Role of National Building Code in Fostering the Transition to Sustainable Construction

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Abstract. Developing country like India are experiencing fast development in the construction industry. This rapid development in infrastructure consumes a massive amount of natural/non-renewable resources and generates waste, hazardous emissions into the atmosphere affecting the surrounding ecology, community in terms of environmental, social, economical, and technical aspects all through their life span/period. This calls for strong action in bringing awareness, implementing, evaluating, and monitoring the standard of building sustainability for developing countries such as India. The National Building Code (NBC) of India has recommended some guidelines in achieving sustainability in its 'Approach to Sustainability 2016'. Similarly, the existing IGBC and GRIHA were developed before the revision of NBC 2016. Therefore, the objective of the study is to conduct a comprehensive study on the similarities and dissimilarities and examine whether they are possible to alter as per the prevailing conditions and necessities in India. The findings of the study set a benchmark for sustainable building measurement, which helps to reduce the negative impact on the environment. Further, the present study initiates to develop a new and novel framework that benefits contributors, participants, and organizations in enhancing the building sustainability standards.

Keywords: Sustainability · Evaluation · NBC · IGBC · GRIHA

1 Introduction

Due to the rapid increase in modernization, technology, and population, urbanization is also increasing at a higher rate. As per the 2011 population census, India's urban population is 377 million and it may grow up to 814 million by 2050 (Valuresearchonline.com 2021). All these factors give rise to the demand for residential and commercial buildings. Environmental deterioration, social inequality, and financial turmoil are all consequences of unplanned and fast urbanization and energy consumption. These worldwide issues have compelled society to reconsider infrastructure development to advance the building industry's idea of sustainable development (Reddy et al. 2021). Modern building materials and techniques are detrimental to our atmosphere and community as they emit greenhouse gases (GHGs), dust, energy, and water consumption. With numerous evidence of environmental deterioration concerns, the grandeur of contemporary industry has been questioned. As a result, the world needs new development and industrialization role models that are ecologically friendly and sustainable (Arukala and Pancharathi

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2020). Amongst the most difficult aspects of engineering design is deciding which material to use among the many options available. In the current situation, new and creative materials are required to replace old materials, which have either become extinct or are posing a significant threat to sustainability (Reddy et al. 2020). A sustainable building consumes less electricity, increases the efficiency of energy, produces less pollution, and allows occupants more favorable spaces relative to a normal building. The use of advanced materials and non-renewable energy resources in sustainable building lowers the impact on the environment. There are three basic indicators of sustainable building: environmental, cultural, and economic sustainability (Fig. 1). It depends on the type of country, the expectation of people often changes due to regional differences, and culture is also an important aspect in achieving sustainability. In recent decades, the market for sustainable buildings has grown rapidly worldwide. There was a need for improved sustainable building demand evaluation and benchmarking methods. This evaluation and comparative study help to gain the knowledge and range of utilization of sustainable practices in buildingdevelopment.During the year 2000, India launched a new evaluation method Indian Green Building Council (IGBC) by making revisions to Leadership in Energy and Environmental Design (LEED). Thereafter, in the year 2007, The Energy and Resources Institute (TERI) created India's national green building ranking scheme named Green Rating for Integrated Habitat Assessment (GRIHA) (Griha 2013).

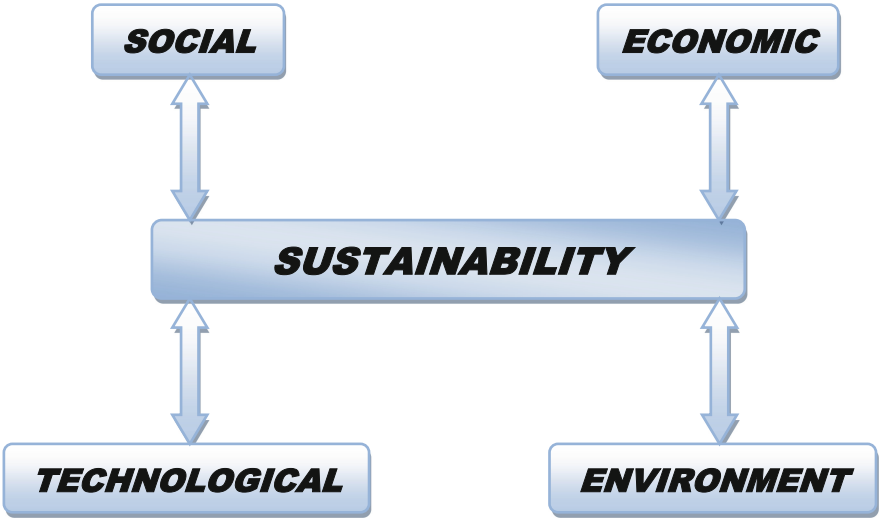

Fig. 1. Sustainability indicators schematic diagram.

