A Predictive Analytics on Structural Design and Construction Engineering (SDCE) to enhance the Global Quality using Big Data

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Abstract

Today's status of Civilology served as a benchmark on Structural Design and Construction Engineering (SDCE) to create a sustainable world and enhance the global quality of life using current trends of Big Data techniques. Civilology serve competently, collaboratively, and ethically as master in planners, designers, constructors, and operators of society's economic and social engine - the built environment; stewards of the natural environment and its resources; innovators and integrators of ideas and technology across the public, private, and academic sectors; managers of risk and uncertainty caused by natural events, accidents, and other threats; and in this paper we include the discussions and decisions to shaping public environmental and infrastructure policy. A Predictive analytics is about to make risk management much easier. The difference between a successful construction company and a struggling construction company lies in their ability to manage risk. In this paper the proposed method provides beta tests with leading edge companies to manage their risk through the use of predictive analytics. We analyze data from subcontractors, materials suppliers, design plans, and the site itself to analyze risk factors based on historical data. It provides a dashboard where GCs (General contractors) can identify which elements of their project are highest risk and need attention, and allows them to drill down to see the reasons for the risk assessment. Project IQ (Integrity and Quality) learns both from past data and from how the GC interacts with the information it provides, in order to continuously provide better and more accurate risk assessments. Finally we presented on future of SDCE to enhance the global quality using innovation technology of Big Data Predictive Analytics (BDPA).

Keywords: *Collaborate on intra-disciplinary, cross-disciplinary, and multi-disciplinary traditional and virtual teams of Civilology, Structural Design and Construction Engineering (SDCE), Predictive analytics.*

1. Introduction

The Future of Structural Design and Construction Engineering (SDCE) were convened in response to the status of, concerns with, and opportunities for the civilology profession. That is, professional (licensed) civil engineers, non-licensed civil engineers, technologists, and technicians. "Destiny is not a matter of chance; it is a matter of choice" by Statesman William Jennings Bryan and said there are only two futures for civil engineering around the globe; the one the profession creates for itself or, in a void, the one others create for civil engineering. The Future of SDCE proved to be a stimulating, uplifting, collaborative, and creative, also to guide policies, plans, processes, and progress within the global civilology community. The Civilology community is global with many diverse interests; it could and perhaps should rally around a common vision to the benefit of all. Also, it creates a sustainable world and enhances the global quality of life [1].

The attributes as includes desirable knowledge, skills, and attitudes possessed by the individual consistent with the profession's aspiration [8]. The knowledge is largely cognitive and consists of theories, principles, and fundamentals. For example, geometry, calculus, vectors, momentum, friction, stress and strain, fluid mechanics, energy, continuity, and variability. In contrast, skill refers to the ability to do tasks. Examples are using a spreadsheet; continuous learning; problem solving; critical, global, and integrative/system, creative thinking; teamwork; communication; and self-assessment. Formal education is the primary source of knowledge, whereas skills are developed via formal education, focused training, and on-the-job experience. Similarly, Attitudes conducive to effective professional practice include commitment, curiosity, honesty, integrity, objectivity, optimism, sensitivity, thoroughness, and tolerance.

The SDCE is knowledgeable. He or she understands the theories, principles, and/or fundamentals of Mathematics, physics, chemistry, biology, mechanics, and materials, which are the foundation of engineering; Design of structures, facilities, and systems, Risk/uncertainty, such as risk identification, data-based and knowledge-based types, and probability and statistics Sustainability, including social, economic, and physical dimensions; Public policy and administration, including elements such as the political process, laws and regulations, and funding mechanisms; Business basics, such as legal forms of ownership, profit, income statements and balance sheets, decision or engineering economics, and marketing; Social sciences, including economics, history, and sociology; Ethical behavior, including client confidentiality, codes of ethics within and outside of engineering societies, anticorruption and the differences between legal requirements and ethical expectations, and the profession's responsibility to hold paramount public health, safety, and welfare [3].

