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Application of TOPSIS Method for Alternate Construction Technology Selection for Efficient Performance of Sustainable and Affordable Housing

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ABSTRACT: India's Urban Population has grown over the past 3-4 decades from 109 million in 1971 to 377 million in 2011 and is expected to grow to almost 600 million by 2030. This influx of population is causing an increased demand for affordable housing in urban areas. There are numerous parameters that need to be considered for selection of these technologies to make the project economically viable which is the utmost priority for Affordable Housing. Accounting to the post occupancy affordability of housing, sustainability must be incorporated to help reduce the overall life cycle costing of the building simultaneously ensuring a comfortable and affordable living for LIG and EWS. The framework was developed using the method of "Technique for Order Preference by Similarity to Ideal Solution (TOPSIS)", which helps identify the best ACT for a particular project by analyzing its closeness to the Ideal Solution. The attempt is to make the decision making of technology selection efficient considering the possible risk and for ensuring that the project meets the criteria of affordability in the truest sense.

KEYWORDS: Affordable Housing, Sustainability, Multi Criteria Decision Making (MCDM), TOPSIS, Alternate Construction Technique

I. INTRODUCTION

India's Urban Population has grown over the past 3-4 decades from 109 million in 1971 to 377 million in 2011 and is expected to grow to almost 600 million by 2030 [1]. Census 2011 has estimated 65 million slum population in the 4041 statutory towns. The technical committee constituted by this Ministry has estimated housing shortage at 18.78 million during the 12th FYP period of which over 95% of this housing shortage is estimated in the Economically Weaker Sections (EWS) and Low-Income Group (LIG) categories [1].

The rapid influx of population in the urban area and rising demand of affordable housing to accommodate this influx is one of the key concerns for India. Since inception of the realization there has been multiple policies proposed to meet the demand as well as making them affordable for the EWS and LIG, by incorporating employment generation policies and affordable housing by spatial optimization and innovation in material and technology. The Ministry of Housing and Urban Poverty Alleviation (MoHUPA) has been working continuously towards the issue of urban influx via policies like Pradhan Mantri AwasYojna (PMAY) in 2015, Indira AwasYojna (IAY) in 1996, EWS Housing scheme in 1991,

National Slum Development program in 1996, Valmiki Ambedkar Awas Yojna in 2001, Jawaharlal Nehru National Urban Renewal Mission (JNNURM) in 2005, and Pradhan Mantri Awas Yojna Gramin in 2015 [2].

There have been multiple alternate construction technologies being employed to ensure speedy construction and cost optimization to meet the growing demand for affordable housing in India's Urban areas. [1] states mandatory attributes that a technology must comply for housing which are strength and stability requirements, performance and statutory compliance, fire resistance, thermal comfort, acoustic perform, weather-resistance and water tightness. functional requirements, constructability, economic viability, maintenance, sustainability and finish quality yet there is no clear illustration of how to ensure these attributes.

There is a need to develop a tool to establish a logical equation between site's geographical, social and economic constraints with the various attributes of performance of the alternate construction technologies to yield best possible solution ensuring sustainable proposals.

II. OBJECTIVES

1. To develop an understanding of sustainable and affordable housing in Indian context.
2. To identify the performance parameters for various alternate construction technology for mass affordable housing.
3. To formulate a framework for appropriate selection of technology for mass affordable housing with respect performance parameters identified.
4. To validate the developed formwork with the help of various case studies.

III. LITERATURE REVIEW

• Affordable Housing

The economic slowdown of 2009 changed the business climate, the prior mean of funding project from advance payment from pre-booking collapsed due to falling demand, forcing real estate developers to focus on affordable housing offering all the basic amenities and facilities with quality, better construction but at a price point that is affordable by any income group [3].

It is appropriate to define affordability in housing as being a function of three broad parameters - the monthly household income (MHI) of prospective buyers, the size of the dwelling unit and the affordability of the home buyer (the ratio of the price of the home to annual income or the ratio of EMI to monthly income). [1] defines affordability as Dwelling Units (DUs) with Carpet Area shall be between 21 to 27 Sqm. for Economically Weaker Section (EWS) category and 28 to 60 Sqm. for Lower Income Group (LIG) category with selection criteria as EWS having an annual household income up to 1 lakh and LIG having an annual household income between 1 to 2 lakhs [4]. [5] defines affordability in terms of rental and median multiple indicators, [6] consider purchase affordability the criterion while some researchers [7] also consider the repayment affordability as a measure.

