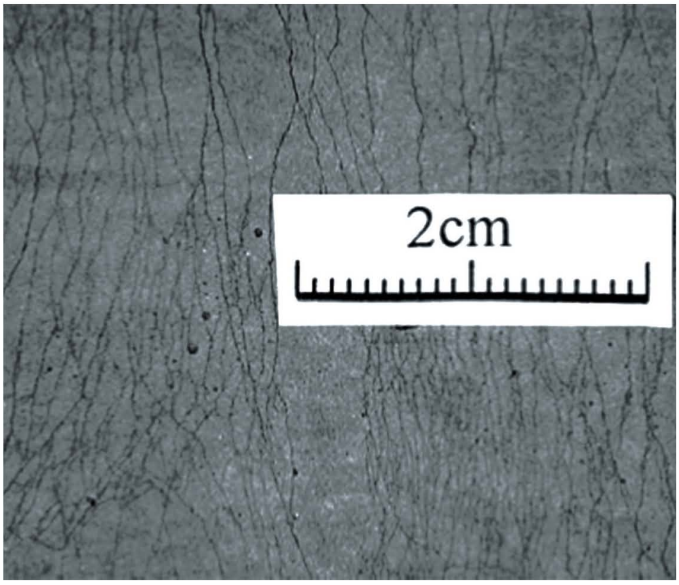


Figure 5 : Micro cracks developed in ecc

Figure 6 : polyvinyl alcohol fiber

nomenon has been observed in a variety of conventional cement and concretes; however, above a certain crack width self-healing becomes less effective. It is the tightly controlled crack widths seen in ECC that ensure all cracks thoroughly heal when exposed to the natural environment.

Preparation of ECC

In terms of material constituents, ECC utilizes similar ingredients as fiber reinforced Concrete (FRC). It contains water, cement, sand, fiber, and some common chemical additives. Coarse aggregates are not used as they tend to adversely affect the unique ductile behavior of the composite. ECC is made from CEM I 42,5R Portland cement, siliceous fly ash, quartz sand, water, super plasticizer and fibrous reinforcement in the form of short polyvinyl alcohol (PVA) fibres. The particle size (diameter) of composite components does not exceed 200 μm: 1–100 μm (cement), 1-45 μm (fly ash), up to 200 μm (sand).

An example of the proportion of the components (by mass) is as follows: cement: fly ash: sand: water = 1:1.2:0.8:0.55. Super plasticizer is used in the amount of about 3% of the weight of the cement. PVA (Polyvinyl alcohol) fibres with a length of 12 mm and diameter of 39 μm are added in the amount of 2% by volume (26 kg/m3). A typical composition employs w/c ratio and sand/cement ratio of 0.5 or lower. A very high amount of fly ash, whose particles are smaller than cement grains, provides the uniformity of the cement matrix. The addition of fibres increases ductility (plasticity) of the composite.

ECC can be prepared in ready-mix plants and transported to construction sites using conventional ready-mix trucks because of the relatively small amount of fibers, and its chopped nature. The mixing process of ECC is the same as that followed in normal concrete. As the mix has self – consolidating characteristics, it need not be vibrated while placing. The moderately low fiber content has also made shotcreting ECC viable. Also, the most expensive component of the composite, fibers, is minimized resulting in ECC that is more acceptable to the highly cost sensitive construction industry.

Engineered cementitious composite is a mortar based composite that belongs to the high performance fibre reinforced composite category. It exhibits better properties in terms of strain capacity, crack resistance, durability, and damage tolerance when compared to conventional concrete. The cost of ECC is currently three times that of normal concrete per cubic yard.

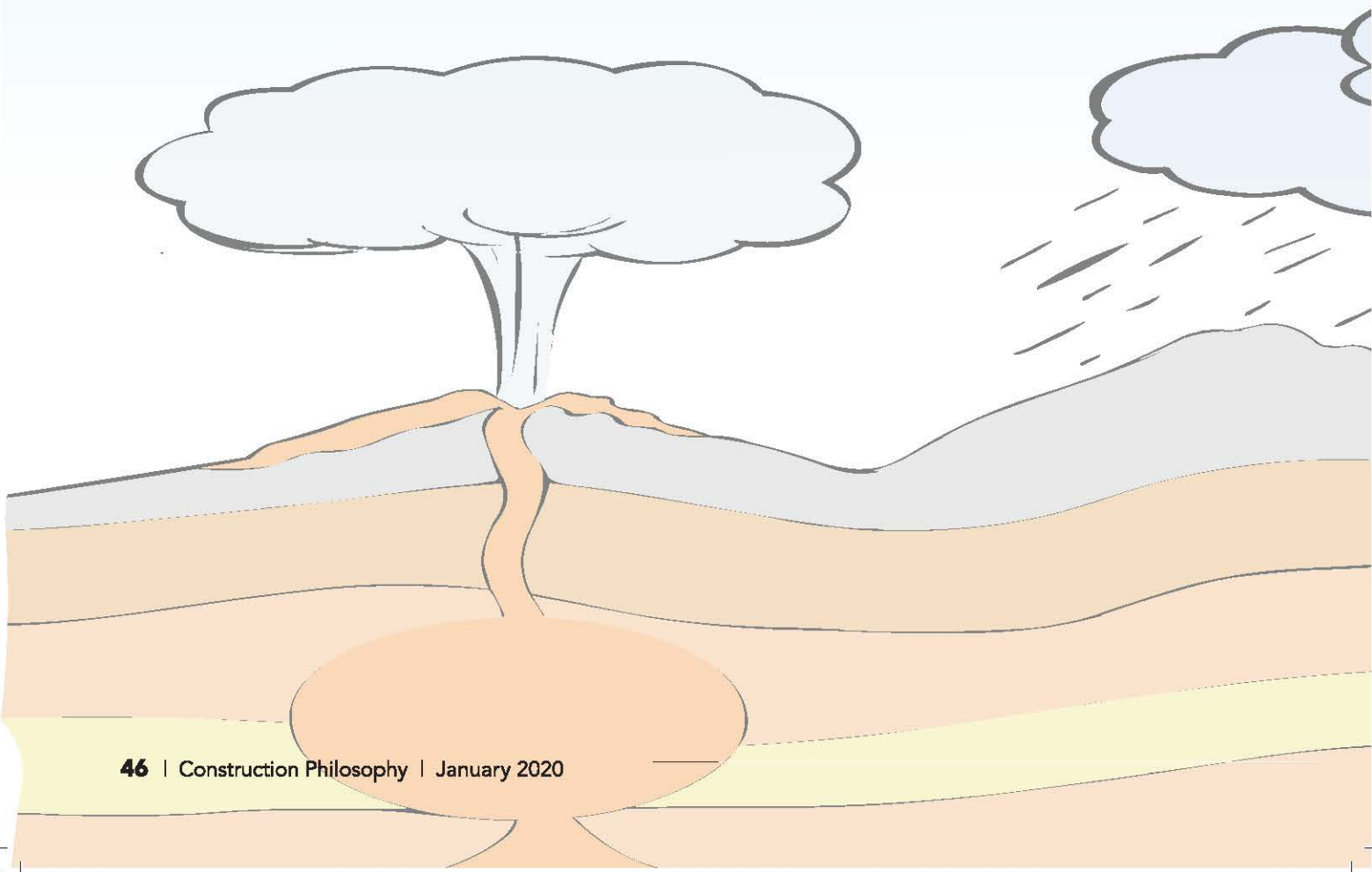
However initial construction cost savings can be achieved when ECC is used, through smaller structural member size, reduced or eliminated steel reinforcement, faster construction offered by the unique fresh and hardened properties of ECC. Engineered cementitious composites are designed to produce a strong and flexible material that can be used in numerous applications where fiber reinforced concrete may not be suitable.

A. Verghese Chummar

Rock formations

Critical for geotechnical design

Good knowledge about the different rocks and their characteristics is necessary for any foundation design. The conventional technique of following shear and settlement is not enough.



Foundation designs are often made by considering only the shear and settlement characteristics of the soil or rock foundation beneath. However, the behaviour of the rock formation is very much influenced by how the layer was formed, whether it is in-situ disintegrated, sedimentary, metamorphic or deposited. Here is a brief look at different types of rocks and how they are formed.

Igneous rock

Igneous rock is the mother of all rocks and soil from which all other types of rocks and soil are derived. Igneous rock is formed when hot, molten rock originating deep within the earth, near active plate boundaries or hot spots, rises towards the surface and crystalizes.

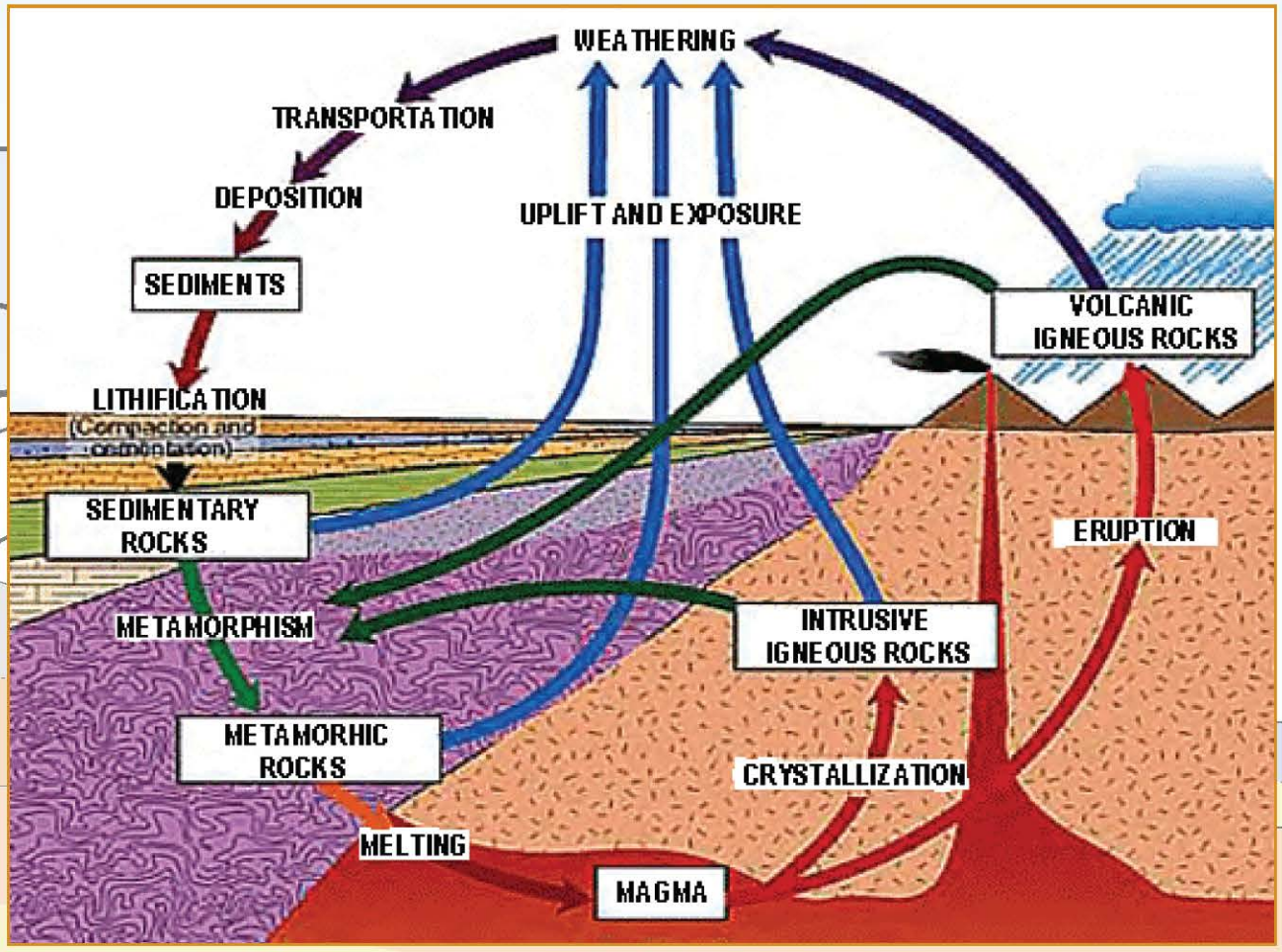
If the molten rock flows close to the earth surface, it solidifies almost instantly upon exposure to the relatively cool temperature of the atmosphere. This quick cooling results in smaller grained mineral crystals that don't have much time to grow. Basalt is an example of this kind of extrusive formation.

