

SHAPING THE FUTURE OF RESEARCH IN CIVIL ENGINEERING THROUGH 3I (INSTITUTE -INDUSTRY INTERACTION) INTERDISCIPLINARY COLLABORATION APPROACH

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ABSTRACT

The aim of any future research is to increase the scale of interdisciplinary cooperation. This paper explores possible ways to minimize the gap between Education, Research and Industry so as to meet the expectations from Industry in Civil Engineering. This paper delves into **3I approach (Institute - Industry Interaction) in Civil Engineering** and emphasizes the fact that Industry and Institute are two strategic columns and need to be connected through a beam called Research so that the society benefits as a whole. The paper also provides few cases showing how people with varied subject knowledge and skillsets researched and collaborated and created path breaking works in Civil Engineering and sustainable construction

INTRODUCTION

The Living organism as a perfect example of Interdisciplinary collaboration

It is needless to say every living organism, be it plant, animal /human body, during their life span, each part of performs their specialized function in unison and contribute effectively to self-growth. Whenever any part gets affected, whole body works in unison to fight the negativity to survive. The human brain is such an unparalleled repository of knowledge that if allowed to explore, regardless of age, it acquires newer knowledge and has decoded the secrets of Universe right from powerful megapixel eye of the eagle, the hard-working bee, systematic tiny ant which work as a team and sunflower which turns each day in direction of sunlight and Mimosa Pudica which closes when anybody touches it. In Civil Engineering also, people with different levels of skills right from earthwork excavator to mason, painter, bar bender etc implement the design dream of Civil Engineer in creating structures that have stood and continue to stand as a testimony to Human excellence. In fact the Civil Engineering structural designs draw inspiration from human body (joints of bone /muscle) and joints in structural connections. In fact, many of Researchers in Civil Engineering have been inspired by Non-Civil

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Engineers as shown in ensuing paragraphs. Biomimicry is a principle used in engineering based on emulating the elements, models and systems found in nature to find engineering solutions to technological challenges and this type of design makes sustainable systems.

Historical Interdisciplinary collaboration In Civil Engineering

One of pioneering examples of Research in civil Engineering was the Joseph Monier, A French Gardener who used concrete and steel in making flower pots and exhibited them in 1867 Paris Exposition showing how beautifully two diverse materials could combine to provide a powerful use and propelled the imminent rise of RCC design and construction technology and later this cascaded over the time such as Prestressed concrete, and use of alternates like FRP Concrete, Bamboo Reinforced concrete to reduce cost of construction. Almost everyone is aware of invention of water wheel and how Archimedes decoded principle of Buoyancy and ran shouting ‘Eureka Eureka’ and set the foundation for Hydraulics and fluid Mechanics. Similarly, all are aware of Joseph Aspidin who discovered cement and how Charles Good year through Vulcanisation of Rubber revolutionized transport Engineering. The great Leonardo Da Vinci was multi-talented & a painter too. Similarly in Geotechnical Engineering, it was an Agriculture scientist Atterberg who devised criteria for classifying soils based on liquid limit, plastic limit and shrinkage thus setting up the criteria for soil classification. Similarly it was Brownian motion of Robert Brown that was used to explain the colloidal behavior of clays. Any Geotechnical Engineer can never forget the fact that father of Geotechnical Engineering Karl Terzaghi was originally a Mechanical Engineer who developed a keen interest on Geology and Earth materials and through his spring analogy explained consolidation process of soils and brought respect to Youngest Branch of Civil Engineering in 1930 through his Book ‘ErdbauMechanik’. In fact, if we delve deep into the history, we will easily know how Civil Engineering was inspired by Scientists and Researchers (Physics, Chemistry, Biology, Economics, Geology, Geography and even Arts). Similarly, when we look at subject specific scientists example Rankine had contributed in almost all three Mother trades, not to forget Coulomb who was a Physicist. The Great Temples were built by Kings who were not Engineers and rather became known as Engineer Kings.

