AN EFFICIENT APPROACH FOR PREDICTING ON-SITE ENVIRONMENTAL IMPACTS FOR CONSTRUCTION WITH THE HELP OF KPI

KOMMINENI VENKATESHWARA RAO
Govt Womens Polytechnic College Bhopal, Madhya Pradesh, India

P.PADMAJA
RGPV Diploma Wing , Bhopal, Madhya Pradesh, India

ABSTRACT

Construction is one of the prominent indicators of development. As the nation progresses in development ,construction activities that includes, development of dwelling places, recreation facilities , transportation corridors both in-ways, waterways and air ways are fast growing to match the needs and demands of mankind. At the same time making a dent on the ecosystem, natural resources and humans. Thus, it is necessary to carryout impact assessment of these activities on vital parameters of the environment, by monitoring some identified Key Performance Indicators in the performance area. This data can be used to choose economic, sustainable methods that meet the future challenges.

KEY WORDS : Performance indicators, Impact assessment, Construction Industry

INTRODUCTION

The environmental sustainability is the biggest challenge for the construction industry contributing 25-40% of carbon emissions on the global scale. The Indian emissions from construction industry are even more since construction methods are still traditional. Climate change and the environment is a global agenda, and the world is giving importance to sustainable development. Emission norms revised once the advanced technology has reached manufacturing from the research and development stage. To enforce the standards, it is necessary for predicting the on-site environment.

For analysing the environmental consequences, the environmental impact assessment gets carried out for examining the plan, policy, program or actual projects before the decision to move forward with proposed action.

Construction industry contributes a considerable quantity of emissions in the environment. The literature reviewed has presented various cases of pollution and solutions for them. In [1] the environmental imbalances are studied while laying the pipeline. The study helped in setting the parameters for the sub-goals. Hazard analysis assisted in identifying the source of pollution the probability of occurrence of an adverse effect and create a tree of causes of atmospheric pollution due to the pipeline construction. The research pays particular attention to the impact from the particulate matter of inorganic and abrasive dust on the air while pipeline construction.
Research has got carried out for reducing construction waste that affects the environment. In [2] the results of the study on the harmful impact construction wastes have on the urban environment, and construction environmental safety gets described. The basis of research results is on the statistical data and indicators calculated with the use of ecological pollution assessment in the restoration system of urban buildings technical conditions. The scientific basis for the technique for the reduction of environmental pollution from construction wastes on the analytic summary of experimental and practical results for environmental security guaranteeing at large scale revamp and current restoration of the buildings and structures. It is also based on the practical utilisation of the system analysis, probability theory method and disperse system theory. It is essential to execute some stages implementing the developed technique for reducing environmental deterioration from

construction wastes. The stages involve various steps starting from data gathering to the system formation with best performance aspects which are more resource saving and energy efficient for the accumulation of construction wastes from urban construction units.

The environment has a higher impact on the construction of roads compared to buildings. Pollutants discharging through drainages on highways is a serious concern. Unlike building construction, the pollutants in highway construction is not concentrated and affects the areas through which they pass. To minimise the impact smart road construction methodologies have got proposed. The main features for smart roads are:

i. Automatic Information exchange in the supply chain of asphalt road construction.

ii. Sensing and communication technologies enable real-time path planning of compactors.

iii. Belief-desire-intention software agents and real-time sensory inputs.

iv. Methods and results to simulated and field-realistic experiments get presented.
v. benefits asphalt compactor operators and improve the quality of roads.

These qualities of smart roads get discussed in *(Robin Kuenzel et al., 2016)*

The forthcoming tasks get solved under specific studies:

Gathering of primary data about construction debris accrual; definition and comparison of technological combinations at each system utilitarian stage intended for the curtailment of construction wastes disposal into the surroundings; assessment criteria calculation of resource saving and energy efficiency; most favourable working parameters of each implementation stage get created. The employment of urban construction technique shows that the resource saving criteria range from 55.22% to 88.84%; the potential of construction wastes recycling is 450 million tons of damaged construction elements (parts).

The environment impact assessment model got proposed in (Li et al., 2010)

PROBLEM STATEMENT

The current study aims at predicting the on-site impact for construction through an efficient approach using Key Performance Indicators (KPI).