Sometimes the molten lava gets trapped deep inside the earth where it cools very slowly over many thousands or millions of years to form intrusive rock. When the individual mineral grains have a very long time to grow, they attain a relatively large size and the result is an intrusive rock like granite that has a coarse grained texture.

Disintegrated rock

Under conditions of high temperature and heavy rainfall with alternate wet and dry periods like in India and other tropics, soil leaches out, changing the texture of the igneous rock and leaving only oxides of iron and aluminum. Such disintegrated rock with high ferrous content is laterite. Those with alumina content will have the characteristic greyish white colour.

Laterite is widespread in India (10% of the total geographical area) and is a great source of building material as it can be easily cut with a



spade but hardens like iron when exposed to air.

Sedimentary rock

Sedimentary rocks are created when pieces of rock loosens up through weathering and are transported from their place of formation by means of water or wind and deposited in a basin or depression, usually lakes and oceans, where sediments get accumulated. Sedimentary rocks are differentiated based on the size of their grains, the smallest grains being clay, then silt and, lastly, sand.

After transportation and deposition, external or internal chemicals are needed for the loose rock to get consolidated into sedimentary rocks. The action of external chemicals makes it exogenetic formation while internal chemical action makes it endogenetic. Sand stones are exogenetic while limestone and dolomite are endogenetic.

Metamorphic rock

These rocks were originally either igneous or sedimentary. These have been altered by pressure, heat or infiltration of other hot chemicals so that the original characteristics of the rocks are changed. These rocks are resistant to weathering. Slate, gneiss, marble and schist are metamorphic rocks.

Deposited soil

The sedimentary rocks carried away by water and wind deposited without any chemical intrusion or pressure becomes soil. Depending on the depositing method they become either very fine-grained as in clay; less fine as in silt and sand; and larger grains called gravel. A combination of any of these could be silty clay, clayey silt and so on.

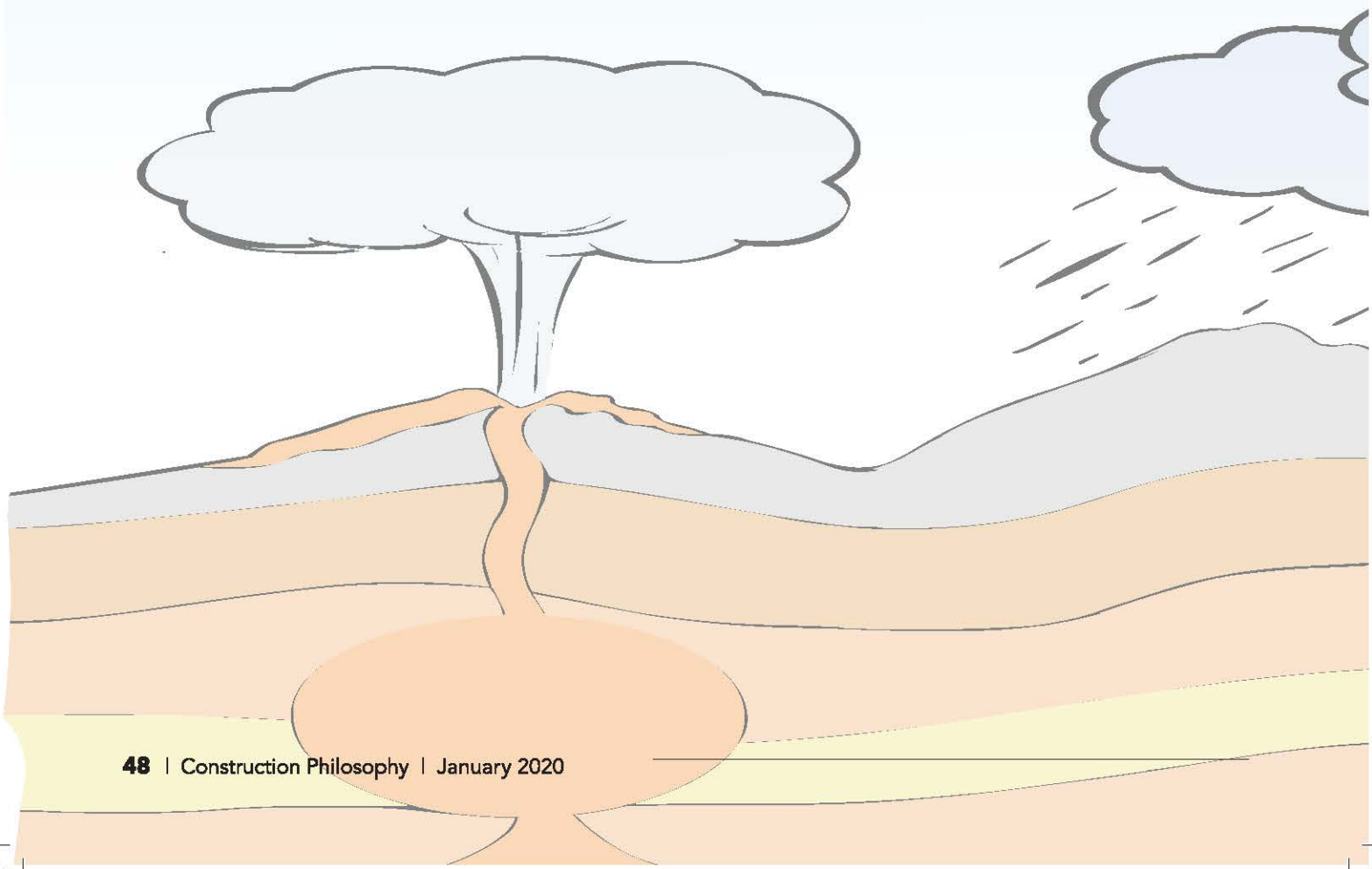
Behaviour of different formations

a. Igneous Rocks

These having been originally formed in-situ, are very strong with sufficient, multiple layers for transferring load, so there is hardly any settlement. The weakness, however, in these rock formations are the crevices. Many a time, these crevices are vertical or near vertical. Extreme care has to be taken to observe the behaviour of these crevices.

If lateral confinement is present, the movement under loading will be limited. However, in its absence, stabilization of the crevices can be achieved by grouting. A maximum load carrying capacity of 10 kg per sq. cm can be achieved with this type of rock formation.

If the crevices are in the horizontal direction, it can take much higher load intensity, even up to



20 kg per sq. cm, with small degree of settlement. Igneous rocks without any crevices can take a load which is more than the crushing strength of even concrete.

b. Sedimentary rocks

These being disintegrated in-situ, will not undergo much settlement under loading. Even if there is any small settlement, it will be elastic. The problem with these formations, however, is the washing out of the binding material by the flow of water. If the binding material is washed out, the grains become free and the strength reduces drastically. This usually occurs during dewatering, when water is pumped out from foundation pits by upward flow of water, or when rain water flows over the cut surface. After ensuring that proper precautions are taken, these layers can be loaded between 5 and 7.5 kg per sq. cm depending on the disintegration. Vertical cuts could also be given during excavation to prevent water from flowing over the open cut surface.

c. Metamorphic rocks

A proper analysis has to be made in foundation design for metamorphic rocks. Since it is resistant to both the action of water and weathering, a well-formed metamorphic rock can be loaded up to 10 kg per sq. cm.