There are numerous policies for affordable housing in India have been launched. Some of them are as follows:

1. National Urban Housing & Habitat Policy (NUHHP) - It aims to accelerate the pace of development of housing and related infrastructure; create adequate rental and ownership housing stock while improving affordability through capital or interest subsidies; and use technology to modernize the housing sector for energy and cost efficiency, productivity and quality, green and intelligent building, and mitigate disaster impacts [6].
2. Pradhan Mantri Awas Yojana – Gramin (PMAY-G) - With the aim of addressing gaps in rural housing and providing Housing for All by 2022 [8].
3. Pradhan Mantri Awas Yojana – Urban (PMAY-U) - The PMAY was launched in June 2015, aimed at providing affordable housing to the urban poor, but in November 2016, a rural component was added. The PMAY-U, aims at subsidizing the construction of around 1 crore urban houses, by providing Central assistance to 1 crore eligible families (beneficiaries) over the period FY2015-22 [8].
4. In-situ slum redevelopment (ISSR) with participation of private developers - Provides pucca houses to eligible slum dwellers by redevelopment of existing slums on private/public land. Private partners are selected via an open bidding process, based on the lowest cost of construction per unit; extra FSI/TDR/FAR is provided to make the projects financially viable. A grant of Rs. 1 lakh per house is provided by the Central Government to the planning/ implementing authorities of the states/UTs [8]; [5].

- **Sustainability**

Sustainability is defined as a global process that also tries to help create an enduring future where environmental and social factors are considered simultaneously with economic factors [9].

Most of the EWS and LIG dwellers spend high percentage of their earnings on maintenance as compared to other groups. Green affordable housing will additionally reduce energy need in operational period thereby reducing burden of energy expenses and will also aim at replacing older and more polluting technology with newer less polluting one [10]. Linking sustainability with quality rather than pricing can create opportunities for upcoming housing projects, especially since India's socio-economic milieu warrants different perceptions of affordability. The underlying idea is that people should be able to maintain comfortable living standards within affordable sustainable housing [11]. If construction is energy-efficient it will reduce the long-term costs of maintaining a house and improve its durability particularly in terms of issues that are related to damp [12].

[13] highlighted the fact that housing developers, financiers, and consumers needed to change their approach to sustainable housing projects because they can effectively:

1. Lower operating costs
2. Reduce energy bills by about 30% by making energy-saving improvements in building design
3. Improve comfort through better design and energy efficiency
4. Improve health through improved ventilation systems and the use of non-toxic or at least less-toxic materials

Focusing on current growing demand for housing in urban India, the concerns are regarding speed, ease and cost of construction. There is no explicit focus on combining energy and material efficiency with achieving thermal comfort and improving quality of life [14].

- **TOPSIS**

TOPSIS was proposed by Hwang and Yoon (1981) [15] as an alternative to ELECTRE [16]. TOPSIS is a simple mathematical method for Multi-Criteria Decision Matrix. It is based on the concept of the compromise solution [15]. TOPSIS include compromise between different criteria, where a bad result in one criterion can be compensated by a good result in another criterion [17]. It considers a scalar value that accounts for both the best and worst alternative at the same time [16].

Advantages of TOPSIS as stated in [16]:

1. The performance is slightly affected by the number of alternatives and rank discrepancies are amplified to a lesser extent for increasing values of the number of alternatives and the number of criteria.
2. Easy decision making using both negative and positive criteria.
3. It is relatively easy to implement, understand and fast as it provides a well-structured analytical systematic process.
4. It is useful for qualitative and quantitative data.
5. A number of criteria can be applied during the decision process.
6. The output (based on a well-structured analytical framework) can be a preferential ranking of the feasible alternatives based on a numerical-values which provide a better understanding of differences and similarities among alternatives.
7. It has very large flexibility in the definition of the choice set.
8. TOPSIS has been proved to be one of the best methods in addressing rank reversal issue, which is the change in the ranking of alternatives when a non-optimal alternative is introduced.

