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Government of India  
Ministry of Housing & Urban Poverty Alleviation  
[HFA-IV]

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Nirman Bhawan, New Delhi  
Dated the 22<sup>nd</sup> July, 2015.

To,  
The Principal Secretary (Housing),  
(All States/UTs)

Subject: Multi-attributes Evaluation criteria for selection of Emerging Technologies.

Sir/Madam,

The Ministry of Housing and Urban Poverty Alleviation has launched a new mission on "Housing for All (HFA) on the 25<sup>th</sup> June, 2015 covering the urban poor. A copy of the Scheme Guidelines of the mission has been circulated to all the State Governments/Union Territories *vide* the Ministry's O.M. No. N-11026/06/2014-PPG/FTS-11733 dated 25.06.2015. The guidelines are also available on the Ministry's web site [www.mhupa.gov.in](http://www.mhupa.gov.in).

2. The housing shortage is estimated at about two crore houses by the year 2022. The massive scale of construction required to meet this shortage with the constraints of depleting natural resources, rising costs, non-availability of some basic building materials, environmental concerns necessitate that alternate emerging technologies be explored in place of conventional materials and practices.

3. The National Building Code (NBC) covers conventional building materials and construction technologies. However, the NBC does not prevent use of alternate materials, method of design and construction not prescribed by the Code, provided any such alternative is found to be satisfactory and conforms to the relevant provisions of NBC. Recognising that there was no mechanism to evaluate new alternate materials and technologies and provide guidance for the informed choice of manufacturers and users, Building Materials and Technology Promotion Council (BMTPC) under the Ministry of Housing and Urban Poverty Alleviation had been authorised through a Government Notification in 1999 to issue Performance Appraisal Certificates (PAC) for giving independent opinion of the fitness for intended use of the new and innovative alternatives in the building construction sector. This Performance Appraisal Certification Scheme (PACS) is a voluntary third party certification scheme. The notification, *inter-alia*, in section 4.4 provides that BMTPC will, from time to time, bring out and publish building guides on performance criteria, appraisal parameters and test methods, etc.

4. In the above background, BMTPC has now, in consultation with other experts and professionals in the field, prepared a draft document on multi-attribute evaluation criteria. The document envisages listing out the mandatory and desirable attributes for alternate new materials, products, components and new systems. The multi-attributes listed out in the document fall in two categories viz. Mandatory attributes and Preferred and Desirable attributes. The detailed multi-attribute criteria is given at **Annex-2** of the document.

5. It is expected that the broad multi-attribute evaluation criteria for emerging housing technologies with additional parameters will help the process of PACs more meaningful and practical. Before finalisation of the document, it has been decided to invite the comments of the State Governments/Union Territories on the draft document. It is accordingly, requested that the comments may be forwarded to the **Executive Director, Building Materials and Technology Promotion Council (BMTPC)** at FAX no. 011-2464 2849 or email [ska@bmtpc.org](mailto:ska@bmtpc.org) latest by 07.08.2015.

Yours faithfully,



(S. K. Valiathan)

Deputy Secretary to the Govt. of India  
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ANNEX-2

Multi-Attributes Evaluation Methodology  
for  
Selection of Emerging Housing  
Technologies



Building Materials & Technology Promotion Council  
Ministry of Housing & Urban Poverty Alleviation  
Government of India  
New Delhi

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# 1 Mandatory Attributes (PA<sup>1</sup>)

## 1.1 Strength and Stability Requirements (SA<sup>2</sup>)

**Definition:** The structural adequacy of a housing technology, in terms of strength and stability, is an important attribute in the selection of the technology. The system used for construction should be capable of withstanding the design loads calculated as per Indian Standards (IS). Following tertiary attributes are used to make a determination for this mandatory secondary attribute.