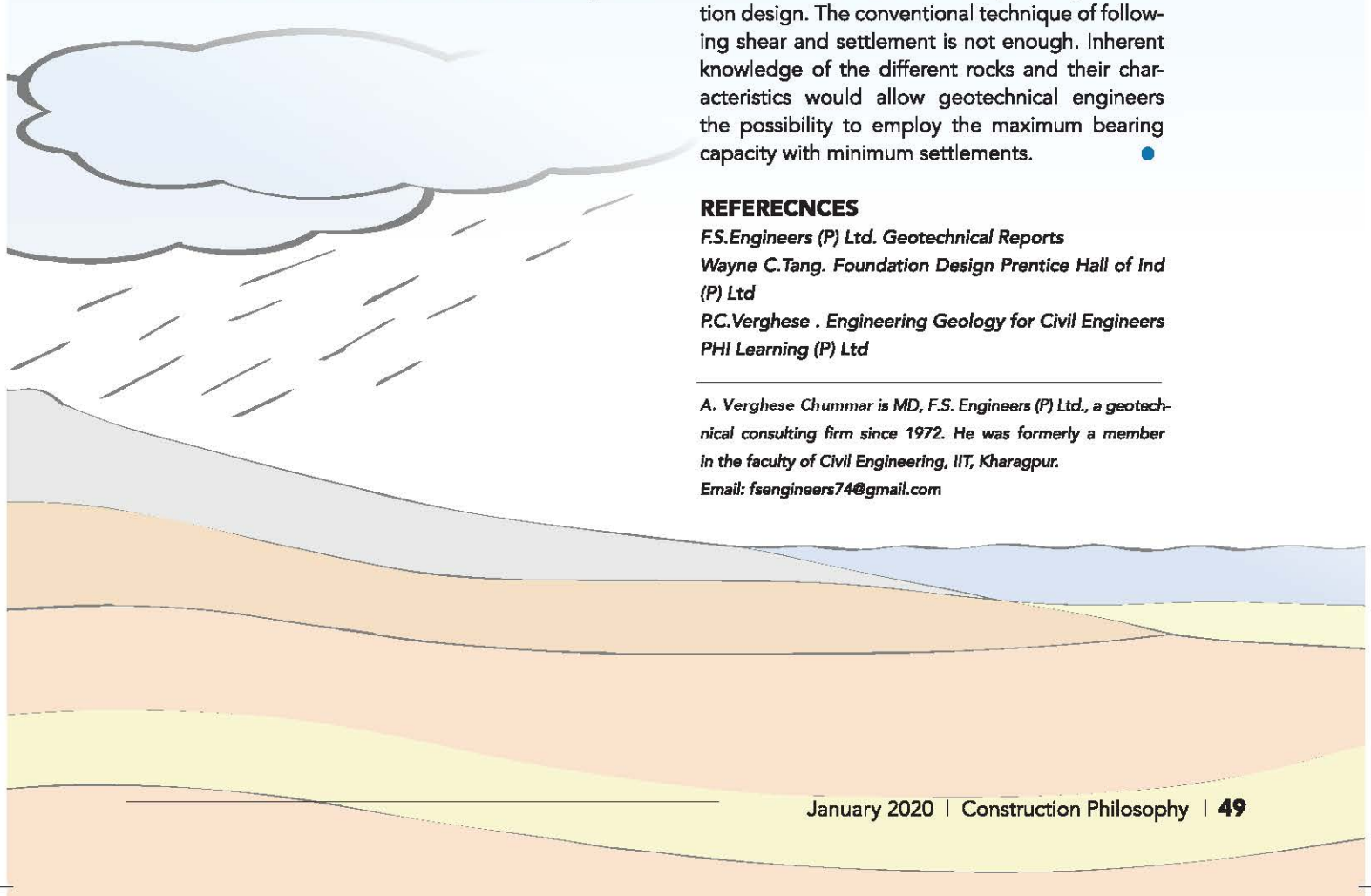
d. Deposited soil

Clay deposits, fine silt and sand requires a detailed study. Clay has the propensity for settlement due to the process of consolidation. Settlement due to consolidation is a time-bound process that can be accurately studied in the laboratory and any foundation has to be designed based entirely on the allowable settlements.

The problem with clay is that it swells. Clay exerts a pressure of about 1 to 2 kg per sq. cm on swelling and shrinks substantially as well while drying. These factors have to be taken into consideration. Treatment with lime intrusion reduces the swelling properties of clay and this has been successfully adopted.

Loose silt layers below water table are vulnerable to liquefaction under earthquake forces. A possible method of improving the liquefaction characteristics is add density to loose silt with coarse grained sand. It is also possible to adopt techniques like using piles into deeper foundation to take the load to a firmer stratum.

Good knowledge about the different rocks and their characteristics is necessary for any foundation design. The conventional technique of following shear and settlement is not enough. Inherent knowledge of the different rocks and their characteristics would allow geotechnical engineers the possibility to employ the maximum bearing capacity with minimum settlements.



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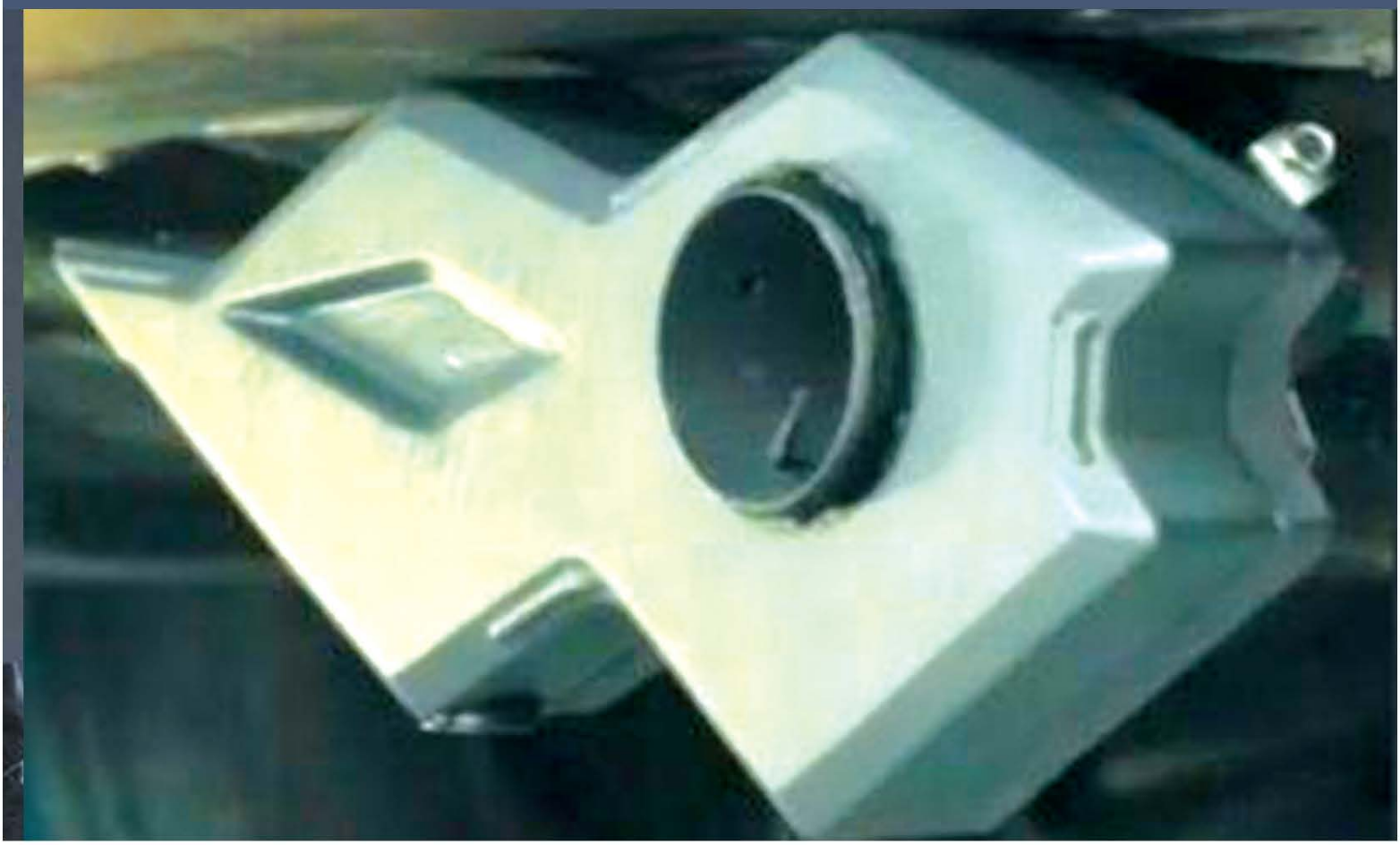
IIT alumnus develops device to fight air pollution


Debayan Saha

In an attempt to curb air pollution caused by vehicles on the road, Debayan Saha, an IIT Kharagpur graduate, has developed a device called '-2.5' (Minus2Point5), which influences the pollutants like PM 2.5 in such a way that they act like magnet, attracting particulate pollutants from the ambient atmosphere to get attached to it.

Delhi, the national capital, has turned into the capital of air pollution as well. A study of 1650 cites conducted by the World Health Organization (WHO) had found the air quality in Delhi to be the worst among major cities in the world. Estimates show that around 2.5 million people in India die every year due to diseases arising from air pollution. And, no wonder, efforts are underway at different levels to stem the dip in air quality.

Of all the major air pollutants, particulate matter below 2.5 nanometer (PM 2.5) renders humans ill through constant exposure. The source of PM 2.5 is mostly combustion based. More than 95% of emissions from diesel, petrol, open waste combustion fall under PM2.5. The size of this particle



enables it to enter the lungs and bloodstream easily and cause harm.

In an attempt to curb air pollution caused by vehicles on the road, Debayan Saha, an IIT Kharagpur graduate, has developed a device called '-2.5' (Minus2Point5). Inspired by the fundamentals of physics and Michael Faraday, the device developed by this Global Biodesign Fellow at Stanford University uses a technology that is a combination of electric energy and wave energy. This influences the pollutants like PM 2.5 in such a way that they act like magnet, attracting particulate pollutants from the ambient atmosphere to get attached to it. As the volume of particulate matter that gets attached to the device grows bigger, they fall off safely to the ground.

Saha claims that when fitted to the exhaust pipe of one car, the device can neutralize pollutants emitted by 10 cars in its vicinity. The device starts when the vehicle is started. The advantage of using this device, according to him, is that it does not have any filter and hence does not require frequent replacement or cleaning.

PerSapiens, the startup promoted by Saha with Dr. Shahi Ranjan, a biomedical scientist from NUS, and Yogesh Agarwal, also an IIT alumnus, has set combating air pollution as one of its important goals. Saha and his team are in talks with various organisations to commercialise the product.

CP News and Features

EXCON scales new heights in 2019

Construction industry is booming. With that comes the urgent need for latest technologies and machinery. The Tenth Edition of **EXCON**, organised by the Confederation of Indian industry (CII), at BIEC Bengaluru from December 10 to 14, to reflect the fast-paced changes happening in the industry and the many technologies that are coming in, proved a huge draw this year as well.

EXCON EXPO, easily South Asia's largest construction equipment exhibition, was inaugurated jointly by Union Minister for Road Transport and Highways and MSME Nitin Gadkari and Karnataka Chief Minister B.S. Yeddyurappa. Being the largest of its kind, the event was attended by well over 2000 exhibitors, including 390 overseas companies from over 21 countries. It covered a display area of about 3 lakh square metres, attracted over 70,000 business visitors and saw several product launches by various companies.

With the theme, 'Smart i-Tech-Next Gen India @75', the event showcased the latest technologies and machinery in the construction industry. The CII team left no stone unturned to make the event a thumping success as was evident from the meticulous planning that had gone into the layout of the EXCON venue, the many side-events, product launches and the way each guest found the expo a wholesome and rewarding experience. They were ably supported in their endeavour by the Indian Construction Equipment Manufacturers' Association (ICEMA) and the Builders Association of India (BAI).

Women in focus

The 10th Edition of **EXCON** also created history with its special focus on women in the male-dominated construction industry. The event thus saw introduction of Women Building India- Equal Opportunity Awards to doff the hat at all those women professionals who have made an indelible mark in the industry. Besides the honour roll-call, there were also seminars on women's emerging role in the construction sector.