1.1 An Overview of Sustainable Building Assessment Tools in India

1.1.1 National Building Code (NBC)

It is an Indian version of comprehensive building code, adopting mostly by organizations engaged in building construction works like the roads and building department, public

works department, other government construction departments, local bodies, and private construction firms. The first NBC code was issued by BIS (Bureau of Indian Standards) in 1970 based on the recommendations of the Planning Commission (Table 1). In 2016, the updated code was published as the National Building Code of India 2016, representing state-of-the-art and current applicable international activities. The following are the main updates introduced in this third revision of the code: accessibility in buildings and built environment for persons with disabilities and the elderly, provisions on fire and life safety, earthquake resistant design of buildings, namely part 11-Approach to Sustainability (NBC 2016).

Table 1. NBC-year of publishing, updates, and revisions

Year	Description
1970	First NBC published
1983	First Revision of NBC
1987	NBC-1983 updated two times
1997	NBC-1983 updated third time
2005	Second Revision of NBC
2015	2005-NBC Amended two times
2016	Third Revision of NBC

1.1.2 Indian Green Building Council

It is an Indian version launched by CII -USGBC LEED (Leadership of Energy and Environmental Design) in 2001. The Indian Green Building Council is a member of the Green Business Center of CII-Godrej. The IGBC's vision is to serve as the main provider of solutions and to be a central organization to support all Green Building initiatives in India, an organization that spreads and encourages sustainability through sustainable construction. With over 2000 buildings registered for IGBC rating, IGBC is the most popular rating scheme in India. Given the set criteria and standard guidelines, the IGBC is a rating instrument for surveying building performance. In the year 2000, the IGBC (LEED India) benchmarks for the Green Building Rating System were created and the final rating was released in 2003 and is now available for new and existing buildings. The purpose of the IGBC Green New Buildings grading system is to promote a holistic approach to produce attention on occupant comfort and well-being, environment-friendly structures, via architectural design, water efficiency, effective treatment of waste, energy efficiency, and sustainable buildings (IGBC 2015).

1.1.3 Green Rating for Integrated Habitat Assessment

Green Rating for Integrated Habitat Assessment was a sustainable construction ranking system established by TERI (The Institute of Energy and Resources) and supported by

the MNRE of the Indian Government (Ministry of New and Renewable Energy). It is also often referred to as India's National Green Building Ranking scheme in 2007. A sustainable development philosophy the 4 'R' (Refuse, Reduce, Reuse and Reinvent) was adopted by the GRIHA (GRIHA 2010).

2 Literature Review

Every nation is designing its recommendations to create and reach sustainable standards to the maximum level. India implemented the following evaluation methods in response to the LEED revision: Indian Green Building Council (IGBC) in 2000 and in the year 2007, Green Rating for Integrated Habitat Assessment (GRIHA) which is prepared and released by The Energy and Resources Institute (TERI). They discovered that the eight parameters and 48 sub-parameters are the best assessment criteria for assessing and achieving sustainable building construction in India. Some parameters that are used in GRIHA are not incorporated in IGBC, and vice versa. The final result demonstrates that environmental factors are more critical than other considerations (Reddy et al. 2018). Jozef Svajlenka (2018) studied an overview of the assessment of two wood-based construction technologies in terms of building sustainability using the suggested efficient evaluation approach. For proper analysis, they selected two wooden-based methods/technologies are: a) Log Construction System (traditional construction system) (25 buildings), and b) Column Construction System (35 buildings). The research of this study circumstances clearly outlinedthe need to improve construction productivity and sustainability globally (JozefSvajlenka and Kozlovska 2018). The goal of this article is to create design principles that satisfy all of the rating system's maximum requirements. To establish the major emphasis areas of all 3 rating systems, the approach used in this study included a quick overview of all rating systems and a performance comparison of similarity and dissimilarity. The design elements developed in this article will be a valuable resource for India's sustainable house design (Gangwar et al. 2020). The case study, of partnership network initiatives under the Forest Biodiversity Program with Southern Finland METSO Company, created a multi-criteria framework for analyzing and tracking the social and cultural consequences of forest resource management. The objective of this study was to develop a method for quantifying, evaluating, and following up on the socio-cultural impacts of developmental forest resource management projects. Usually, most of the studies follow two kinds of indicators namely: a) The project's performance measured numerically (hectares, number of participants, etc.) and b) expert evaluations (here, the experts were the project coordinators) and subjective tests were used to base expert judgments, and values were collected using a verbal scale. This approach takes into account a broad variety of social and cultural development perspectives. It employs both expert evaluation standards and operational statistics (Rantala et al. 2012). Further, this method examines the effects of construction phase operations based on the outcomes of Building Sustainability Assessment Schemes (BSAS) ratings. Most of the rating systems were calculated on the five main criteria project management, the responsible acquisition of building materials, the use of legal wood materials, the construction waste, and the protection against environmental contamination. All these are used to assess the sustainability of the researched structures during the construction