### 1.1.1 Stability against Vertical Loads (TA<sup>3</sup>)

**Definition:** The ability of a structure to maintain its integrity without failure, both in during-construction phase and past construction phase, when placed under vertical loads calculated as per IS Codes. Loads which are to be considered for checking the load bearing strength of the system can be of two types:

- Dead Load (DL): Calculated as per IS 875 (1) or whatever as applicable
- Imposed Load (IL): Calculated as per IS 875 (2) or whatever as applicable
- In order to ensure optimal structural stability, the response of the system is also to be checked for combination of DL and IL (i.e. DL+IL) as described in Clause 8.1 of IS 875 Part 5

### 1.1.2 Stability against Lateral Forces (TA)

**Definition:** Ability of the structure to sustain its function namely safety and serviceability against earthquake and wind forces. Structure should be designed for earthquake exposure and wind forces both in during construction and past construction phases.

- The Earthquake Load/seismic load (EL) is to be calculated as per IS 1893 -1 (2002)
- Wind Load (WL) is to be calculated as per IS 875 (3)
- As per IS 875 Part -5, the response of the system is to be checked for:
  - DL+IL+WL
  - DL+IL+EL

<sup>1</sup> PA is Primary Attribute in the Evaluation Framework

<sup>2</sup> SA is Secondary Attribute in the Evaluation Framework

<sup>3</sup> TA is Tertiary Attribute in the Evaluation Framework

### 1.1.3 Performance of Joints (TA)

**Definition:** It refers to the finished quality and serviceability of joints and connections of building elements. For example, beam-column junctions, connectivity between precast members and cast in situ members, connections between sub-structure and super-structure, and host elements such as doors and windows.

- Assess joint stability – probability of rupturing, losing equilibrium etc.
- Assess performance of joints

### 1.2 Performance and Statutory Compliance (SA)

**Definition:** The proposed system has to be checked for overall performance and compliance against statutory provisions prevalent at the time and location of application. Following tertiary attributes are used to make a determination for this mandatory secondary attribute.

#### 1.2.1 Violation of statutory provisions (TA)

**Definition:** Compliance of the building system and technology with all the statutory regulations at national, state and local level as applicable (if any) such as MOEF, Bye-laws etc.

- Declaration should be given by the technology providers stating that the system shall not violate any statutory provisions applicable.

### 1.3 Fire Resistance (TA)

**Definition:** It refers to property of building elements to satisfy for a stated period, resistance to collapse, resistance to penetration of flame and hot gases, resistance to temperature rise when subjected to fire. Performance of the system against fire is to be checked in the following aspects.

- Compliance with IS 3809:2002
- Fire rating as per the current National Building Code (NBC)

### 1.4 Thermal Comfort (TA)

**Definition:** It is measured by the thermal resistance offered by the technology, i.e. the heat flow through a building that depends on the temperature difference, the conductivity and the thickness of the elements. Thermal comfort offered by any system can be assessed by:

- Comparing the thermal transmittance loss of the system with that of traditional construction
- Compliance with IS 3792:1978

### 1.5 Acoustic Performance (TA)

**Definition:** Acoustic performance refers to the reduction or elimination of external noise or decrease the transmission of unwanted noise in the constructed dwelling. Selected technology should restrict the reflection of sound thereby inducing privacy in the rooms of the constructed dwelling. Following are the criteria on which the acoustic performance of a system can be evaluated:

- Sound Transmission loss as per IS 1950 :1962
  - 30 dB or less – Poor
  - 40 dB – Fair
  - 45 dB – Good
  - 50 dB - very good
  - 60 dB - Excellent
- Compliance with MOEF norms: 55 dB at day time and 45 dB at night time
- Compliance with IS 1950: 1962: 65-80 dB for heavy traffic area and 60-70 dB for other areas

### 1.6 Weather-Resistance (TA)

**Definition:** Weather-tightness of a building is the resistance of a building to the weather conditions both prevalent and extreme. An emerging technology should by its design and through its construction detailing provide for 'Deflection'; 'Drainage'; 'Drying'; and 'Durability' conditions of the building. Weather-tightness attribute allows the building to be evaluated against weather elements of heat, wind, dust, rain, and snow as applicable. Following criteria is to be considered for evaluation:

- Qualitatively, is the proposed technology more effective against weather conditions, when compared with traditional system?