The KPI for the construction sector was first proposed in (Chan & Chan, 2004) because the construction industry is dynamic. The concept of project success has remained ambiguously defined in the construction industry. Project success is almost the ultimate goal for every project. Some writers consider time, cost and quality as arbitrary criteria; others suggest that success is something more complex. The paper developed a framework for measuring the success of construction projects. In this paper, a set of key performance indicators (KPIs), measured both objectively and subjectively get developed through a comprehensive literature review. Three case studies also test the validity of the proposed KPIs. Then, the limitations of the suggested KPIs get discussed. With the development of KPIs, a benchmark for measuring the performance of a construction project can get set. It also provides significant insights into developing a general and comprehensive base for further research.

Paper *(Gonzalez & Navvaro, 2006)* discusses that a considerable quantity of CO_2 gets emitted to the atmosphere at different stages of the building life cycle: in the production of materials and products, in the construction of the building, in the setting on site, in the exploitation, the renovations, the later rehabilitation and finally demolition. The paper shows the possibility of reducing the CO_2 emissions up to 30% in the construction stage, through a cautious selection of

low environmental impact materials. This study intends to gauge the net quantity of CO_2 discharge reduced by the approach presented in the appropriate phase of material selection within the life cycle of a building. This material selection and the bio-climatic characteristics must get defined from the early design project phase. The investigation presented here has been carried out on a case study of three terraced houses built in Spain, comparing them with a building with similar characteristics but constructed in a conventional way and with no selection of materials. The houses have got constructed following low environmental impact criteria, including alternative energies for future use and maintenance.

In the paper *(Li et al., 2010),* A quantitative assessment of the environmental impact of construction activities can help decision-makers identify major ecological impact factors and make environmentally friendly construction plans in the early stages of construction. This paper presents an integrated lifecycle environmental impact assessment model that applies to construction phase studies, where impact factors get examined according to two aspects of a typical construction process: construction equipment and ancillary materials. Environmental impacts get categorised into three safeguard subjects: ecosystems, natural resources and human health. A disability-adjusted life year (DALY) model for assessing human health damage due to construction dust gets developed. Also, the environmental impact of earthwork construction gets evaluated as a case study to demonstrate the application of the proposed model. Results indicate that the proposed model can adequately quantify the environmental impacts of construction processes, and can potentially get used as a tool for contractors to select environmentally friendly construction plans.

AIM

The principal aim of this research/project is to predict the impact of construction on environmental degradation in a way that is more accurate, precise, without bias and instruments used for measuring parameters should be highly sensitive for better data collection. The assessment of environmental aspect includes the development of key performance indicators, formulation of the significance limits and determination of the overall ecological impact of the construction project.

OBJECTIVES

The objectives in this study are to find the contribution of construction towards environmental degradation regarding :

1. Assessment of particulate emissions in the air.
2. Water pollution.
3. Landfills because of rubbish created by the construction industry.
4. Other local issues.

These factors are included in determining pollution using KPI.

RESEARCH METHODOLOGY

The KPI measurement needs to be carried out on Key Responsibility Areas (KRA). The Key Responsible Areas are the areas that are deemed to be having maximum pollution. In the national level, the three KRAs get identified, and the impact study gets performed.

Given below are the places where we use the key performance indicators in this research. The onsite environmental impact by construction industry study is to get conducted at

1. Bangalore (Karnataka)
2. Mumbai (Maharashtra)
3. Delhi

These cities are significant sites for the construction industry due to higher demand. The sampling gets done on these cities at various locations. Air, water and soil samples got taken from an area

with higher construction activity and area with least construction activity. The caution gets maintained when selecting the locations; we have to see to it that the selection of sites for comparison is similar in environmental conditions before construction work. These two kinds of samples get examined, and the results of the samples get compared. This study will show the impact of construction on environmental degradation. The KPI will help to assess the effects of construction on pollution.

In the paper (Haapio & Viitaniemi, 2008), Since the field of environmental assessment tools for buildings is vast, this study aims at clarifying that field by analysing and categorising existing tools. The differences between the tools get discussed, and the current situation within the tools gets critically analysed. But the comparison of the tools is difficult, if not impossible. For example, the tools get designed for assessing different types of buildings, and they emphasise different phases of the life cycle. In addition to environmental aspects, a sustainable building contains both economic and social aspects. The switchover from green building to sustainable building and the requirements for future are challenging for developing environmental assessment tools. Moreover, the benefits of using the tools should get analysed — how the tools and their results have affected decision making?

In the paper (Wathern, P. (Ed.), 2013), the comprehensive treatment of environmental impact assessment (EIA) provides a review of theory and practice over the past ten years. EIA gets viewed as both art and science, concerning both the technical aspects of appraisal and the effects of EIA on the decision-making process. Adopted in many countries, EIA gets established as a significant procedure to assess the environmental implications of legislation, the implementation of policy/plans and the initiation of development projects. EIA is becoming an essential part of environmental management.