Drawbacks of TOPSIS as mentioned in [16]:

1. The operation of normalized decision matrix in which the normalized scale for each criterion is usually derived and a narrow gap among the performed measures in the TOPSIS method is not good for ranking and cannot reflect the true dominance of alternatives.
2. TOPSIS never considered the risk assessment for a decision maker.
3. Similar to AHP method, TOPSIS presents the problem of ranking reversal as the final ranking can swap when new alternatives are included in the model.

Implementation - [18] explained the method of implementing TOPSIS in the following steps:

- Step 1: Performance Scoring of alternative on different criteria - Suppose there are 'n' the alternative 'a' = $a^1, a^2, a^3, \dots, a^n$ and 'm' criteria 'i' = $i^1, i^2, i^3, \dots, i^m$. Decision Matrix: $X = (x_{ai})$, alternatives are shown on 'n' row and criteria are shown on 'm' column, Rank : $n \times m$
- Step 2: Normalization - Distributive Normalization - $r_{ai} = x_{ai} / \sqrt{\sum_{a=1}^n x_{ai}^2}$ [18]
Ideal Normalization - If the criteria is to be maximized $r_{ai} = x_{ai} / x_{ai}^{\max}$ $a = 1, 2, \dots, n$ [18] [19]. If the criteria is to be minimized $r_{ai} = x_{ai} / x_{ai}^{\min}$ $a = 1, 2, \dots, n$ [18] [19].
- Step 3: Weighted Normalized Decision Matrix - w_i = criteria weight and normalized score r_{ai} where $a = 1, 2, 3, \dots, n, i = 1, 2, 3, \dots, m$, obtain the weight score v_{ai} as; $v_{ai} = w_i \times r_{ai}$
- Step 4: Distance Computation from ideal and anti-ideal points - Weighted score obtain in the previous step is used. To compare each alternative with the virtual ideal alternative. To compare each alternative with the virtual anti-ideal alternative.

Defining Virtual alternative:

Method 1 - Construct Virtual Ideal Alternative ($v_1^b, v_2^b, v_3^b, \dots, v_n^b$); Using best score of each criterion; maximum, if criteria is to be maximized; Minimum, if criteria is to be minimized [18] [19]. Construct Virtual Anti-Ideal Alternative ($v_1^w, v_2^w, v_3^w, \dots, v_n^w$); Using worst score of each criterion; opposite of ideal alternative definition [18] [19]

Method 2 - Irrespective of the value of criterion 1 & 0 are taken as ideal and anti-ideal solution: Ideal (1,1,1,...); Anti-Ideal (0,0,0,...) [18].

Method 3 - Ideal and Anti-Ideal are defined by decision maker must lie in the range calculated using previous two methods [18].

Calculate the distance using Euclidean distance:

Distance of each alternative from ideal point

$$d_{aideal} = \sqrt{\sum_{i=1}^m (v_{ai} - v_i^b)^2} \text{ where } a = 1, 2, 3, \dots, m; i = 1, 2, 3, \dots, n \text{ [18] [19]}$$

Distance of each alternative from anti-ideal point

$$d_{aanti} = \sqrt{\sum_{i=1}^m (v_{ai} - v_i^w)^2} \text{ where } a = 1, 2, 3, \dots, m; i = 1, 2, 3, \dots, n \text{ [18] [19]}$$

- Step 5: Computing closeness ratio for each alternative $c_a = d_{aanti} / (d_{aideal} + d_{aanti})$, c_a lies between 0 and 1 where a value approaching 1 indicates the preferred alternative [18] [19]

IV. FRAMEWORK STRUCTURE

- Survey for Weightage identification

Minimum Respondents Required - Kish (1965) showed that the sample size can be calculated as following equation for 94% confidence level (Practical Factors Affecting Delay in High Rise Construction – A Case Study in a Construction Organization, 2014)

$$N = n' / [1 + (n'/N)]$$

N = total number of populations

n = sample size from finite population

n' = sample size from infinite population = S^2 / V^2 ;

where, S is the variance of the population elements and V is a standard error of sampling population. (Usually $S = 0.5$ and $V = 0.06$)

So, for 50 respondents:

$$n = n' / [1 + (n'/N)]$$

$$n' = S^2 / V^2 = (0.5)^2 / (0.06)^2 = 69.44$$

$$N = 50$$

$$n = 69.44 / [1 + (69.44 / 50)] = 29$$

This means that the number of responses for the survey should be at least 29 in order to achieve 94% confidence level. The actual number of responses received is 34, Moser and Kalton (1971) showed that a response rate of less than 30% is likely to produce results subject to non-response bias. Based on this, obtained response rates of 76.92% is reasonable and will reflect good results and outputs (Practical Factors Affecting Delay in High Rise Construction – A Case Study in a Construction Organization, 2014)

Respondent Profile - The sample included Architects, Engineers and Project Managers associated with or having experience in Affordable and Sustainable Housing in the industry. Almost 94% of respondents were above 5 years of experience, hence the data collected is reliable.