phase. The chosen criteria are an important aspect of existing sustainability assessment schemes such as BREEAM and LEED. In Lithuania, seven administrative buildings with BREEAM or LEED certification were evaluated. Assessments of construction stage requirements, as well as their effect on the final assessment score, were calculated for chosen buildings in all categories. The outcomes have shown that the application of the LEED rating system was in a higher and effective range in other foreign countries when compared with Lithuania. According to a review of the literature, several authors of research publications compare BREEAM, LEED, and other systems as well as their realistic applications, explore CO_2 emission reductions attributable to the implementation of building sustainability appraisal schemes, and investigate issues and causes that obstruct the adoption of sustainable construction technology (Apanavičienė et al. 2020). The comparative studies of GRIHA along with the IGBC (LEED India) rating system were compared both with regards to their certification cost, influence and popularity, performance criteria, and benchmarks (rating score). With the increase in demand for sustainable buildings or green buildings, the demand for Green rating and assessment tools is also increasing. India has two main building environment assessment tools i.e. Indian Green Building Council (IGBC) designed with global standards and Green Rating for Integrated Habitat Assessment (GRIHA) designed indigenously (Table 2). IGBC was backed by the Confederation of Indian Industry as well as uses global standard norms of LEED. Meanwhile, GRIHA is specially developed according to Indian conditions and assisted by the Ministry of New and Renewable Energy (Kanaujia et al. 2017).

Table 2. IGBC and GRIHA ratings and their respective certification points

IGBC	
Rating	**Points**
Certified	40-49
Silver	50-59
Gold	60-69
Platinum	80 and above

GRIHA	
Rating	**% Points**
One star	50-60
Two star	61-70
Three star	71-80
Four star	81-90
Five star	91-100

The variables that substantially impact material sustainability are evaluated by qualitative research using a quadruple-bottom line model in this research, which is founded on policies and values of sustainability relevant to the construction sector (Economic, Social, Technological, and Environmental). These parameters and indications are then used in evaluating resource performance in three segments of the material service life: preconstruction, building, and post-construction, to establish a Sustainable Material Performance Index (SMPI). The study's goal is to provide a concept-oriented decision-making method for choosing a sustainable material that does not require Life Cycle Inventory (LCI) data.The study's findings aid in logical decision-making and their integration into the design development process, regulations, and certification services for products (Reddy et al. 2019a, b, c). Also, this study emphasized on, the long-term behavior of a material is evaluated using sustainable parameters and indices across the resource entire lifecycle (i.e., Pre-Construction, Construction, and Post-Construction phases). Using AHP (Analytic Hierarchy Process), a judgment structure is developed

to rank sustainable materials among accessible options.The created structure makes it easier for the designer to choose the most sustainable material based on their preferences (Reddy et al. 2019a, b, c). The cement industry requires a lot of energy and emits a lot of pollution. To achieve sustainable concrete, various by-products and pozzolanic ingredients are utilized to decrease the impacts (environmental impact, energy, and resources) prepared by traditional materials. Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) is used to prioritize an alternate source based on quantitative characteristics. The findings show that, when all factors are considered, flyash-based concrete performs better and is favored over others (Reddy et al. 2019a, b, c). It attempts to meet the need for a new dimension, namely technical advancements in the building industry's sustainability and established Sustainable Building Assessment Tool (SBAT) (Arukala et al. 2020). The study's goal is to determine the interrelationship of standards and requirements for evaluating building sustainability. The results show that of all the 8 criteria in the Technology perspective, Materials and Waste Management (MW) and Energy Efficiency (EE) received the most weight (Reddy et al. 2021).