Cases of Interdisciplinary collaboration In India Post Independence (Few examples)

The Krishna Raja Sagar Dam (Popularly called Kannambadi) is a clear example of interdisciplinary collaboration between people having different levels of education and prosperity and complete support to research (The proactive Wodeyars, the brilliant Engineer Sir MV and Diwan T Ananda Rao, people of Mandya District, the farmers who parted with their land not to forget the queen Her excellency

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Kempananjammani Vani Vilasa who mortgaged her jewels to support the project). Such was the work that Government established Karnataka Engineering Research Station which started as a small research unit in water resources and today has diversified in multi disciplines of Civil Engineering.

If we look at the gigantic Vidhana Soudha , the man who lead efforts was Karnataka's second Chief Minister Kengal Hanumanthai, a lawyer who took the comment of visiting Russian dignitaries that Bengaluru did not have any structure which showcased Indian Culture and was instead showcasing British Architecture seriously and thus the greatest Assembly Building was built by a Civil Engineer (Mr B R Manickam, a Civil Engineer who was designated as Government Architect) and his team of workers mostly Prisoners who were set free on its completion and inaugurated by our first Prime Minister Pandit Nehru. Similarly, the Bhakra Nangal Dam was not built by a qualified Graduate /Post Graduate Civil Engineer but an 8th Grade pass Harvey Slocum. Starting in his late 40s, his last project was the massive and extremely challenging Bhakra Dam in northern India. Slocum was hand-picked by Prime Minister Nehru as lead construction engineer for the project. He worked on Bhakra from 1952 until his death on the job in 1961 at the age of 74. At the time of its completion, Bhakra was the tallest concrete dam in the world, provided irrigation to over 6.5 million acres of new farmland and hydroelectric power to over 5,000 villages. In Bhilai Steel Plant, when a Blast furnace Broke down as cast iron got solidified , experts from US, UK and Germany suggested the dismantling. The Indian Government brought in the Russian Blast Furnace operator Konstantin Khabarov from Magnitogorsk and in 12 days the Blast furnace was restored .

From the above, we can easily conclude that every level of education /age has scope for interdisciplinary research and Collaboration provided we have the mindset, and our research must delve into history

Current Research - Bridging the gap between Industry and Institute

The gap between Research and Practitioner especially in Civil Engineering is initially acute with Industry resisting change (for example use of fly ash) and relying on natural materials until MoEF made it mandatory in early 2000 based on Fly ash Mission report to use fly ash in Highway construction and do proper research to make it useful if it was non pozzolanic through lime addition. Later on MORTH promoted use of plastic and rubber wastes, blast furnace slag materials etc. These days Thermal Power Producers have their own Research centres and provide ready mix Plastering material. Similarly BWSSB provides treated waste water, for construction to name a few. IRC (Indian Roads Congress) has successfully collaborated with many Institutes such as UVCE, BTRA, Highway

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Multidisciplinary Streams
August 2024**

Research Station ,Highways Department ,TN ,IIT and many more. We are the seventh Largest country in world, and have the largest working population with world class IIT/NIT/University Engineering Colleges all having syllabus which is more or less common across India. Our Research Institutes (Under CSIR) produce some of highest quality research in Frontier areas of Civil Engineering Science and technology. We may therefore conclude confidently that the gap between what Engineers learn in College and what they are implementing while working in Industry has reduced greatly.