Cronbach's Alpha - This method is used to measure the reliability of the questionnaire between each group and the mean of the whole groups of the questionnaire.

$$\alpha = \frac{K-1}{K} \frac{\sum_{i=1}^K \sum_{j=1}^K r_{ij}}{K}$$

where,

K = number of items

y² = Variance of Component

x² = Variance of the observed total cumulative score

Number of Items	34
Item Variance	5.42
Variance of Total Score	21.83
Cronbach Alpha	0.77
Internal Consistency in percentage	77.4%

Survey Outcome - The survey data was analyzed to calculate the weightages for individual broad criteria. the weightages identified are as follows:

Table 1 Weightage identified through survey

Broad Criteria for Technology Selection	Weightage
Economic Viability	10.76 %
Strength, Stability and Disaster Resilience	13.21 %
functional requirements	8.64 %
Constructability	15.14 %
Construction Material and Technology	8.70 %
Service Life and Durability	15.06 %
Environmental and Energy Performance	8.54 %
Codes Compliance	11.83 %
Occupant's perceptions	8.13 %
Total	100.00 %

Outcome Discussion:

1. Economic Viability - On conventional scale of affordability economic viability becomes the utmost priority. Economic viability is the dependent variable on various other parameters that indirectly contribute to the economic viability. The weightage for economic viability is 10.76%, though the weightage of economic viability is not the highest, but other parameters have partial weightage included for economy of the project.
2. Strength, Stability and Disaster Resilience - The weightage of Strength, Stability and Disaster Resilience was calculated to be 13.21 %, which is third highest weightage among the nine broad criteria. It is obvious that strength, stability and disaster resilience is one of the mandatory criteria for assessing the performance of a construction technology, but at the same time it is obvious that a technology won't be adopted if it does not meet the minimum standard requirement, hence the third position is justified.
3. Functional requirements - Functional requirement is at third last priority as functional performance of a project is less dependent on the technology and more on the designer and minimum standard requirement. The weightage identified for functional requirement is 8.64 %.
4. Constructability - Constructability is at the highest priority with weightage of 15.14 %, this can be justified with the argument that the feasibility of a technology can be decided but the implementation feasibility becomes an imperative parameter when the concerns are as per the specifications of the project like scale, site area, etc. so, if it is difficult to execute, then no matter how feasible an option is, the project is difficult to implement.
5. Construction Material and Technology - Construction material and technology was given a weightage of 8.70 %. It contributes both towards economy as well as sustainability parameters. On one hand an efficient and locally available material and technology makes a project more feasible and on the other hand a sustainable material and technology makes the project environment friendly. It also helps in reducing the maintenance and overall lifecycle cost of the building.

6. Service Life and Durability - Service life and durability achieved second priority with 15.06 % weightage. The second priority is because of the consideration that a facility must serve longer to yield its best value and also with larger span the lifecycle cost of the building reduces as well.
7. Environmental and Energy Performance - Environmental and Energy performance is a mandatory concern for the growing concern for environment deterioration. It is imperative to make a building sustainable to reduce environmental deterioration, increase building lifespan and reduce building lifecycle cost.
8. Codes Compliance - Code compliance is necessary as these provide with the minimum standard that must be achieved. Also, it helps in quality assurance as well. Hence code compliance was given 11.83 % of weightage.
9. Occupant's perceptions - Occupants' perception was given the weightage of 8.13 % which is the lowest weightage, though users are the center of any facility yet their perception is given less priority since this parameter do not have a tangible aspect unless it is associated with marketability. As far as affordable housing is concerned user's perception becomes one of the most neglected aspects.