## 1.7 Water Tightness (TA)

**Definition:** It refers to the overall water tightness of the building system both externally and internally, especially along in the sunken portions and along the joints (and connections) between components. This ensures resistance of the building technology against leakage in a variety of prevalent weather and climatic conditions. Following aspects should be checked in waterproofing.

- Requirement of additional waterproofing.
- Effectiveness of waterproofing.
- Chances of fungal growth or contaminants on building elements.

## 2 Preferred and Desired Attributes for Evaluation of Emerging Housing Technologies (PA)

### 2.1 Functional Requirements (SA)

**Definition:** Secondary desirable attribute for assessing the technology or system against generally accepted functional requirements of housing.

#### 2.1.1 Design Flexibility (TA)

**Definition:** Design flexibility is defined as the ability of the technology to reconfigure the design of the houses as per the requirements with an understanding of possibility of changes as per the functional uses. In simpler terms, it is the ability of a building system to adjust and adapt to changes during the design, construction, and use phases with minimum disruption in process and with minimum cost impact.

The design flexibility should be checked in two following aspects:

- Degree of difficulty in incorporating changes during construction phase
- Provisions for post-construction expandability

#### 2.1.2 Restriction on Number of Floors (TA)

**Definition:** It indicates the height restriction for construction due to structural safety and stability issues or construction process related issues. This attribute determines any restriction on the maximum number of floors (storeys) that can be constructed using the system.

- Limitation on number of floors that can be constructed using the technology under consideration.

#### 2.1.3 Service Life and Durability (TA)

**Definition:** Service life and durability is about end users' realistic expectations that, subject to less maintenance, a building technology will last for a specified number of years. It also deals with the susceptibility of the technology to different environmental conditions. As it is quite difficult to get data about the average service life of all the systems, especially because many of them are newly introduced, durability can be judged by considering the following parameters:

- Suitability/Limitations for using in all environmental conditions
- Performance under accelerated environment test
- Expected service life of the system with respect to conventional system

#### 2.1.4 End-user-friendliness (TA)

**Definition:** It is defined as the ability of the system to meet the specific requirements of the end users. End-user-friendliness indicates the customer satisfaction and also suitability of the system for building Indian houses across regions and states. It includes criteria cultural and social criteria such as "nailability", provision for adding fixtures like coolers, air conditioners, etc. Following criteria is to be considered for evaluation:

- Suitability of the constructed building for adopting changes after construction by the occupant.

### 2.2 Constructability (SA)

**Definition:** Constructability, similar to design for manufacture and assembly, is defined as the relative ease of construction given a selected building design. It is the extent to which a building design with a chosen technology provides for ease of construction while meeting the overall requirements of the building. Using the construction expertise, during the design phase, steps are taken to optimize parameters like build-ability, cost effectiveness, resource efficiency, time schedule, quality, safety and overall project goals.

#### 2.2.1 Simplicity in Execution and Versatility (TA)

**Definition:** Steps required during construction and complexity of the process required for the building technology defines simplicity in execution and versatility during construction. With a view to increase productivity and efficiency of the overall system, it is desirable that the method of execution should be simple, otherwise extensive training and retraining of labour, increased requirement of skilled labour and delays due to system complexity might affect both construction cost and time. Following criteria are to be checked for this attribute:

- No of components for the assembly.
- Ease of construction (such as fixing reinforcements, placing of concrete, fixing building services, assembly and erection procedures, etc.).

- Provision for using any particular element of the system to serve different functional requirements.

### 2.2.2 Design Compatibility (TA)

**Definition:** *Compatibility with architectural design or architectural design flexibility allowing expression of form, function and aesthetics in design evolution. Following is the criteria for evaluation:*

- Ability to make curved surfaces (e.g. curved walls, domes, arches)
- Concealed piping electrical and plumbing services and provision for incorporating the mechanical, electrical and plumbing services within the proposed building component thickness
- Ability to make sunken floors
- Suitability for wet areas
- Ability to make sunshades and other appurtenances required for a typical house in the regional context

### 2.2.3 Foundation Type (TA)

**Definition:** *This attribute captures the type of foundations required for erecting the building with the selected technology. Following criteria are to be evaluated for this aspect:*

- Requirement of shallow or deep foundation for erecting the technology.
- Requirement of Heavy or light foundation for erecting the technology.