Education course -Tier I/II Institutes

The syllabus for Graduate Engineering Course is almost same in India whether it is IIT/NIT/ Govt Engineering /Private Colleges. The entrance exam for Post-graduation is also the same (GATE). Despite this, a disparity in skills from students passing out from IIT /NIT /Other Engineering Colleges is seen initially, which later tapers down as the Industry practice is more or less uniform and follow the established Indian Standard codes of Practice (BIS) and have cross reference to International standards. Another striking feature is Indians who acquired Education from same they go abroad meaning there is a disconnect not in course but lack of motivation and encouragement to do research and self- study. To address this, there is a need for Industry Institute Partnership to come on a single platform where research and laboratory experiments/trials should be implemented on projects and outcomes deliberated and success stories documented and lessons from failures understood. In Civil Engineering, it should be made mandatory that Industry work in close collaboration with Institute and organize frequent interactions between students, researchers and subject matter experts (Practitioners) and Government regulation bodies (example Bureau of Indian Standards). Finally, the internships should not begin not in the final year but after first year itself in short spells and each student be taken through the working rigors on site and made to work on -site with semi-skilled trades so that they learn to value the education which Graduate Engineers have invested their time and money and respect the efforts of semi-skilled and un-skilled workers . In fact many Post graduate researcher students (Social Welfare / arts and humanities) students have done research projects on Construction Industry covering formal and informal sectors and shown growing gap between Super skilled, Skilled, semi-skilled and unskilled workers. By observing the workers, the Young Engineer may knowingly /unknowingly come out with a solution for a problem. The best example for this is the technique of Corduroy method for stabilization of weak sub-soils (Organic swamps) where road Building in earlier days was very difficult .This technique later on with inter-disciplinary collaboration later led to use of Geosynthetics as wood became scarce and deforestation became a challenge



Corduroy logs

Course to Practice Interdisciplinary gap in Civil Engineering at various levels

In four year, Graduate Civil Engineering Course, Graduate students interact minimally with Architecture and there is only course called Architecture and Town Planning. After the second year, there is hardly any collaboration between Civil Engineering and Electrical, Mechanical group (These trades are collectively known as Mother trades). The Civil Engineering course curriculum does not provide training in bar bending, masonry, scaffolding ,painting , carpentry , flooring (tile work) , Electrical and plumbing. To date, all these works are done by school dropouts who either learnt trade by watching /working under a skilled supervisor (Contractor) or followed a family tradition. Unfortunately, with pay related and mobility issues of these workers, this has led to a huge shortage of these resources. In Geotechnical field works itself, we have region specific workers (Tamil Nadu, Jharkhand, Chattisgarh etc). This needs to be researched and addressed.

Education - Research vs Industry as a Career

Given the fact that nearly 98% of earning population and filing IT returns in India are below EWS definition and therefore aim of these families is to ensure that their children enrolling in Civil Engineering score good marks , get admission into a good college and complete the degree course without backlogs and get an employment in a good company that pays on time or score good marks to go for Higher education. Graduate Education fees are generally exorbitant, and many parents take loans. Therefore, very few Graduates go for research given the fact that it is not seen as an attractive career choice, and they have to repay loans taken for education. While working, few take up IAS /IES/CDS/PSU exams as these offer stable career and recognition. Very few are enterprising enough to start their own organizations and prosper. This needs to be researched and addressed.

Regular course vs Distance Education- Efforts of Government in Bridging the gap

Not all are able to attend regular courses of Graduate education. For those who manage to get it, the opportunity for employment is very competitive while the focus on research is minimal clearly indicating that efforts need to be scaled up to a much larger dimension than what we are doing now. Prior to Digital era, we had Evening Colleges, Open Universities (In-fact our IGNOU is world's Largest Open University) and by collaborating with Doordarshan & All India Radio (Now known as Prasar Bharati), they have the GYAN Vani Radio and TV channels that take education to those who cannot afford to attend Regular courses at their doorstep. For those students who failed to make it to Elite Institutions such as IIT & IIM, Government through the NPTEL revolutionized offerings in specific subjects thus gave the advantage of credits and academic recognitions for students pursuing multi courses on NPTEL Portal. There is a need to research the benefits which students and Industry is getting on account of this initiative of Government of India

Bodies engaged in Research in Heritage Structures

Bodies such as UNESCO, ICOMOS, ASI have carried out painstaking efforts to decode how civilizations and civilization structures flourished and how natural materials were used and as a result we have a wide repository of Knowledge. It is undoubtedly a matter of great curiosity that how previous generations despite not having state of art technologies and equipment built well foundations for Taj Mahal, Rock cut Kailasanatha Temple, Very deep Rani ka Vav Well, liquefaction resistant Temple foundation in Puri and uplift resistant Brihadeshwara temple complex (That too without any reinforcements). Unfortunately, this knowledge is available either in restricted circulation or is not fully available to public. There is a need to bring on platform all agencies who have worked and collate the information and make it as a compendium for every heritage structure regardless of big /small. To conclude, this requires an initiative at Engineering College level and support from the industry