Stage 1: (Data collection)

Main parameters for environmental aspects are:

1. Emission to air concerning greenhouse gas emission

Greenhouse gas emissions from a building are mainly CO2. The CO2 emissions from reinforced concrete get discussed in (Hermawan et al., 2015). The research has shown that construction activities generate greenhouse gasses.

2. Release of water

The release of water from the buildings under construction consists of a mixture of primer, paints, cement particles. The cement particles tend to clog the water that flows through the drainage system.

3. Waste Generation

Waste generation can get minimised by recycling the waste materials. (Kofoworola & Gheewala, 2009) Conducted a study and the result is that betwixt 2002 and 2005, a mean of 1.1 million tons of construction waste got generated every year in Thailand. This waste comprises about 7.7% of the total amount of waste disposed of in both junkyards and open dumping locations annually during the same period. Estimation is that between 70 and 4,000 jobs would have got created between 2002 and 2005 if all recycling of construction wastes in Thailand had been possible. Additionally, there would have been a contribution of an average savings of 3.0×10^5 GJ (approx.) per annum in the final energy consumed by the construction sector of the country within the same duration based on

the recycling scenario analysed.

4. Local issues

The burning of waste is a problem that cannot be solved as it is unregulated. The piling of ash is an essential issue as air, water and soil get contaminated by ash particles. The ash has a massive share in landfills in countries like India. This ash can get utilised for manufacturing ash bricks. Constructing buildings using fly-ash bricks which get manufactured from the ash deposits will help is partially solving the landfill problems. The solution of manufacturing fly-ash bricks gets discussed in (Obada Kayali, 2005).

5. Land contamination

Stage 2: (Defining the indicators for the collected data)
For defining the Indicators for the collected data, the given below are the measurements required for deriving the KPI. The KPI derivation principles are laid down in ISO 14031:1999 standards.

1. The volume of excavated material per sq.m. of floor area C+0.3N (cu.m/sq.m)

This measurement is required because floor area which got excavated and had the soil removed necessitates dumping the removed soil on another location thereby creating landfills.

2. Quantity of concrete per sq.m of floor area (cu.m/sq.m)
Concrete disables the soil to absorb water in the surface. It is challenging to remove the solidified spilt concrete from the floor. The spilt concrete on the soil reduces the water absorbing power thereby creates water stagnant. These stagnant water can act as breeding ground for insects which spread the water borne diseases.

3. Site occupation per sq.m of floor area (sq.m/sq.m)
If the constructed area gets reduced, the occupation will require a lesser tree uprooted; which means that the floor area to plays an important role in site occupation.

4. Water consumption per sq.m of floor area (cu.m/sq.m)
The water consumption per square metre of floor area plays an important role in key performance indicators. Lower is the consumption of water; better is the performance. A building that consumes less quantity of water helps in water conservation. Hence it is also considered as the Key performance indicator

5. The weight of structural floors, foundations, facades, partition walls, pavements and roofs/sq.m of floor area (kg/sq. m)

The weight of the constructed portions too play an important role in calculating the KPI. It helps in determining the density of the structure thereby helps in determining the strength of the structure. Higher density results in better strength.

6. Floor area (sq.m)
Floor area is the total area of floor in a room or building

7. Facing brick closure (%)
The brick which satisfies the architectural requirements such as form, finish and function (Strength/ absorption) is eligible to be used on external faces is known as " Facing bricks".

8. Synthetic paints and varnishes (%)

The synthetic paints are one of the primary sources of pollution. Till the synthetic colours are intact on the wall, it does not create problems but if the synthetic paints wash off due to ageing these paints mix with the environment and might dissolve in water thereby making it unfit for drinking. Varnishes not only pollutes like paint but besides, it produces foul smell which shows that these synthetic paints and varnishes create air pollution.

9. Floor area with

a. discontinuous ceramic or stone surfaces (%)

This discontinuous surface gets generally placed outside the building that gets constructed. The discontinuous ceramic/stone surface allows the rainwater to seep through the ground, and this is used mainly in places such as car parking/lawns.

b. Continuous ceramic or stone surface (%)

This type of placement is usually used in rooftops, flooring within the building. These unlike discontinuous stone/ceramic surface does not allow seepage of water. The water flow on the top is usually diverted through vents and directed to groundwater recharging.