3 Study Methodology

The detailed workflow or the study methodology has been shown with a schematic diagram (See: Fig. 2).

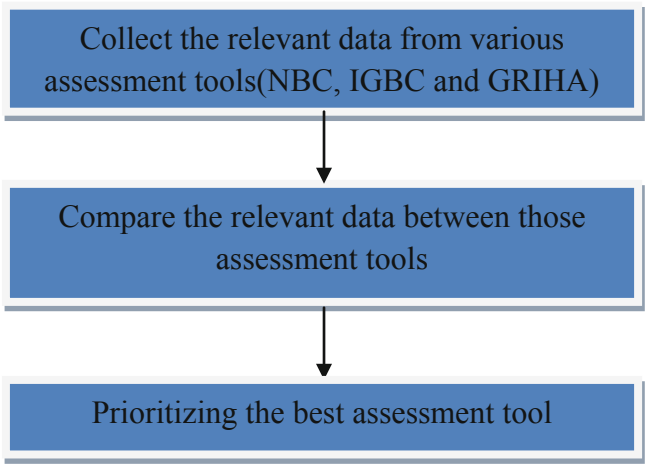

Fig. 2. Study methodology for establishing a sustainable evaluation tool.

4 Comparative Relation Among Assessment Tools

Many sustainable building appraisal tools were used all around the world. Every nation has developed its assessment tools based on regional variations and conditions. Similarly, developing countries like India consist of two assessment tools like IGBC and

GRIHA and were established in the years 2001 and 2007 respectively. In the year 2016, NBC was revised for the third time and incorporated with a new concept "Approach to Sustainability – Part 11" (NBC 2016). Therefore, in this research, the major parameters, Elements of NBC – Approach to sustainability are summarized and compared with the two assessing tools existing in India (NBC, GRIHA, and IGBC) to know the similarities, dissimilarities, importance, and depth of these existing assessing tools (See: Table 3). The parameter incorporated in their respective assessment tools were shown with an Indicator '✓', whereas the indicator '✗' illustrates that the element/aspect was not incorporated in their respective assessment tool (GRIHA 2013).

5 Results and Discussion

Based on the comparison, the study outlined all criteria and elements/aspects/parameters from NBC proposed by the Bureau of Indian Standards (BIS) and compared with the two prominent Indian building assessment tools (IGBC and GRIHA).The parameters from NBC like site design and development, parking design, water management, and solid management, building services optimization, O and M, and constructional practices were mentioned according to the Indian standards. The existing Indian assessment tools were developed based on developed countries' tools. The comparison showed some dissimilarity in parameters i.e., heat island effect and parking design, off-street, bicycle Lanes, pedestrian Access-Safety and comfort parking, external and internal wall finishes, thermal insulation materials, daylighting and controls, and external noise reduction/mitigation practices which were not mentioned in GRIHA, and IGBC was mentioned in the NBC. While referring to the GRIHA and IGBCa new parameter i.e., innovation in design was not mentioned in NBC. From the findings, it is observed that almost all the parameters that are present in NBC were also considered in IGBC and GRIHA except heat island effect and parking design, off-street, bicycle Lanes, pedestrian Access-Safety and comfort parking, external and internal wall finishes, thermal insulation materials, daylighting and controls, and external noise reduction/mitigation practices. These tools have dealt with almost all parameters and standards related to NBC parameters and standards but relatively missthetechnicality in explaining each criterion. Off-street parking is a main issue in Indian urban and fast developing cities to overcome it one should refer to the NBC to design sustainably. In developing country like India, it is very crucial to implement and follow the guidelines in achieving sustainable construction to mitigate social, cultural, and economic problems. Overall, the research has shown that the two assessment tools GRIHA and IGBC are in line with the NBC guidelines approach to sustainability. However, the parameters in NBC seem to be more in detail. All the criteria and elements involved in NBC have been satisfying all Indian climatic conditions, regional parameters, Parking design, transportation, socio-cultural factors, environmental factors, technological factors, and economic, etc.