The Civilology is skillful as collaborate on intra-disciplinary, cross-disciplinary, and multi-disciplinary traditional and virtual teams. Apply basic engineering tools, such as statistical analysis, computer models, design codes and standards, and project monitoring methods; Learn about, assess, and master new technology to enhance individual and organizational effectiveness and efficiency; Communicate with technical and non-technical audiences, convincingly and with passion, through listening, speaking, writing, mathematics, and visuals; Manage tasks, projects, and programs to provide expected deliverables while satisfying budget, schedule, and other constraints; Lead by formulating and articulating environmental, infrastructure, and other improvements and build consensus by practicing inclusiveness, empathy, compassion, persuasiveness, patience, and critical thinking [7].

The SDCE embraces attitudes conducive to effective professional practice. Creativity and entrepreneurship that leads to proactive identification of possibilities and opportunities and taking action to develop them; Commitment to ethics, personal and organizational goals, and worthy teams and organizations; Curiosity, which is a basis for continued learning, fresh approaches, development of new technology or innovative applications of existing technology, and new endeavors; Honesty and integrity telling the truth and keeping one's word.; Optimism in the face of challenges and setbacks, recognizing the power inherent in vision, commitment, planning, persistence, flexibility, and teamwork; Respect for and tolerance of the rights, values, views, property, possessions, and sensitivities of others; Thoroughness and self-discipline in keeping with the public health, safety, and welfare implications for most engineering projects and the high-degree of interdependence within project teams and between teams and their stakeholders. Many of the preceding attributes are shared with other professions. Civilology's uniqueness is revealed in how the attributes enable the profession to do what it does and, more importantly, to become what it wants to be. This is inherent in the global aspiration vision [17].

2. Design and Practice of Sustainable

The global civil engineering profession includes SDCE has increasingly recognized the reality of shrinking resources, the desire for sustainable practices and design, and the need for social equity in the consumption of resources. SDCE have helped raise global expectations for sustainability and for environmental stewardship. The profession has led world acceptance of green design and has been at the forefront in making environmental considerations part of life-cycle and cost-benefit analyses. SDCE have urged clients to use new, environmentally-friendly technologies to improve the quality of life in urban environments. Designs routinely incorporate recycling, either by using recycled materials, or by making project components recyclable at the end of their useful life. New processes, less harmful to the environment, have been implemented, and most new construction is based on green and smart-building technologies. Many new buildings actually produce more energy than they consume. The Design of Sustainable Building Strategies is Shown in figure 1.

Figure 1. Design of Sustainable Building Strategies

Today, people occupy more space on the planet than they did 30 years ago, and they are straining the earth's environment, particularly the needs for energy, fresh water, clean air, and safe waste disposal. During the past 30 years, gradual global warming has profoundly affected the more than half of the world's population that lives within 50 miles of coastal areas. These areas have become much harsher places to live because of sea-level rise, increased storm activity, and greater susceptibility to flooding.