Benefits of Industry -Institute Research in Civil Engineering

In India Padma Sri Dr Vasudevan, a Professor from Department of Chemistry (Thiagarajar College of Engineering), Madurai innovatively used the plastic waste and today nearly 30,000km of roads have been constructed using this material. Apart from this Indian Roads Congress have come out with a draft guideline for use of various wastes as a filling material instead of dependance on natural good quality soils thus not only utilizing the waste material, but saving precious land required for waste disposal . Research has led to building of floating solar projects on fly ash ponds and fly ash dumps. In Bangalore itself, treated wastewater is being pumped from a BWSSB sewage treatment plant as a

Shaping the future of Research and its Innovative Methodologies in Various
Multidisciplinary Streams
August 2024

part of K & C Valley Project to Water scarce Kolar District as a part of Lake refilling and recharging and was appreciated by United Nations General Assembly Chief. Considering the diminishing natural water sources and over -exploitation of ground water table through borewells, research is currently ongoing on use of treated water for non -potable uses on a even larger scale.

Certification and Licensing of Engineering Practice

Another area of engineering that deserves attention of the interaction between Institutes and Industry is the aspect of Professional License for practicing engineers In India. The construction industry desires to execute projects with the most optimum design executed in the shortest possible time. Maintaining the quality and rigor of engineering principles and construction quality and safety is the very critical role that engineers must play in industry. Armed with only a college degree, engineers sometimes find it difficult to discharge this critical responsibility for design and construction of critical structures with the required degree of design and construction safety and quality. A “Professional Engineering” license binds the engineer to a “Code of Ethics” for design and approval of public use structures. This system is in practice in many countries, and it has ensured a robust ecosystem for the engineering profession to be driven by ethical principles. In this area, the various academic and professional institutes can join hands to promote this culture by training and certifying the knowledge and integrity of the engineers before they can be entrusted to work as public utility projects. This collaboration will go a long way to lift the bane of criticism when structures of great public importance fail disastrously as has been witnessed in recent events around the country.

Final thoughts

All future research therefore should be to breakdown the barriers and allow free dissemination of knowledge for betterment of mankind through a calibrated **3I approach** (Industry Institute Interaction) where Educational Institutes involve their subject matter experts with Industry Practitioners and share knowledge. Future research should realize the vision of our People’s President, His excellency Late Dr APJ Kalam Sir ‘s vision of National Prosperity Index.

National Prosperity Index = A+B+ C

- A= GDP (Consistent Economic Growth)
- B= Lift 22% of People below BPL gradually
- C= Promote value systems in every endeavor

**Shaping the future of Research and its Innovative Methodologies in Various
Multidisciplinary Streams
August 2024**

At the Industry level, research should focus on sharpening the skills of workers at every level right from Contractor to Supervisor and in their respective works in both technical and commercial and statutory obligations. Due to lack of this training, many a time we can see projects dragging beyond a time line with cost over runs as disconnect arises between Design Engineer, Construction Engineer and worker who is in between actually implementing the work

Construction skills research and training Institutes should be set up to cater to these areas and slowly broadened to other areas at every state, so that local unemployment issues get sorted out.

For those passionate for a research career in Engineering, there is a need to make research attractive by providing better pay /incentives which can happen only if Industry joins hand with Institute and funds research Studies /Projects .

To address the huge shortage in qualified manpower at ground level in every aspect of Civil Engineering (Basic to advanced). there is a need to upgrade ITI/ NCVTs training courses in Construction Industry to Level as seen in GTTC/CMTI for those who could not go for higher education due to various reasons.

All research is focused on use of sustainable technologies and is done on a laboratory scale by Qualified Engineers, however the training need for workers is ignored. The worker who will implement the technology needs to be trained

REFERENCES

Published information (Newspaper and social media) on various case studies mentioned here