### 2.2.4 Skilled Labour (TA)

**Definition:** *It refers to projection and identification of trained work force required for adopting housing technology for construction. Following criteria are to be considered for this attribute:*

- Type of labour required (such as skilled/ semiskilled/ unskilled)
- Level of training required

### 2.2.5 Equipment (TA)

**Definition:** It refers to identification of appropriate equipment related to each stage of construction such as hoist, batching plant, cranes, and any other specialized equipment while adopting a particular technology. Following criteria should be checked for equipment:

- Type of Equipment required, such as heavy/light or standard/specialized.
- Requirement of manufacturing plant and if it is required then, whether is it centralized or on-site?

### 2.2.6 Construction Safety (TA)

**Definition:** Safety deals with the identification and elimination of hazards associated with the technology thereby resulting in zero accidents, and zero lost time injury. The performance of a system against this attribute may be evaluated by:

- Comparing the degree of risk/hazard involved in the system with that of conventional construction method.

### 2.2.7 Temporary Services Requirement (TA)

**Definition:** It refers to the requirement of temporary services for the implementation of the housing technology i.e. mainly the requirement of water, power & other services during construction phase. The performance of a system against this attribute may be evaluated by:

- Requirement of initial power for implementing the technology
- Requirement of water for implementing the technology

## 2.3 Economic Viability (SA)

**Definition:** Economic viability of a chosen technology is its economic competitiveness in the present market conditions and business environment. The technology under consideration must be economically viable for all the stakeholders.

### 2.3.1 Initial Cost (TA)

**Definition:** It pertains to the overall cost of construction involved in labour, materials, plant and machinery and overheads. For evaluating the systems on this attribute, the following costs are to be compared with that of conventional system:

- Capital Cost.

2.3.2 Speed of Construction (TA)

**Definition:** Speed of construction is linked to the time taken to complete all construction steps and processes for a given technology. Time savings during construction is significant to all stakeholders, therefore, the following criteria needs to be considered for assessing the attribute:

- Evaluating the speed of construction in comparison with traditional construction.

2.3.3 Economies of Scale (TA)

**Definition:** This attribute deals with the Economic feasibility of adoption of housing technology for constructing any number of dwellings so that the component of fixed cost is least variant with the number of dwellings. Following criteria is to be checked for this attribute:

- Minimum number of dwellings to be constructed using the technology.

2.3.4 Lead Time (TA)

**Definition:** Lead time is the latency (delay) between the initiation and execution in adopting the technology for construction of dwellings. Following criteria is to be considered for evaluating the attribute:

- The lead time involved for the technology in comparison with that of conventional system.

2.3.5 Efficiency of Design (TA)

**Definition:** Land being a scarce resource calls for a need to optimize the utilization of spaces. While evaluating emerging construction technologies, space savings and land utilization also becomes an important factor to consider as availability of space is also a constraint for modern construction. The optimal use of space can be measured by taking into account the following consideration:

- The efficiency of design which is given as the ratio of the built-up-area to carpet area.

2.3.6 Supply Chain Reliability (TA)

**Definition:** Construction projects typically involve series of inter-related activities in which successful completion of any particular activity is dependent upon that of its

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predecessor activities. Thus the failure of even one supplier may lead into the collapse of the entire system. It is always preferable that while selecting suppliers for any housing technology, practitioners should always look for only highly reliable organizations (HROs) in order to ensure delivery of most suitable technologies at the most suitable prices and in the right time. Following consideration is to be assessed for evaluating the attribute:

- The availability of reliable suppliers for a particular construction technology in the very initial stage.