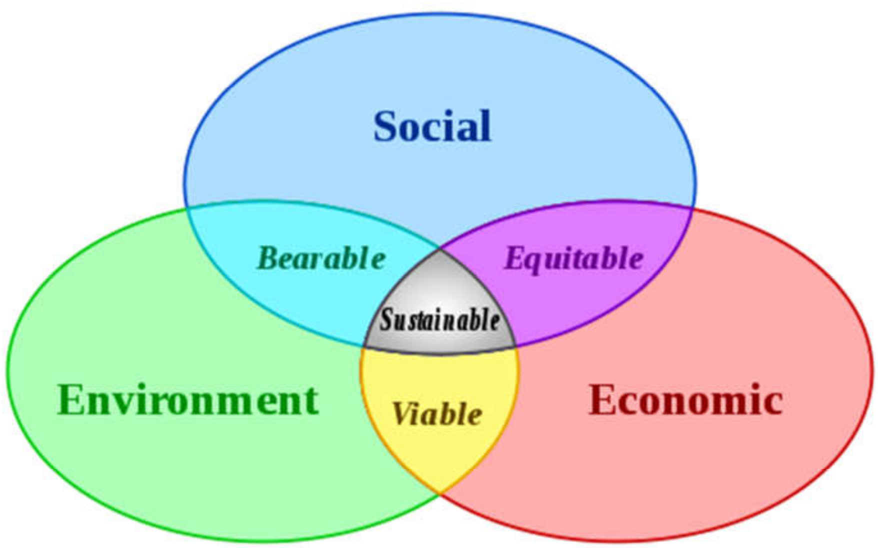

Figure 2 Three tier model of Sustainable Development

Growing population, shrinking resources, and climate change have put sustainability at the forefront of issues requiring global attention. Shifting demographics and population growth continue to strain the overburdened infrastructure. The shift of people from rural areas to cities and exurban areas has accelerated, resulting in increased population density around the world. In the developed world, infrastructure is aging, and maintenance or replacement has not kept pace with its deterioration.

In the developing world, the need for new infrastructure outstrips society's ability to put it in place. Influenced by civil engineering leadership, people now better understand the crucial link between infrastructure and quality of life, which has caused a major public policy shift in favor of improved infrastructure maintenance and accelerated infrastructure construction. Improved understanding of the environment and the acceptance of broadly shared environmental values have led to an increased understanding that global environmental problems must be solved with global solutions. Nations unwilling to accept these values face worldwide pressure to conform to global norms for sustainability to improve the quality of life around the world. The Three tier model of Sustainable Development is shown in figure 2.

Demands of SDCE for sustainable energy, fresh water, clean air, and safe waste disposal drive infrastructure development on a global scale. Constrained resources and growing energy demands have led to the need to prioritize energy resources and use alternative fuels. The use of clean coal along with carbon sequestration, nuclear energy, and renewable sources such as wind, solar, waves, and geothermal have made it possible to meet growing demands. In addition, increased urbanization has led to greatly increased use of mass transit and much less reliance on personal automobiles, which has greatly reduced demand for fossil fuels. Most vehicles now use fuel cell technology or renewable resources, such as ethanol. The need for fresh water continues to be a global issue. Rapid urbanization in developing countries has made it a challenge to meet ever-growing demands for clean water. Improved water purification methods, desalination technologies, and increasing use of closed-loop systems have helped meet needs. There is a growing use of gray-water systems and a changing philosophy to purify water at the point-of-use in decentralized systems. This has reduced the need to treat large quantities of water to drinking water standards when only a small fraction is taken internally by humans. It has also led to energy savings for water treatment.

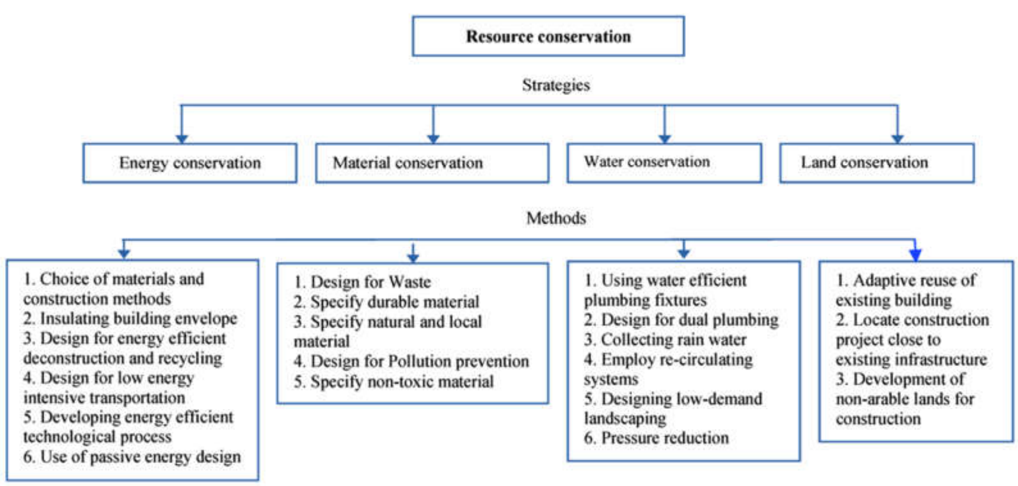

Figure 3. Sustainable Resource conservation Strategies

The principles of sustainability based on SDCE are also driving demands for safe waste disposal and for increased recycling and re-use to make substantial reductions in the waste stream. Advances in nuclear technology have changed the requirements for disposal of highly radioactive nuclear waste. Life-cycle design philosophies have taken hold resulting in nearly zero net waste and great savings in energy consumed for waste disposal. Virtually everything is recycled and re-used [13]. Figure 3. Shows Sustainable Resource conservation Strategies