EXCON 2019 venue also played host to several conferences and seminars on themes and sectors such as Defence and Paramilitary, Micro Small & Medium Enterprises (MSMEs), Components & Parts, Green Buildings, Smart Cities, Urban Development and Logistics. The event also saw exhibitors coming in with all categories of construction equipment, ranging from aggregate and asphalt equipment to piling equipment.

Among them were such international brands as JCB, Sany, Bobcat, Volvo, Scania, Schwing Stetter, Caterpillar, Mahindra, Komatsu, Larsen & Toubro, to name a few. Exclusive pavilions were set up to showcase latest advances in Artificial Intelligence (AI), Internet of Things (IoT) and Mechatronics relevant to the construction industry.

JCB India, one of the leading earthmoving and construction equipment companies in the country today, launched its new intelligent machines including the new ecoXpert 3DX Backhoe Loader, a machine with fuel savings of up to 12% and up to 22% lesser maintenance cost and its new range of side-engine Tele-handlers

at the event besides introducing the NXT series and the Quarry Master range of excavators. The new 3DX comes loaded with JCB's 'IntelliPerformance' and 'IntelliDig' technology, which will give customers real time information about the performance of the machine.

Komatsu India Pvt Ltd and Larsen & Toubro put together a magnificent show at **EXCON**, showcasing their technological prowess and service capabilities. Komatsu, Scania and L&T had 19 machines on display at **EXCON** this year. The star of the show was Komatsu PC210-10MO Hydraulic Excavator, the next generation machine, which was also launched at the event. L&T launched Komatsu G2-LI, a multipurpose grease designed for all components covering majority of the Komatsu range of construction equipment. It is an extreme pressure lithium grease with excellent mechanical stability, which means that this grease maintains its consistency for long hours.

D85 Crawler Dozer and GD535 Motor Grader, imported from Komatsu Ltd, were also on view. Other Komatsu machines on display at the L&T Pavilion included a wide range of hydraulic excavators—PC71, PC130, PC300-8, PC350-8 and PC450— manufactured by Komatsu India Pvt Ltd at Oragadam, Chennai, and which are popular in the construction industry in the country.

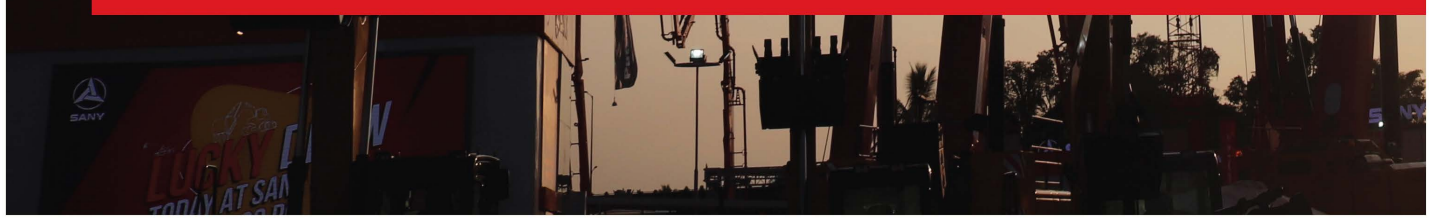
Playing its part in the 'Make in India' initiative, L&T Construction Equipment Ltd offered a wide range of road machines such as the Wheel Loader, Vibratory Compactors, Pneumatic Tyred Roller, Hydraulic Paver and Skid Steer Loader. These equipment incorporate

a world-class features and are fitted with L&T DigiEye for online tracking. These machines are for multiple applications such as earthwork, land development, irrigation, blue metal quarry and have already marked their signature across the industry.

Mahindra Truck and Bus (MTB), a part of the Mahindra Group, displayed its range of outclass best performing tippers. These tippers are well suited for construction related applications. MTB also displayed its LCV tipper—the Load king OPTIMO. This model, with its compact architecture, is ideal for last-mile applications like sand mining and construction.

Volvo Construction Equipment (Volvo CE) had arrived with a wide range of construction and mining equipment that serve the key industrial segments of road construction, mining and general construction. As it offers products with the highest reliability, productivity, safety, combined with lowest cost of operation, Volvo CE is a natural choice for organizations and contractors who play a pivotal role in infrastructure growth in India.

Schwing Stetter displayed all of their 22 new products this year. Schwing Stetter India aims to position itself as one of the most prominent infrastructure equipment partners in the country with their new product line. They are becoming an active performing enterprise in all government projects. Internet of Things (IoT) solutions, dashboard for batching plants, gateway device, hi-tech weighing systems, and a Schwing smart-track and Stetter concrete transit mixer with mobile app were received with vows at the event.



Scania Commercial Vehicles India exhibited its recently launched NTG Heavy Tipper, parts and service solutions along with BS-IV CEV ready industrial engines, at EXCON. The launch of NTG and the opening of its central warehouse in Nagpur have made 2019 an important year for Scania in India.

Sany, one of the largest equipment manufacturers in the world, unveiled over twelve new products at EXCON and these included the complete excavator range, truck crawler, and all-terrain cranes, road equipment including graders, mining equipment and piling rig. Sany's newly launched products will soon be available all over India. Its hydraulic excavators, piling machinery, crawler cranes, mobile port machinery and road machinery are considered to be the best while its concrete machinery ranks first in the world.

A must-go event now

India is one of the largest industrial markets in the world and the footfall at **EXCON** truly reflected this. Besides several national players, scores of international experts and service seekers were could be seen milling around the various stalls to see the new products and technologies on display.

From all available indications, the equipment majors were a happy lot seeing the enthusiastic response to their wares from the visitors. One also could see that **EXCON**, into its 10th edition, is here to stay as a must-go happening in the international events calendar of the construction industry.

CP News and Features

A.N.Prakash

Ignore documentation to your peril

due to lack of knowledge of the legal implications, documentation and record keeping is relegated to the lower end of priorities. In such situations, records of commitments made are not maintained or are insufficient or improperly maintained, which is a very risky thing to do.

The primary objective of construction project management is to ensure that a project is delivered successfully—to the specified quality, within budgeted cost and on time. In order to achieve these objectives, one of the most important elements of construction project management is 'Contract Management'.

Contract management plays a major role in the project life cycle. Commencing from the tendering process with the preparation of tender documents, proceeding to award of work by converting the tender document into a contract document and administering the contract through the construction phase to the close out phase, contract management plays a signal role in any construction project.

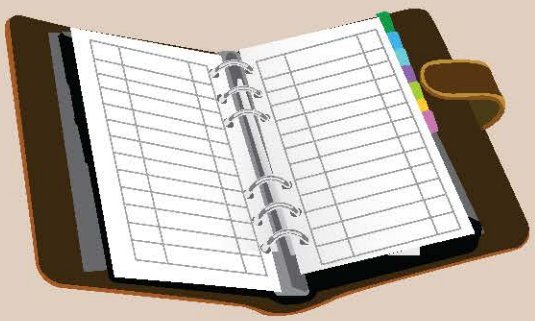
Once the contract is awarded and the construction site is handed over to the successful contractor, it becomes the responsibility of the contractor to deliver the project as per the terms of the contract. The parties who have entered into a contract must also adhere to the terms and conditions of the contract. Needless to say, for the success of any project and its smooth running and completion, it is necessary to ensure that the contractual obligations specified in the contract document are adhered to.

It is at this stage the site staff play a major role. Key among the many tasks that the site staff have to perform is to be aware of is the importance of maintaining essential records of communication, documents and correspondence.

The site personnel have the advantage of meeting with the vendors every day and discuss with them inevitable site issues and challenges that are part and parcel of a construction project. Most of the time, the site personnel spend their time in resolving day-to-day issues and coordinating with several agencies to avoid causing hindrances to each other.

This is a time-consuming process. As a result, and also due to lack of knowledge of the legal implications, documentation and record keeping is relegated to the lower end of priorities. In such situations, records of commitments made are not maintained or are insufficient or improperly maintained, which is a very risky thing to do.

Following are a few of the very important



documents that are to be maintained at any project site. These documents play a major role during arbitration processes in the event of major differences between the parties involved.

Site dairy (weather records, DPR,)
Site Instructions book
Drawings register
Register of tests conducted on materials for quality assurance.
Minutes of meetings (decisions taken)
All correspondence, both electronic and hard copies.
Site progress photographs
Statutory compliance documents.
Quality compliance records (Nemmadi.in App)
Safety (records of any reportable incidents)

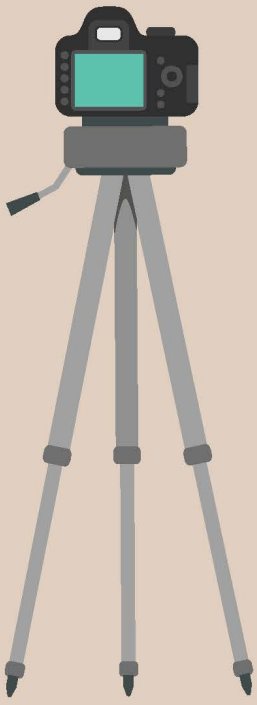
Site Dairy

What should the site dairy record and who should maintain the site dairy? The site dairy should preferably be maintained by the project manager representing the client in the project office. The project dairy is also project specific, commercial, hospital, residential, etc., it is necessary to have the recorded information countersigned by vendors' representative too, to avoid dispute or disagreement at a later stage. The information recorded in the dairy would be required for contractual reasons.

c) Rainfall measured.
d) Personnel schedule.
e) Equipment schedule.
f) Record of any reportable accidents that occur.
g) Production targets and achievements.
h) Site instructions received.
i) Drawings received.
j) Issues that are causing delays.
k) Work that is to be rectified.
l) Site meetings held and the date for the next one.

Drawing register

Drawing register (hard copies of the drawings are a must at the site) maintains record of all Good for Construction (GFC) drawings or working drawings released from the office of architects and consulting engineers. The drawing register records and maintains the list of drawings that are issued, date on which they are issued, number of copies and revisions records how many copies have been issued to whom.



Changes to drawings may result in a variation if the work that is to be changed has already started. On the other hand, if the work has not yet started and materials have not been purchased for the original design, the change may not result in a claim.

Site photographs

A few decades ago, before the advent of phones with cameras, it was an ordeal to record project status using digital camera. With the advent of phone cameras, photography is possible by anyone who possesses a cell phone. And cell phones are ubiquitous today.

Needless to say, there cannot be a better way of recording site conditions than a photograph with date and time. They are invaluable. To give a better perspective of progress of work, it is advisable to take few progress photographs from the same vantage points. Also, with CCTVs installed at various locations, real time proceedings at the site can be video recorded.