Table 3. Comparison of criteria between the various sustainable evaluation tools in India

S.No	CRITERIA	ELEMENTS/ASPECTS	NBC	IGBC	GRIHA
1.	SITE, LANDSCAPE, FORM DESIGN AND DEVELOPMENT	Site Assessment Prior to Design	✓	✓	✓
		Preserving top soil and Topography	✓	✓	✓
		Ecological design / conserving biodiversity	✓	✓	✓
		Urban agricultural practices / social forestry	✓	✓	✓
		Microclimatic conditions	✓	✓	✓
		Building Form, Orientation and Shading	✓	✓	✓
2.	PARKING DESIGN	Heat island effect and parking design	✓	✓	×
		Reduced Environmental Impacts from Parking Facilities	✓	✓	✓
		Bicycle Lanes, Pedestrian Access - Safety and Comfort	✓	×	×
		Off-Street Parking	✓	✓	×
3.	MATERIALS	Environmental Concerns and Human Health and Safety Aspects Related to Building Materials	✓	✓	✓
		Minimizing Green House Gas (GHG) Emission	✓	✓	✓
		Cement concrete	✓	✓	✓
		Burnt clay bricks and tiles	✓	✓	✓
		Floor and floor coverings	✓	✓	✓
		External and internal wall finishes	✓	✓	×
		Glazing	✓	✓	✓
		Door and window frames	✓	✓	✓
		Thermal insulation materials	✓	×	×
		Waterproofing materials	✓	✓	✓
		Handling of Materials and Equipment	✓	✓	✓
4.	WATER MANAGEMENT	Planning and Design of Water Supply System	✓	✓	✓
		Water Sourcing	✓	✓	✓
		Strategies for Water Efficiency	✓	✓	✓
		Rainwater Harvesting / Strategies for Water Conservation	✓	✓	✓
		Management of Waste Water	✓	✓	✓
		Treated Waste Water Use for Landscape and Irrigation	✓	✓	✓
		Process Water Requirement and Effluent Treatment	✓	✓	✓
5.	SOLID WASTE MANAGEMENT	Planning and Design of Solid Waste System	✓	✓	✓
		Identification, Segregation, and Storage of Wastes	✓	✓	✓
		Provisions for Waste(s) Requiring Special Management	✓	✓	✓
		Handling and Disposal of Waste	✓	✓	✓
6.	BUILDING SERVICES and ENERGY OPTIMIZATION	Natural and Mechanical Ventilation Strategies	✓	✓	✓
		Passive Heating / Cooling Techniques	✓	✓	✓
		Pre-Cooling of Ventilation Air	✓	✓	✓
		Vertical Landscaping and Roof Gardens	✓	✓	✓
		HVAC System	✓	✓	✓
		Renewable Energy(Solar and Photovoltaic Technologies) Integration	✓	✓	✓
		Daylighting and Controls	✓	✓	×
		External noise reduction/mitigation practices	✓	×	✓
		Ozone Depletion Potential	✓	✓	✓

(*continued*)

Table 3. (*continued*)

S.No	CRITERIA	ELEMENTS/ASPECTS	NBC	IGBC	GRIHA
7.	CONSTRUCTIONAL PRACTICES	Pre-Construction and Pre-Requisites	✓	✓	✓
		Identification of Sustainability Issues During Construction	✓	✓	✓
		Preparation of Construction Management Plan	✓	✓	✓
		Post-Construction Closeout	✓	✓	✓
		Disaster Risk Assessment and Mitigation during Construction	✓	✓	✓
		Heritage Buildings and New Construction	✓	✓	✓
		Identification of Sustainability Issues During Construction	✓	✓	✓
8.	OPERATION, MAINTENANCE AND BUILDING PERFORMANCE TRACKING	Commissioning and Handover	✓	✓	✓
		Operation and Maintenance	✓	✓	✓
		Building Performance Tracking (Measurement and Verification)	✓	✓	✓
9.	INNOVATION	Innovations in Design	✖	✓	✓

Considered:✓ Not Considered: ✖

6 Conclusion

The present study considered comprehensive research to know whether the National Building Code (NBC) was showing any similarities/dissimilarities when compared with existing tools and further recommend any missing guidelines and changes that may require in the future for achieving sustainable construction. The research concludes that NBC 2016-Approach to sustainability guidelines is fully equipped and can be used for the development of policy-making, sustainable assessment tools in achieving sustainable construction growth in India. NBC has focused mainly on incorporating the regional parameters like site design, climatic conditions, parking design, etc., which reflects the regional sustainability. The parameters represented in the NBC like material, water, and energy efficiency, waste management, transportation, construction practices, site management, etc., were very much useful in fulfilling present needs in achieving sustainable construction when compared to IGBC and GRIHA, as these lack in considering the regional interest of the location. Therefore NBC 2016 part 11-approach to sustainability can be referred to as a methodology/procedure/guidelines/strategies/technique/etc. for practice towards making a new sustainable assessment tool with more reliability and concise assessment towards nation growth.