3. Big Data Predictive Analytics (BDPA)

In today's day and age, data is becoming more and more important in almost every industry. In Structural Design and Construction Engineering (SDCE), even the smallest slip-up or miscalculation can lead to millions of dollars lost or not finishing a project on time. Using new and advanced data analysis, such as predictive analysis, jobs can be completed more efficiently and on time using predictive analysis to identify trends and more able to identify problems that may occur [12].

To the best of our knowledge, there is currently no comprehensive predictive analytic of Big Data techniques in the context of the SDCE industry. This paper fills the void and presents a wide-ranging interdisciplinary, cross-disciplinary, and multi-disciplinary traditional and virtual teams of civilology fields such as statistics, data mining and warehousing, machine learning, and Big Data Predictive Analytics (BDPA) in the context of the SDCE industry. We discuss the current state of adoption of Big Data in the SDCE industry and discuss the future potential of such technologies across the multiple domain-specific sub-areas of the SDCE industry [1].

The Big Data Predictive Analytics (BDPA) has a rich intellectual tradition and borrows from a wide variety of fields. There have been traditionally many related disciplines that have essentially the same core focus: finding useful patterns in data (but with a different emphasis). These related fields are Statistics, Data Mining, Predictive Analytics, Business Analytics, and Knowledge Discovery from Data (KDD), Data Analytics, Data Science and now Big Data [8]. Fig 4 shows the relevance of these multidisciplinary fields to Big Data. So, Big Data Predictive Analytics is a broadening of the field of data analytics and incorporates many of the techniques that have already been performed. This is the key reason that most of the existing work, presented in subsequent subsections, has focused on data analytics rather than Big Data is that the Big Data revolution i.e., the ability to process large amounts of diverse data on a large scale has only recently happened. The proposed method can be possibly extended to the environments, dealing with large, diverse datasets.

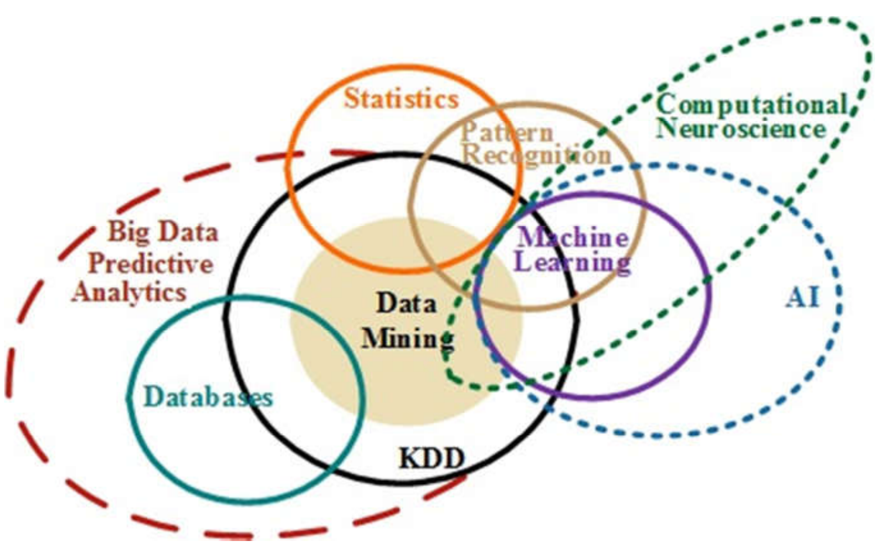

Figure 4. Multidisciplinary Nature of Big Data Predictive Analytics

Some ML-based tools have been developed for Big Data predictive analytics. ML has many applications across the SDCE applications, such as the modeling of judicial reasoning and predicting the outcomes of litigation is thoroughly studied using Statistics, Data mining, and Machine learning Techniques [11]. Table 2 highlights Big Data Predictive Analytics (BDPA) ML Tools.