Site photographs are invaluable in recording conditions on a particular date and time. A picture tells the whole story. However, it is important to capture additional information about the picture as well. The additional information is needed to place the image in time and place so that it can be utilised.

Staff at project sites would do well to remember the above checklist and keep the above mentioned records along with many other important documents.

***A.N. Prakash** is Managing Director, A N Prakash Construction Project Management Consultants Pvt. Ltd.*

When it comes to building
A NEW WORLD,

It is not always about
The OUTPUT

Sometimes it is only about
The INPUT

Join hands with
Construction Philosophy to
DO IT RIGHT

An event jointly with all
Civil Engineering associations,
A Construction Sector
Open Panel Discussion

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Prof. Manish Kumar
Prof. Suhasini N. Madhekar
Harshavardhan Vairagade

WASTE TO WEALTH

Low-cost base isolators made of scrap tyre rubber pads are excellent alternatives for base isolation

Base isolation is a well-defined building protection system against earthquakes. Elastomer-based isolators have been widely studied and used globally. Steel or nylon fibre reinforcement inside the elastomeric isolators provide high vertical stiffness, whereas rubber segments between reinforcement layers provide low horizontal stiffness. Automobile tyres have a similar effect as that of the steel plates or nylon fibres, inside the conventional elastomer-based isolators, writes Prof. Manish Kumar, Prof. Suhasini N. Madhekar and Harshavardhan Vairagade.

Earthquakes have caused tremendous loss of property and lives around the world. Attenuating the effects of severe ground motions on structures is one of the most researched topics. Reduction of seismic demand on structures can be achieved by providing certain degree of flexibility to the structures by installing devices with low horizontal stiffness. There are many seismic isolation devices to serve this purpose and, among these, elastomeric bearings are the most widely used.

Insertion of flexible layer increases deflection of the structure, thereby increasing its duration and reducing the base shear. An alternative low-cost seismic isolation system can be put in place if we use scrap rubber tyres. The primary objective here is to develop a base isolation system from easily available waste tyres at an affordable cost, which will be effective in reducing the seismic demand on structures.

Scrap Tyre Rubber Pads (STRP) provide several advantages such as low-cost, weight reduction, ease of handling and environmental benefits. Lightweight seismic isolation pads can be made at a low cost through recycling otherwise useless material—the scrap tyres. Steel reinforcement inside the conventional elastomeric isolators provides high vertical stiffness, whereas rubber segments between reinforcement layers would provide low horizontal stiffness. Rectangular shaped layers cut from tread sections of used tyres and then piled on top of each other can function as an elastomeric bearing. STRP may be used as a low-cost alternative to conventional bearings, for seismic isolation of massive structures, masonry structures, pedestrian bridges and for equipment isolation.

Properties of STRP specimen, viz. vertical and horizontal stiffness and shear modulus were evaluated were part of our study. Experiments were performed on STRP of dimensions 200×200×130 mm. The steel and rubber layers were vulcanized together to make them behave like a composite. The test results showed that the STRP is an attractive and viable alternative to commercially available isolation systems. The cost of one STRP sample is very low and easily affordable, compared to the cost of conventional isolators. STRP may be used as a low-cost alternative to conventional elastomeric bearings for seismic isolation.

Seismic Isolation

The seismic forces on the structures can be reduced if the fundamental time period of the structure is lengthened or the energy dissipating capability is increased. Seismic isolation is a method of controlling the seismic response of structures through yielding of the isolators, possessing generally bi-linear force deformation relationship. It decouples the structure from the horizontal components of the ground motion by interposing structural elements with low horizontal stiffness between the structure and the foundation. This gives the structure a fundamental frequency that is much lower than both; its fixed-base frequency and the predominant frequencies of the earthquake ground motion.

Elastomeric Bearings

Elastomeric bearings consist of multiple layers of elastomer and steel shims, which carry gravity load of the superstructure and provide horizontal flexibility to reduce the level of seismic forces transmitted to the superstructure. The reason behind the popularity of the elastomeric bearings is the restoring force provided by the elastomeric material. Fig. 1 shows a typical circular elastomeric bearing. These bearings are composite elements made up of natural or synthetic rubber layers bonded to reinforcing steel shims in alternate layers. Rubber, owing to its low shear modulus, accommodates large horizontal displacements, and steel shims combined with almost incompressible rubber provide high vertical stiffness. High damping capacity, high horizontal flexibility, and high vertical stiffness are their important characteristics.

Scrap Tyre Rubber Pads (STRP) provide several advantages such as low-cost, weight reduction, ease of handling and environmental benefits. Lightweight seismic isolation pads can be made at a low cost through recycling otherwise useless material—the scrap tyres

Scrap Tyre Rubber Pads

Steel or fibre reinforcement inside the elastomeric isolators provides high vertical stiffness, whereas rubber segments between reinforcement layers provide low horizontal stiffness. Automobile tyres are produced by vulcanizing rubber with either steel or nylon fibre mesh in different forms which have a similar effect as the steel plates inside the conventional elastomer-based isolators. Since the tyres are designed for friction, load transfer between scrap tyre layers would be large enough to keep all layers intact.

Fig. 1. Typical elastomeric bearing

Types of tyres

(i) Nylon Tyres: They consist of layers made from nylon cord. Such cross ply tyres provide a strong and rigid sidewall causing the tyre to overheat when used on a hard road surface and thus cause the tyre to wear out quickly. Thus, these types of tyres are not suitable for trucks and buses.

(ii) Radial tyres: They consist of steel reinforcement vulcanized with rubber. The flexibility and the strength help the radial tyres to absorb the impact shocks and the bumps more effectively than the cross ply tyres. The vertical load carrying capacity of the isolators made from nylon tyres is less as compared to the radial tyres as the radial tyres consist of steel mesh, which helps them to bear larger vertical loads.

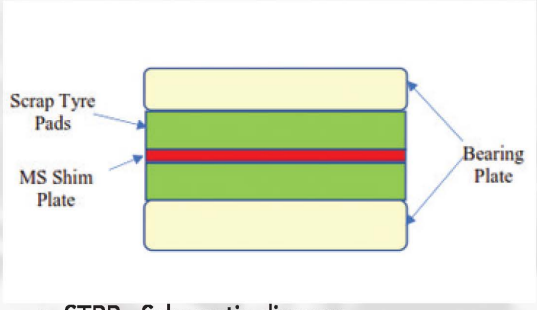
Fig. 2. Stages in preparation of STRP samples

The seismic forces on the structures can be reduced if the fundamental time period of the structure is lengthened or the energy dissipating capability is increased.

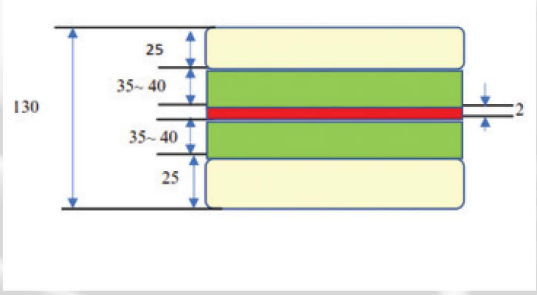
Preparation of STRP specimen

As part of our study, several samples of STRP bearings were prepared by processing them through various stages, as shown in Fig. 2. The number of elastomer layers used in the conventional elastomeric bearings generally varies from four to eight. The more the number of strips, more flexible are the STRP bearings in the horizontal direction. However, a greater number of strips results in reduction of their stability.

Fig. 3 shows STRP samples used for the study. Fig. 4 shows test set up for compression test and for shear test.



a. STRP - Schematic diagram



b. STRP - Dimensions

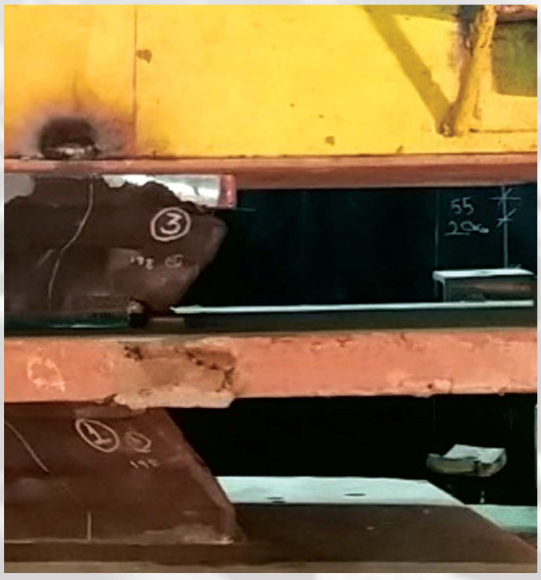
c. STRP Specimen

Fig. 4. Testing [Heavy Structures Lab, IIT Bombay]

a. Test set up

Base isolation system using STRP isolators can be used as a low-cost alternative to conventional elastomer-based pads for seismic isolation of massive structures (e.g. stone wall rural masonry) or for temperature induced deformation compensation of rural bridges.

b. Failure in compression



c. Failure in shear

Conclusions

The study focuses on development and testing of alternative free-of-charge isolators made from scrap tyres. The idea and investigation of using scrap tyres and thin steel plates instead of conventional elastomeric pads is to have no-cost seismic isolation. Weight reduction, ease of handling, simple shear stiffness adjustment by changing the layer numbers, and positive environmental impact are the complementary advantages. Based on the test results, following conclusions are drawn.

1)The low vertical strength is associated with nylon mesh in scrap tyres and additional steel shim plates may be used between tyre layers to significantly improve the axial load capacity of STRPs.

2)The shear modulus values of the STRP specimens reveal that the rubber used in tyres are harder when compared with natural rubber, since tyres should be durable under arduous nature conditions. The high shear modulus values of STRPs would allow the isolation of large amount of masses only.

3)Base isolation system using STRP isolators may be used as a low-cost alternative to conventional elastomer-based pads for seismic isolation of massive structures (e.g. stone wall rural masonry) or for temperature induced deformation compensation of rural bridges.

4)The cost of one STRP sample works out to be less than Rs. 10,000/-, which is easily affordable, compared to the cost of conventional isolators.