V. CONCLUSION

- Discussion of Outcome
 - As per the Framework outcome, conventional means is the best solution for a project at Agartala, whereas the second optimal solution proposed was Prefabricated Sandwich panel system, which has great resemblance with conventional system when combined with RCC. The outcome can be deciphered for following conclusions and recommendation:
 - Considering the risk associated with adoption of new technology for a sensitive area like Agartala which is located at Seismic Zone V, with undulating terrain, the proposal was made for using conventional or close to conventional systems.
 - Since the existing proposal includes use of LGSF-IFC, the infill concrete can be replaced by EPS Sandwich Panel for better performing building [20]
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REFERENCES

- [1] MHUPA, Affordable Housing in Partnership, Scheme Guideline, India: Government of India, 2013.
- [2] A. G. Warriar, P. Tadepalli and S. Palaniappan, "Low-Cost Housing in India: A Review," vol. 294, no. 012092, 2019.
- [3] R. Joshy, "Spatial Analysis of Affordable Houses In India," vol. 5, no. 12, 2018.
- [4] K. Kumar and D. Nayal, "Critical Review of use of Glass Fiber Reinforced Gypsum (GFRG) Panels in Housing in India," *International Journal of Engineering Research & Technology (IJERT)*; ISSN: 2278-0181, vol. 9, no. 2, pp. 763-766, 2020.
- [5] RBI, "Affordable Housing in India," *RBI Bulletin*, pp. 13-25, 2018.
- [6] K. Gopalan and M. Venkataraman, "Affordable housing: Policy and practice," vol. 27, 2015.
- [7] Q. G. a. R. J. Hill, "Measuring Housing Affordability: Looking Beyond the Median," vol. 18, 2009.
- [8] FICCI, "AFFORDABLE HOUSING," *ICRA Limited*, 2020.
- [9] P. Newman, "Sustainability and housing: More than a roof over head," Melbourne, 31st October, 2002.
- [10] S. Das, A. Rastogi and K. Kumar, "Applicability of Risk Assessment Tools and Techniques for a Construction Project," *Journal of Research in Infrastructure Designing*, vol. 4, no. 3, pp. 1-18, 2021.
- [11] S. Seth, "Sustainable housing needs to be affordable too," 3 DECEMBER 2017. [Online]. Available: <https://www.teriin.org/opinion/sustainable-housing-needs-be-affordable-too>. [Accessed 10 FEBRUARY 2021].
- [12] M. Tobias, "Sustainability and Energy Efficiency are Key to Affordable Housing," Michael Tobias, 28 January 2020. [Online]. Available: <https://www.ecomena.org/sustainability-key-to-affordable-housing/>. [Accessed 12 2 2021].
- [13] D. C. S. HAYLES, "AN EXAMINATION OF THE RELATIONSHIP BETWEEN SUSTAINABILITY AND AFFORDABILITY IN RESIDENTIAL HOUSING MARKETS," 2006.
- [14] A. Roychowdhury, R. Sareen and M. S. a. S. Grover, "Optimizing the Third Skin: Energy Efficiency and Thermal Comfort in Affordable Housing," 2020.
- [15] G.-H. Tzeng and J.-J. Huang, Multiple Attribute Decision Making: Method and Application, United States of



America: Taylor & Francis Group, LLC, 2011.

- [16] E. K. Zavadskas, A. Mardani, Z. Turskis, A. Jusoh and K. M. Nor, "Development of TOPSIS Method to Solve Complicated Decision-Making Problems: An Overview on Developments from 2000 to 2015," vol. 15, no. 3, 2016.
- [17] V. N. Zlatko Pavić, "Notes on TOPSIS Method," vol. 1, no. 2, June, 2013.
- [18] P. D. G. Dixit, "MCDM Techniques Using R," 02 February 2019. [Online]. Available: <https://freevidelectures.com/course/4308/nptel-mcdm-techniques-using-r/13>. [Accessed 03 03 2021].
- [19] J. M. G. C. W. Elissa Nadia Madi, "An Exploration of Issues and Limitations in Current Methods of TOPSIS and Fuzzy TOPSIS," 2016.
- [20] M. Harit and K. Kumar, "A Critical Review of Expanded Polystyrene Core Panel System in Buildings in India," *Journal of Sustainable Construction Engineering and Project Management*; , vol. 4, no. 3, pp. 1-7, 2021.



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