Table 1. Big Data Predictive Analytics (BDPA) ML Tools

Tool Name	Description	Supported Language	ML at Scale	Supported Algorithms
Apache Mahout	Mahout is an open source Machine learning frame work	-Java -Scala.	Yes	• Collaborative Filtering • Classification • Clustering • Regression
R	R is open source programming language for statistical analysis	Many languages	Yes	• Collaborative Filtering • Classification • Clustering • Regression
MLbase	To support full life cycle activities such as ML optimizer, MLI and MLlib	-Java -Scala. -Python	Yes	• Collaborative Filtering • Classification • Clustering • Regression
Oryx	Oryx is open source ML library includes HDFS/PMML	-Java	Yes	• Collaborative Filtering • Classification • Clustering • Regression

- **Statistics:**

In scientific studies, rigorous and efficient techniques are used to answer research questions. Careful observations (data) related to SDCE comprise the backbone of underpinning investigations. Statistics is the study of collecting, analyzing, and drawing conclusions from the data, with the primary focus on selecting the right tools and techniques at every data analysis stage. Right from the data collections, to efficiently analyzing it, and then inferring or formulating conclusions out of it, all of these steps come under the scope of statistics. Various fields of analytics are borrowing techniques from statistics.

- **Data Mining:**

Data Mining is concerned with the automatic or semi-automatic exploration and analysis, of large volumes of data, to discover meaningful patterns or rules based on SDCE. Data Mining has the broader scope than other traditional data analysis fields (such as statistics) since it tends to answer non-trivial questions. For patterns discovery and extraction, Data Mining is primarily based on the technique(s) from statistics, machine learning, and pattern recognition. Several models are created and tested to assess the suitability of particular technique(s) for solving the given business problem. Models with the highest accuracy and tolerance are chosen and applied to the actual data for generating predictive results (including predictions, rules, probability, and predictive confidence) [2].

- **Machine Learning Techniques:**

Machine learning (ML), a sub-field of Artificial Intelligence (AI), focuses on the task of enabling computational systems based on SDCE to learn from data about specific task automatically. ML tasks can be categorized into:

i) classification (or supervised learning);
ii) clustering (or unsupervised learning);
iii) association;
iv) numeric prediction

4. Application

Despite the opportunities and benefits accruable from Big Data in SDCE industry, some challenging issues remain of concern. This section discusses some of these challenges and provides suggestions to deal with them for the successful implementation and dissemination of Big Data Predictive Analytics technologies across various domain applications of the SDCE industry.

❖ ***Data Security, Privacy and Protection:***

Prominent among these concerns is the issue of SDCE such as data security, data ownership, and management issues. To scale the hurdles posed by these challenges, several research studies have proposed and implemented security measures such as access control, intrusion prevention, Denial of Service (DoS) prevention, etc.. These issues also require more study in the context of SDCE-related construction data, and the appropriate solutions also need to be adopted in the underlying analytics workflows.

❖ ***Data Quality of Construction Industry Datasets:***

The construction industry is well-known for fragmented data management practices. Despite the aggressive promotion of Building information modeling (BIM), companies using BDPA are rare. Null values, misleading values, outliers, non-standardized values, among others, are some of the essential traits of industry data. And producing high-valued analytics is challenging due to poor data management practices. High-quality data is preliminary for successful BD projects. It is observed that analytics projects usually require approximately 80% of time cleaning noisy datasets before embarking on analytics. So, Big Data projects in construction industry shall also be specially taken care of, for data quality related issues. Otherwise, the resulting insights are likely to mislead, which in turn will result in unpleasant and pessimistic feeling in the industry. Consequently, the industry will be reluctant towards adopting such fascinating trends like Big Data.