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1. *KELLY J. Earthquake Resistant Design with Rubber, Springer, London, 1997.*
2. *BAYEZID ÖZDEN. Low-Cost Seismic Base Isolation Using Scrap Tyre Rubber Pads (STRP). M. Tech dissertation report, The Graduate School of Natural and Applied Sciences of Middle East Technical University, 2006.*
3. *MATSAGAR V. M. and JANGID R. S. Influence of Isolator Characteristics on the Response of Base-Isolated Structures. Engineering Structures, Vol. 26, 2004, pp1735-1749.*

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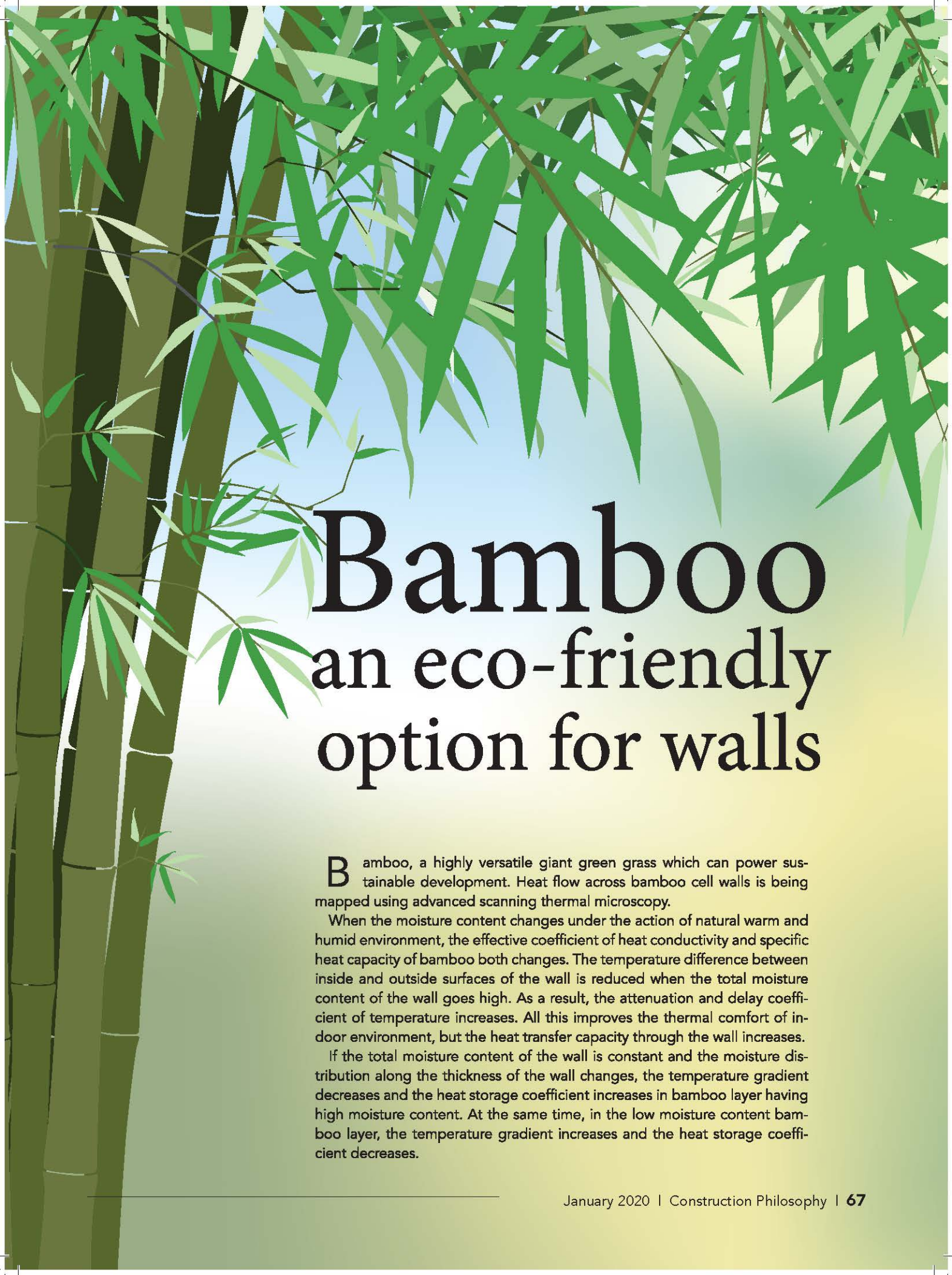


Bamboo
an eco-friendly option for walls

Bamboo, a highly versatile giant green grass which can power sustainable development. Heat flow across bamboo cell walls is being mapped using advanced scanning thermal microscopy.

When the moisture content changes under the action of natural warm and humid environment, the effective coefficient of heat conductivity and specific heat capacity of bamboo both changes. The temperature difference between inside and outside surfaces of the wall is reduced when the total moisture content of the wall goes high. As a result, the attenuation and delay coefficient of temperature increases. All this improves the thermal comfort of indoor environment, but the heat transfer capacity through the wall increases.

If the total moisture content of the wall is constant and the moisture distribution along the thickness of the wall changes, the temperature gradient decreases and the heat storage coefficient increases in bamboo layer having high moisture content. At the same time, in the low moisture content bamboo layer, the temperature gradient increases and the heat storage coefficient decreases.

Renewable plant-based materials like bamboo have huge potential for sustainable and energy-efficient buildings. This highly productive plant is extremely effective in sequestering carbon, taking in twice as much carbon dioxide as trees and meeting all the necessary criteria for sustainable development goals. It helps to mitigate the human impact on climate change. This approach would help keep carbon out of the atmosphere by averting the thoughts of burning timber away.

Scan of the cross-sections of bamboo vascular tissue, the tissue that transports fluid and nutrients within the plant, revealed an intricate fibre structure with alternating layers of thick and thin cell walls. Peaks of thermal conductivity within the bamboo structure coincide with the thicker walls, where chains of cellulose—the basic structural component of plant cell walls—were laid down almost parallel to the plant stem. These thicker layers of bamboo gave strength and stiffness at the same time, the thinner layers having only lower thermal conductivity due to cellulose chains being almost at a right angle to the plant stem.

The thermal properties of bamboo provides insights into how to reduce the energy consumption of bamboo buildings. It also enables modelling of the way bamboo building components behave when exposed to fire so that measures can be incorporated to make bamboo buildings safer.

Heat travels along the structure-supporting thick cell wall fibres in bamboo. So, if exposed to the heat of a fire, bamboo might soften more quickly in the direction of those fibres. This helps to work out how to reinforce the building appropriately.

The wonder plant grows incredibly fast, which makes it easy for farmers to harvest and market the plant. Bamboo can be sold commercially to construct furniture, roofing, fencing, floor tiles, walls, ceiling and many other building materials.

Vishnumaya Menon

Canada beckons aspiring engineers

Regularly updated immigrant laws, flexible class schedules, attractive wages and what more to be aware of before leaving to Canada for further studies.

Canada, as one of the most Permanent Residence supporting country, has gained in importance among destinations for international education. Job opportunities, multiculturalism and the high quality of practical education, although a bit on the higher side of the expense chart, have attracted international students to kick start their professional journey in this country.

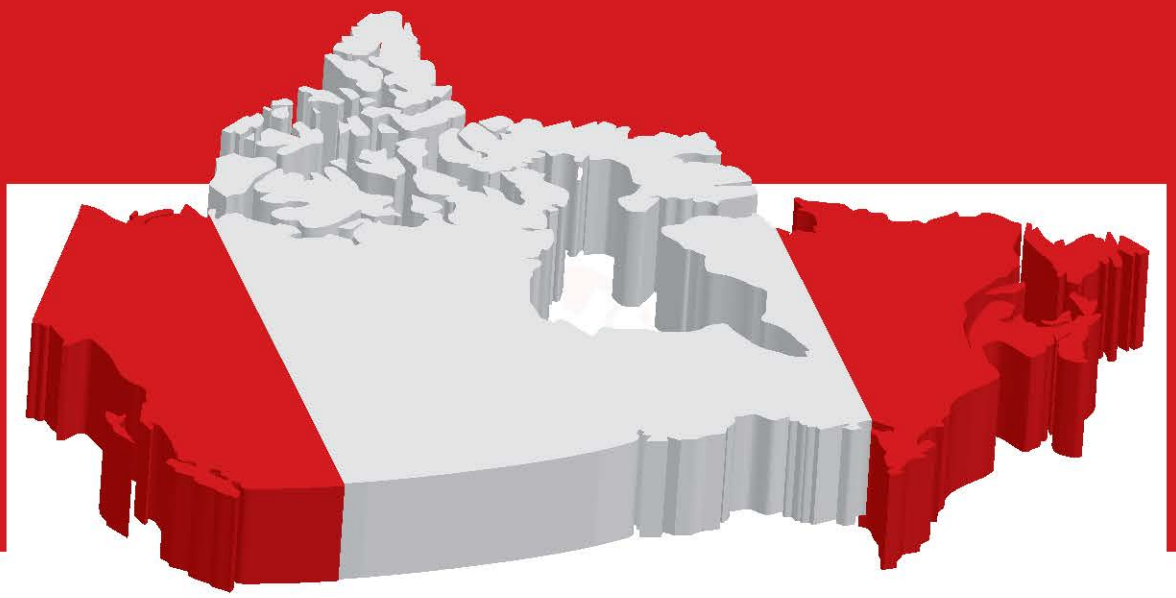
In Canada, there are two choices: universities and public colleges. Universities offer Bachelor's degree, Master's degree and PhD programmes whereas colleges focus more on job oriented practical knowledge and training via College Diploma and Accelerated programmes. Canada has 10 provinces. Each province has a variety of colleges and universities. Choosing a college or university can be confusing. Well, there are government sites which help you filter the college and university according to your choice of study and specialisation.

Choosing a course is the most critical decision one should make. While the educational consultant at your agency provides you with a list of courses that are popular, one should thoroughly explore one's options and find a course that suits one's interest and also the demand in Canada. The official websites such as www.ontariocolleges.ca can help you find courses that are in high demand and their scope. More importantly, when choosing a course in Canada after a Bachelor's degree, one should make sure it is related to the previous education as course mismatch is one of the main reasons for Visa rejection.

For civil engineers, further study options include environmental engineering, structural engineering, urban and regional planning, cities engineering and management, geotechnical engineering, and so on. Most universities offer Masters of Science and Master of Engineering programmes after Bachelor's degree whereas the colleges offer graduate diplomas, post-secondary diplomas and accelerated diplomas. Being a holder of engineering degree, one can skip the first year of the course and directly enrol for the second year in most colleges as part of the accelerated or fast track program. Checking the pre-requisites for the programme in university sites can further provide assistance in this subject.

The duration of the course is another import-

Choosing a course is the most critical decision one should make. While the educational consultant at your agency provides you with a list of courses that are popular, one should thoroughly explore his options and find a course that suits their interest and also a one that has demand in Canada. The syllabus focuses more on detailed study of a particular subject than just covering all the topics that comes under a single subject. A more practical and detailed study is given here for the same subject that I had learned during my engineering class.



ant factor to be considered. The stay back period for you in Canada is decided by the duration of the course. As the policies are regularly updated, checking the official website regularly can help in planning. Also, one has to make sure that the visa is extended after study permit when one changes to a work permit. Failing to update the permits may result in deportation.