CONCLUSION

With spurring economic growth, the boom in construction is inevitable even though there is a plunge in real estate prices. With the increase in business activity, the necessity for the construction of business locations is increasing. Hence environmental degradation through construction is inevitable. The necessity for better infrastructure due to booming population has triggered a spike in infrastructure projects. The possible emissions from the construction projects are listed below.

1. Land Pollution
   - Soil mounds created before laying the plinth beam for starting the construction process.
   - Spillage of concrete and cement mixtures on the floor will also contribute to land pollution.

2. Water Pollution
   - Stagnation of water used for construction.
   - Draining of the water used for cleaning the floors after painting work completes into the nearby water bodies.

3. Air Pollution

The air pollution also occurs while construction activity takes place.
   - The particulate emissions such as dust are the main contributor to air pollution
   - Painting activity too creates air pollution as paints and varnishes emit an undesirable smell.
   - Plants can not clear these kinds of pollution, as Carbon dioxide emissions do not cause them.

4. Noise Pollution

The noise pollution occurs due to heavy construction machinery, earth movers, drilling holes on buildings, breaking stones etc. The noise pollution can get reduced by employing machines that produce least noise and machinery that can absorb noise by placing the stone crushing equipment in a closed environment.

Hence natural cleansing of air is ruled out in this case. Similarly, if chemicals such as paints and primers pollute the water bodies, then the natural cleansing of water bodies is also not possible. Dumping the wastes from construction activities on land too pollutes soil and sometimes water table if the pollution exceeds the limit. It can also affect surface water bodies if washed away by rains.

Significant work has been carried to contain the contaminants related to paints and related chemicals released into water bodies and soil. The leachates before being released into atmosphere can be passed through a bed of activated charcoal ,so that the contaminants can considerably adsorbed and thus pollution can substantially be reduced. Dust being a major air pollutant being released into atmosphere from a wide area source is the major concern. Existing rules and regulations should be modified to address the increasing levels of pollution caused by the gigantic activities in the field of construction.

REFERENCE

1. Tomareva, I. A., Kozlovtseva, E. Y., & Perfilov, V. A. (2017, November). Impact of Pipeline Construction on Air Environment. *In IOP Conference Series: Materials Science and Engineering (Vol. 262, No. 1, p. 012168). IOP Publishing*

2. Bakaeva, N. V., & Klimenko, M. Y. (2017, November). Technique for Reduction of Environmental Pollution from Construction Wastes. *In IOP Conference Series: Materials Science and Engineering (Vol. 262, No. 1, p. 012195). IOP Publishing.*

3. Chan, A. P., & Chan, A. P. (2004). Key performance indicators for measuring construction success. *Benchmarking: an international journal*, *11*(2), 203-221.

4. González, M. J., & Navarro, J. G. (2006). Assessment of the decrease of CO2 emissions in the construction field through the selection of materials: Practical case study of three houses of low environmental impact. *Building and environment*, *41*(7), 902-909.

5. Li, X., Zhu, Y., & Zhang, Z. (2010). An LCA-based environmental impact assessment model for construction processes. *Building and Environment*, *45*(3), 766-775.

6. Haapio, A., & Viitaniemi, P. (2008). A critical review of building environmental assessment tools. *Environmental Impact Assessment Review*, *28*(7), 469-482.

7. Wathern, P. (Ed.). (2013). *Environmental impact assessment: theory and practice*. Routledge.

8. Hermawan, Puti F. Marzuki, Muhamad Abduh & R. Driejana. (2015). Identification of source factors of carbon dioxide (CO2) emissions in concreting of reinforced concrete. *Proceedia Engineering, Elsevier, 125, 692-698*

9. Angeliki Kylili, Paris A Fokaides & Petra Amaparo Lopez Jimenez (2016). *Renewable and Sustainable Energy Reviews, Elsevier, 56, 905-915.*

10. Kayali, O. (2005, April). High-performance bricks from fly ash. In *Proceedings of the World of Coal Ash Conference, Lexington, Kentucky*.

11. Kofoworola, O. F., & Gheewala, S. H. (2009). Estimation of construction waste generation and management in Thailand. *Waste management*, *29*(2), 731-738.

12. Robin Kuenzel, Jochen Teizer, Marcus Mueller, Alexander Blickle. (2016). SmartSite: Intelligent and autonomous environments, machinery and processes to realize smart road construction projects. *Automation in Construction, Elsevier, 71(1), 21-33.*