References

Apanavičienė, R., Maliejus, K., Fokaides, P.: Sustainability assessment of the building construction stage using building sustainability assessment schemes (BSAS). In: IOP Conference Series: Earth and Environmental Science, vol. 410, no. 1, p. 012064. IOP Publishing (2020)

Arukala, S.R., Pancharathi, R.K.: Integration of advances in sustainable technologies for the development of the sustainable building assessment tool. Int. J. Technol. Manag. Sustain. Dev. **19**(3), 335–360 (2020)

Gangwar, G., Kaur, P., Singh, I.: Principles of design for sustainable group housing projects in India. Civ. Eng. Archit. **8**(6), 1234–1250 (2020)

Green Rating for Integrated Habitat Assessment (GRIHA): Technical manual for trainers on sustainable site planning health and well-being during construction. Ministry of New and Renewable Energy, Government of India and The Energy and Resources Institute New GRIHA Manual, vol. 2, pp. 40–63 (2013)

Indian Green Building Councils: Green New Buildings Rating System. New version 3.0, Abridged Reference guide, August 2015

Introduction to National Rating System – GRIHA: An evaluation tool to help design, build, operate, and maintain a resource-efficient built environment. Ministry of New and Renewable Energy, Government of India and The Energy and Resources Institute New GRIHA Manual, vol. 1, pp. 1–89 (2010)

Svajlenka, J., Kozlovska, M.: "Methodology of efficiency assessment in the context of building sustainability. Int. J. Eng. Technol. (IJET) **7**(2.23), 332–334 (2018)

Kanaujia, V., Reddy, A.S., Kumar, K.: Comparative review of indian green building rating systems. J. Energy Res. Environ. Technol. **4**, 194–198 (2017)

Rantala, M., Hujala, T., Kurttila, M.: Measuring and monitoring socio-cultural sustainability in the action of forest biodiversity cooperation networks. Silva Fennica **46**(3), 441–459 (2012)

National Building Code of India (NBC) – Bureau of Indian Standards (BIS), SP 7, vol. 2, pp: 833–930 (2016)

Reddy, A.S., Raj, P.A., Kumar, P.R.: Developing a sustainable building assessment tool (SBAT) for developing countries—case of India. In: Urbanization Challenges in Emerging Economies: Resilience and Sustainability of Infrastructure, pp. 137–148. American Society of Civil Engineers, Reston (2018)

Reddy, A.S., Kumar, P.R., Raj, P.A.: Preference-based multi-criteria framework for developing a Sustainable Material Performance Index (SMPI). Int. J. Sustain. Eng. **12**(6), 390–403 (2019a)

Reddy, A.S., Kumar, P.R., Raj, P.A.: Developing a material sustainable performance score (MSPS) to select an alternative cementitious material. Cem. WapnoBeton **24**(1), 68–79 (2019b)

Reddy, A.S., Kumar, P.R., Raj, P.A.: Assessing interdependency among sustainable criteria and indicators for developing a building assessment tool. Int. J. Sustain. Eng. **14**(4), 647–663 (2021). https://doi.org/10.1080/19397038.2021.1888338

Reddy, A.S., Kumar, P.R., Raj, P.A.: Development of sustainable performance index (SPI) for self-compacting concretes. J. Build. Eng. **27**, 100974 (2020)

Reddy, L.S., Reddy, A.S., Reddy, S.S.P.: A quantitative approach to prioritize sustainable concrete. Civ. Eng. J. **5**(12), 2579–2586 (2019c)

Valuresearchonline.com: As per the 2011 population census, India's urban population is 377 million and it may grow up to 840 million by 2050 (2021). https://www.valueresearchonline.com/stories/49107/financing-cities--the-path-torapid-growth