Unlike in India, where one-hour classes from morning to evening that run continuously for a week, in Canada a student has the option to choose classes he or she wishes to attend and schedule a suitable timetable. Also, the syllabus focuses more on detailed study of a particular subject than just covering all the topics that come under a single subject. My own personal experience was that I got to study the same subjects that I had studied during my civil engineering course, but in much greater detail.

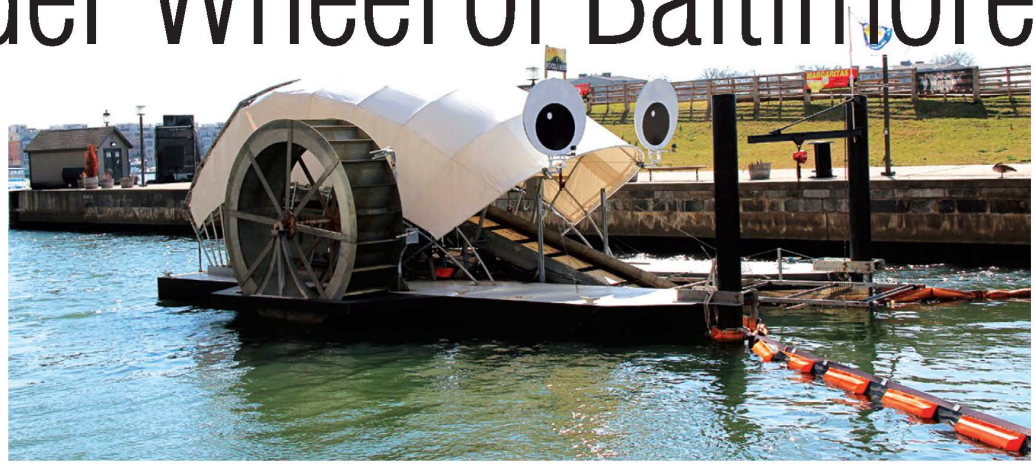
Although one has to do more assignments and tests here, it actually helps us to score well as the examination questions are pretty much direct or of multiple choice variety for most of the subjects. Another thing is the source of study materials, unlike the huge bundles of photostats and notebooks, here all the portions are covered under PowerPoint presentation that are available to us through the college websites. Also, the occasional quizzes that are part of the syllabus also help us to familiarize with the research patterns and resources.

Lastly, the attractive minimum wage and part time opportunities contribute in bringing more students to this country. A student can work for a maximum of 20 hours per week during the study period and 40 hours per week during breaks. One should understand the work permit law clearly. Over working or taking up illegal employment beyond the recommended hours has resulted in many students getting deported. Proper conduct and observance of the local laws will help in providing a smooth transition from student life to professional career in Canada.

To sum up, the country and its beautifully mannered people are more welcoming than one expects, but be sure to layer yourself up as the weather is harsh and completely unwelcoming.

***Vishnumaya Menon**, Graduate diploma student at Centennial College,Toronto*

Wonder Wheel of Baltimore



The Baltimore harbour is cleaner than it has been for decades. Credit for this should go to Mr. Trash Wheel. Yes, that is a pet name, but not of any person, but of a contraption that has been floating upand down the river for sometime now.

It is a solar and water powered trash cleaner that collects litter and debris flowing down the river. In the last 3 years this wonder machine has removed 1.1 million pounds of garbage from the river. This includes 372,650 plastic bottles and 8.9 million cigarette buds.The success with Mr. Trash Wheel has been huge.

The eco-friendly machine is powered by both the sun and the strong river current. The river's current provides power to turn the water wheel of this machine that then acts as a robot to pick up trash and debris from the water.

Once collected, the trash is deposited into a dumpster barge which is built into this machine. When the water current isn't strong enough to power the machine, an attached solar panel provides solar power.

Mr Trash Wheel is the perfect example of a how simplicity can be the key to brilliance.

- CP News and Features

Europe's largest solar park completed

Construction of Nunez de Balboa Solar Park, which is thought to be the largest photovoltaic park in Europe with capacity to generate 500 MW power, has been completed by Iberdrola, a Spanish energy firm, in western Spain.

This €300 million project has been funded by the European Investment Bank and the Spanish state-owned Instituto de Credito Oficial.

The solar park contains 1.43 million photovoltaic panels and 115 inverters, as well two substations on the 1,000 ha site in the region of Extremadura, all of which took approximately a year to complete.

Majority of the park's power output is expected to be supplied to the clients in the banking, telecommunications and retail sectors.

Nunez de Balboa photovoltaic park in Spain

Work on $120 million Zagreb power plant begins

Italian contractor FATA has commenced the construction work on a new gas-fired combined cycle power plant (CCPP) unit in the Croatian capital Zagreb

Built under the Croatia's state-owned power company Hrvatska Elektroprivreda (HEP), the CCPP unit will have a power output of 150 MW and heat output of 114 MW. It will also produce 675 GWh of electricity a year, as well as 450 GWh of thermal energy.

It is expected to reduce gas consumption by 25%, bring down carbon dioxide emission by 150,000 tonnes and result in 95% reduction in the volume of sulfur dioxide, 57% reduction in NOx (nitrogen oxides) and 84% reduction in particulate emissions. The project is expected to be completed by 2022.

The project is valued at €120.7 million and is financed by European Bank for Reconstruction and Development (EBRD) and the European Investment Bank (EIB), with guarantees from the European Fund for Strategic Investments.

The Zagreb combined heat and power (CHP) site

EU boost for Croatia's rail network

Croatian Prime Minister, Andrej Plenković, has given the green signal to the €463 million rail improvement project.

The work includes reconstruction of 44 km of existing track between Karlovac and Zagreb, and construction of a second track from Hrvatski Leskovac to Karlovac.

The project also includes the renovation and transformative works at existing stations.

With the installation of new signaling and telecommunication systems, the trains are expected to move at a speed of 160 km/hr. The Karlovac-to-Zagreb line upgrade will form part of a larger project to build a lowland railway, running from neighboring Hungary to the Croatian port of Rijeka, on the Adriatic coast which is expected to boost Croatia's trade with markets in Central Europe.

Plenković said that Croatia will invest €3 billion in railway infrastructure over the next ten years.

Trains will run at up to 160kmh on the line between Karlovac and Zagreb

Ramboll volunteers enter next phase of quake-proof housing pilot

Volunteers from consultant Ramboll are to continue work on the development of earthquake-resistant bamboo homes after returning from an Indonesian island where the first three have been built. Three houses have been built to serve as templates for others across the country Following the multiple destructive earthquakes in 2018, the need for constructing safe, sustainable houses on the island on Lombok, Indonesia became a necessity. Ramboll worked alongside UCL scientists and a local NGO to build these houses. In order to act as blueprints, three houses were built using this method in the island which is open so that anyone can test the sturdiness of the building.The houses are built using locally available bamboo. The mission was to encourage the adoption of bamboo as a practical, low-cost and, most importantly, safe material to rebuild the island's depleted housing stock.

Expert panel releases report on Brazilian dam collapse

An investigation has found the six factors that caused this year's catastrophic collapse of a dam in Brazil.

The collapse was caught on video, which helped the expert panel identify the causes.

The four-member expert panel has published its 80-page technical report on the collapse of the dam at the Corrego do Feijao Mine in Brazil that killed almost 300 people. The high quality video images of the collapse have helped the investigators in understanding the failure mechanism. The culprit was the flow liquefaction within the tailings in the dam.

The dam was composed of mostly loose, saturated, heavy, and brittle tailings that had high shear stresses within the downstream slope. As a result, the dam was only marginally stable and was close to failure in undrained conditions. It was found that the amount of strain required to trigger strength loss was very small, especially in the weaker tailings. These were the main components that made flow liquefaction possible.

The collapse was caught on video, which helped the expert panel identify the causes.

EVENTS

UPCOMING EVENTS

XXIX ALL INDIA BUILDERS CONVENTION 2020
Venue : Vedic village spa resort, Kolkata
Date : Jan 3-5
Contact : 033-22523940
Web : www.baiconventionkolkata.in

WORKSHOP ON INNOVATIVE TRENDS IN BUILDING CONSTRUCTION
Venue : Hotel Prasanth, Trivandrum
Date : Jan 3-4
Contact : 9447035620, 94470064280
W : secretary@cetaat.in

ASCEND 2020
Venue : Lulu International Convention Centre, Grand Hyatt, Bolgatty, Kochi.
Date : Jan 9- 10
Contact : +91 4712318922, +91 6282013866, +91 6282013998
Web : www.ascendkerala2020.com

WOMEN IN DESIGN
Venue : Nehru Centre Auditorium, Mumbai, Maharashtra
Date : Jan 8-10
Contact : 022-43001234
Web : https://www.wid2020plus.org/

CONSTRO 2020
Venue : College of Agriculture Ground, Shivajinagar, Pune, Maharashtra
Date : Jan 16-19
Contact : +91 9822034103, +91 20 2553 8489
Web : www.constroindia.org/ www.pcerf.org
E-mail : infoconstro@gmail.com

REVOLUTIONISING PORTS CONFERENCE
Venue : Kamika Cruise, Mumbai, Maharashtra
Date : Jan 17
Contact : +91 7045119115
E-mail: anuradha.d@firstconstructioncouncil.com

FUTURE OF ENGINEERING
Venue : IEI BHAVAN Pullepady, Kochi
Date : Jan 18
Contact : +91 9061000115
E- mail : ieikochi@gmail.com

RAIL & METRO AWARDS 2020
Venue : Le Meridien Hotel, New Delhi
Date : Jan 22
Contact : +919811979598
Web : events@railanalysis.com

ASCEND 2020

Kerala to showcase 100 odd projects at the investors' meet to be held at Kochi in the new year

Kerala Government's efforts to promote the State's industrial development would hit the next level with ASCEND 2020, a global investors' meet to be held at Kochi on January 9 and 10, 2020. Over a 100 credible projects, primed for investment, would be showcased at the meet, which would see major players in the global industrial scene in action.

The State government is also planning to use the occasion to give wide publicity to the recent

CONSTRO 2020

Western India's largest construction expo on machinery, materials, methods and projects happens at Pune from January 16 to 19, 2020

Infrastructure industry is on the upswing in India with advanced technologies, machinery and innovative projects taking shape and getting implemented across the country. Reflecting the spurt in infrastructure industry is CONSTRO 2020, an expo of gargantuan dimensions, being organised by the Pune Construction Engineering Research Foundation (PCERF), a unique non-profit organization, at Pune annually. This year, the event happens at the Agricultural College Grounds, Pune, from January 16 to 19, 2020.