❖ ***Cost Implications for Big Data in Construction Industry:***

Every technology incurs cost so introducing BDPA in SDCE is not for free of charge. Companies are required to set up data centres and purchase software licenses, which can be an attractive investment. Also, a skilled IT personnel to keep the entire ecosystem running is another overhead. So BDPA has inevitably substantial cost implication. The SDCE business is considered amongst the low-profit margin businesses, and introducing such costly add-ons to projects is more likely to be opposed and difficult to be defended. However, BDPA has the potential to enhance the overall project delivery by optimizing processes and reducing risks that companies usually bear due to myriad inefficiencies such as delays, litigations, etc. It is highly optimistic that SDCE industry can gain huge revenue from this investment as experienced by other industries, provided the 5right methodology is used to employ BDPA. The exact cost implication of BDPA is, however, difficult to quantify. More studies on cost-benefit analysis of using BDPA technologies in SDCE projects are required.

- ***Internet Connectivity for Big Data Applications:***

To monitor project site activities at real-time, instant data transmission between project sites (dams, highways, etc.) and centralized BDPA repository should be supported. However, project sites usually have low bandwidth; due to unavailability of sophisticated networking infrastructure in rural, underdeveloped areas. Advanced wireless sensor networks need to be extended to tackle internet connectivity issues in these types of BDPA applications; otherwise, the decisions on stale offline data will not be useful for effective monitoring.

- ***Exploiting Big Data to its Full Potential:***

The effectiveness of BDPA cannot be measured just by accumulating large volumes of data; it is more of the use cases or industrial problems that dictate the usefulness of these technologies. It is feared that the SDCE industry might not extract the full value of accessible BDPA using BIM if the conceived use cases are vague. To this end, researchers or domain experts are required to highlight domain-specific problems that are the subject of BDPA. This way BDPA as a technology will not be the driving force rather the industry itself will lead the innovation by applying contemporary tools to solve its topical issues. Additionally, BDPA is not the silver bullet, it merely sets the stage. Skilled professionals and domain experts, empowered with sophisticated analytical workflows, are equally necessary to reap the overall benefits. Without whom, the applications are likely to get into the pitfall of producing too much information that should not be delivering significant insights for the purpose.

5. Conclusion

Although the Structural Design and Construction Engineering (SDCE) industry generates massive amounts of data throughout the life cycle of a building, the adoption of Big Data Predictive Analytics (BDPA) technology in this sector lags the progress made in other fields. With the commoditization of the technology necessary for storing, computing, processing, analyzing, and visualizing Big Data, there is immense interest in leveraging such technologies for improving the efficiency of construction processes. In this exploratory study, we have analyzed the Design of Sustainable Building Strategies extent to which the industry has employed Big Data Predictive Analytics (BDPA) technologies. Towards this end, we have reviewed latest research also relevant research articles that have been published over the last few decades in which the precursor to modern Big Data Predictive Analytics (BDPA) techniques have been deployed in various domain-specific SDCE applications. Principal Big Data technology streams are explained to help users to understand the Sustainable Resource conservation Strategies. Concepts of Big Data Engineering and Big Data Analytics are demarcated; the works utilizing these technologies across various sub-domains of the SDCE industry are deliberated.

6. Future Scope

Civilology in SDCE thus find themselves as keepers of an impressive legacy while raising concerns about future directions. They know they must take more risks. They know they must show more leadership. They know they must control their own destiny rather than letting events control them. The future envisioned, leaders have a target to guide their policies, plans, processes, and progress on a broad and diverse front, within and outside the engineering community. Also the civilology in SDCE community should recognize that: A variety of partners must be engaged, and opportunities for collaboration and action identified: The public and policy-makers must be engaged so that the profession serves society to the fullest: The education and training of future civilology and the continued development of today's civil engineers based on SDCE: A greater level of collaboration and communication among SDCE and those non-engineer stakeholders, seeking to balance a sustainable environment with needed infrastructure. Similarly, experienced engineers should coach and mentor younger engineers with the goal of enhancing knowledge, skills, and attitudes initially acquired during formal education. Finally, research and development was increased to mitigate the effects of natural disasters, with SDCE playing a leading role in devising and implementing the innovations to enhance the global quality of life.

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