PCERF, whose members are drawn from various construction and related fields, has identified 'mechanized and intelligent construction' as core theme of this year's expo. Since its launch in 1985, CONSTRO has been playing a key role in bringing together manufacturers, technology wizards, manufacturers and customers under a single roof for fruitful interactions. All of them would walk into the venue through Constro Gates which have been the defining features of every CONSTRO event. Every entry gates is designed based on specific themes and ultra-careful crafting and finally bringing out the ground-breaking structural innovations.

Contact details: Phone: 020-25447748/PCERF Office- +91 9823508576
Mail: infoconstro2020@gmail.com / Website: www.constroindia.org

amendments to its industrial licensing procedures under which an aspiring entrepreneur can go ahead with his plans without obtaining any licence, taking the State one notch up in 'Ease of Doing Business'. Besides changes in the industrial policy, the meet would also see top officials briefing potential investors about the changes in the land assignment rules and introduction of electronic platform for interaction between them and the government.

The meet is scheduled to happen at the Lulu Bolgatty International Convention Centre, Bolgatty Island, Kochi.
Contact details: Phone: +91 4712318922, +91 6282013866, +91 6282013998
Mail: https://www.ascendkerala2020.com

Rail and Metro Awards 2020

This year's Rail and Metro Awards, introduced to honour companies, professionals and individuals who have demonstrated their creativity, come up with innovative solutions and shown excellence and expertise for the betterment of the railways and the metro system in India, would be given away at a function to be held at Hotel Le Meridien, New Delhi, on January 22, 2020.

The event would also see several networking seminars on rail development and feature an exhibition of the latest in rail travel technologies. The rail conference is an exclusive networking platform for more than 500 rail industry leaders. With 25 exclusive stalls and sponsorship opportunities, the Rail and Metro Awards event is an occasion for big and small players to showcase innovative advancements in the relevant technologies.
Contact details:
Phone: +919811979598
Mail: event@railanalysis.com
Website: http://conference.railanalysis.com/

The 29th All India Builders' Convention (AIBC), which is the annual gathering of members of the Builders' Association of India (BAI), would take place at the Vedic Village Spa Resort, Shikharpur, Rajarhat, Kolkata, from January 3 to 5, 2020

The 29th biennial All India Builders' Convention (AIBC) is here again, this time in Kolkata. This is the occasion for networking among policy planners, technology experts and various stakeholders in the construction industry.

The upcoming event has a three-day fixture with experts of international repute addressing the delegates on various topics of modern construction technologies. People from various construction and related fields, including practicing engineers, consultants, construction companies, companies concerned with infrastructure development and engineers from government agencies and other industry organizations, would attend the event. Past AIBCs have been honoured by the presence of distinguished guests including Presidents, Prime Ministers, Union Ministers and Chief Ministers.
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Website:
www.baiconventionkolkata.in

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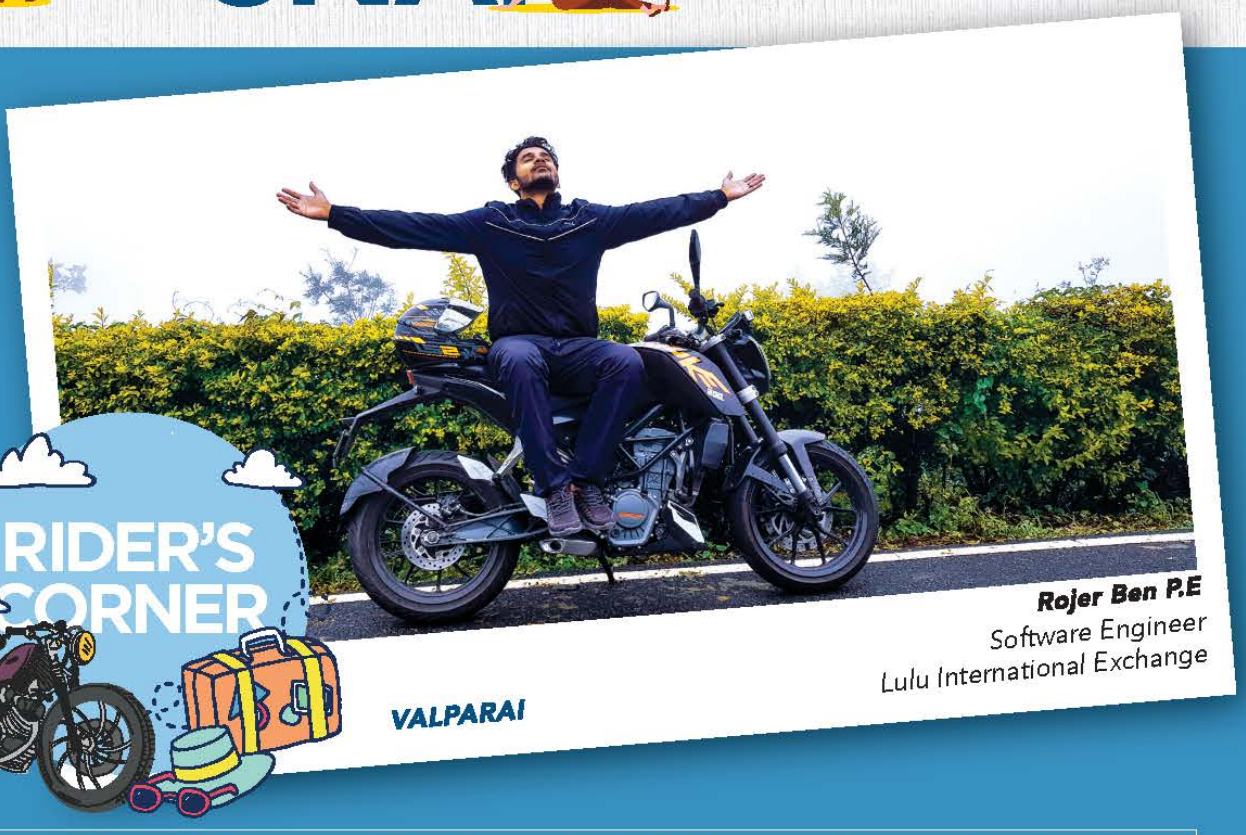
ROSS ISLAND, ANDAMAN AND NICOBAR

Netaji Subhash Chandra Bose Island fomerly known as Ross Island, is an island forming part of Andaman and Nicobar. The island is situated 2km east from central Port Blair. The historic ruins here are a major tourist attraction. The ruins of the bazaar, bakery, stores, water treatment plant, church, printing press, hospital, cemetery, grand ballrooms, the Government House, the Troop Barracks are still present at Ross, textured by thick roots of peepal and serie trees that take us back to an era long gone, but still remembered. Magnificent man-made caves, the old church and grim history associated with this place gives out a unique vibe that can't be found anywhere else in Andaman and Nicobar. Ross Island, currently controlled by the Indian Navy, can be reached by a small boat.

Saniya Elizabeth Sunny
Civil Engineer, Delhi

TAKE A SNAP



Rojer Ben P.E
Software Engineer
Lulu International Exchange

Sent us your clicks to mail@constructionphilosophy.com with a brief of the structure location and a self introduction

TENDERS

TENDER DETAILS

Konkan Railway Corporation Limited
TDR no. : 23130066
Tender Brief : Supply, Fabrication, Testing And Commissioning Of 33Kv And 11Kv Ht Power Cable Network, Gis Substation, Dg Sets, Tunnel Aeration System, Tunnel Electrification, Scada System And Fire Extinguisher Including E & M.
State : Jammu and Kashmir
Due Date : 12/02/2020

Rail Vikas Nigam Limited
TDR no. : 23041715
Tender no. : RVNL/RKSH-KNPG/Tender/Tunnels/ PK-1/RT
Tender Brief : Construction Of Tunnels , Bridges , And Formation Works From Chainage 6 Plus 015 To 18 Plus 444 Under Package-1 In Connection With New Single Line Broad Gauge Rail Link Between Rishikesh And Karanprayag In The State Of Uttarakhand
State : Uttaranchal
Publish Date : 26/12/2019
Due Date : 17/02/2020
Tender Opening Date : 17/02/2020

3) National Highways Authority of India
TDR no. : 22938291
Tender no. : NHAI/VME/PPPAC/2016/Pkg XIII
Tender Brief : Construction Of 8 Lane Access Controlled Expressway From Km 26 . 582 To Km 50 . 700 Of Main Expressway And Km 0 . 0 To Km 3 . 00 Of Spur Shirsad To Masvan Section Of Vadodara Mumbai Expressway In The State Of Maharashtra On Ham Under Bmp Ph II Pkg XIII
State : Delhi
Publish Date : 17/12/2019
Due Date : 17/02/2020
Tender Opening Date : 18/02/2020

4) Rail Vikas Nigam Limited
TDR no. : 22751860
Tender Brief : Tender Construction Of Road Bed , Major Bridges , Minor Bridges , Robs N Rubs Including Road Approaches ,Station Buildings , Staff Quarters , Other Service Buildings , Hl Platforms , Cops , Fobs , General Electrification N Other Works
State : Madhya Pradesh
Due Date : 24/02/2020

5) Building Construction Department
TDR No. :22288044
Tender No. : BCD/Special Works Division, Ranchi/321/2019-20
Tender Brief : Corrigendum - Construction Of Proposed Secretariat Building Of Jharkhand In Core Capital At Site-1 , H . E . C . Area Ranchi
State : Jharkhand
Publish Date : 03-01-2020
Due Date : 22-01-2020
Tender Opening Date : 24-01-2020

1) Company: Atkins, Bengaluru

Qualifications	:	Civil Engineering and Masters degree in Environmental Engineering
Essential Criteria	:	2 to 6 years of experience in the Water & Wastewater Industry.

2) Company: Atkins, Bengaluru

Role	:	Technical Service Officer
Qualification	:	Civil Engineering and Masters degree in Environmental Engineering
Location	:	Bengaluru
Essential Criteria:	:	2 to 6 years of experience in the Water & Wastewater Industry.

3) Company :Sobha Developers

Job Position	:	Quantity Surveyor / Billing Engineer
Ref. Code	:	QS/BE Functional
Area	:	Quantity Survey / Cost Control
Number of Position	:	6 Location : Bangalore / Cochin
Experience	:	Min 4 years experience in Quantity Survey /Billing

4) Planning Manager

Company	:	Hindustan Construction Company Ltd
Experience	:	12 - 15 yrs
Location	:	Jammu, uttar pradesh
Essential criteria: Budgeting		Candidate should have hands on exp. in Planning - Candidate must have working knowledge of MS Project - Candidate should have exp. in Bridges / Highways / Metro / Hydro - Knowledge of Primavera is desired.

DIBEX 2020

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