### 2.3.7 Technology Transfer Possibility (TA)

**Definition:** This attribute pertains to dissemination of technical know-how, skills, resources and production techniques of adopted housing technology from its origin to broader sphere of use. Following criteria is to be used for evaluation of this attribute:

The possibility of producing the adopted technology in India using local resources.

## 2.4 Maintenance (SA)

**Definition:** This attribute deals with the ease with which the regular and periodic maintenance can happen for the adopted technology so as to attain the maximum life period of the constructed building.

### 2.4.1 Maintenance Cost

**Definition:** It refers to the life cycle cost of the system which includes the recurring cost of maintenance as well as the replacement cost at the end of the service life of the system. The following costs are to be compared with that of conventional system:

- Cost for periodic maintenance of the system
- Replacement cost at the end of the service life of the system.

### 2.4.2 Frequency of Maintenance (TA)

**Definition:** It refers to the interval between two successive maintenances, such as regular or occasional required for the adopted technology. Following criteria is to be considered for assessment:

- Requirement of regular or occasional maintenance and corresponding time interval

### 2.4.3 Type of Maintenance (TA)

**Definition:** It refers to the severity of maintenance activities needed for the adopted technology. Following criteria is to be considered for evaluation:

- Requirement for major or routine maintenance.

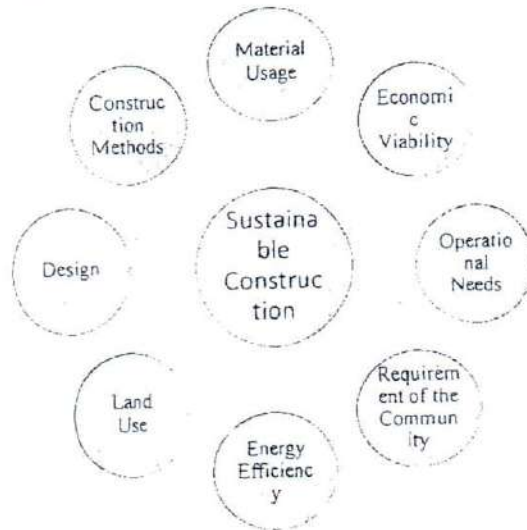
### 2.4.4 Ease of Maintenance (TA)

**Definition:** It refers to the degree of difficulty involved in carrying out maintenance works for the adopted technology. Following considerations are to be used for assessment:

- Availability of workmen needed for maintenance works.
- Availability of tools and technologies needed.
- Availability of materials needed etc.

### 2.5 Sustainability (SA)

**Definition:** Sustainability ensures a better and more sustainable future for the human race and the planet earth at large. It includes those technologies that use less virgin material, less energy, cause less pollution and less waste without compromising on the project's economic viability and the comfort, safety and other requirements of its occupants.



*Fig: Balancing Parameters of Sustainable Construction*



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It is desirable that while evaluating several housing technologies in order to select the most appropriate one, following aspects of sustainable construction practices should also be taken into consideration:

### 2.5.1 Eco-friendly Construction (TA)

**Definition:** It has been seen that building construction often affects the surrounding environment and its natural resources in a negative way. The term eco-friendly construction refers to those construction technologies which are conducive to the principles of sustainable development in terms of use of local and renewable materials, energy efficiency, less emission of hazardous materials and pollutants etc.

Following criteria should be considered for evaluating eco-friendliness of construction technology:

- Use of local materials as otherwise the required transportation causes pollution and consumption of fuel which in turn is a scarce resource in present-day context.
- Use of Non-renewable resources in production.
- Use of waste products.
- Recyclability of material.
- Waste generation and utilization of waste generated.
- Emission of pollutants/ hazardous materials.

### 2.5.2 Embodied Energy (TA)

**Definition:** It refers to the total non-renewable energy consumption in acquisition of raw materials, their processing, manufacturing, transportation to adoption of housing technology. It is an indicative of the building technology's overall impact in the environmental context. Selection of technology and procedure of construction should be done in such a way so as to create a proper balance between climatic conditions, material availability, transportation cost etc.

- However in absence of appropriate data, the exact embodied energy for any system may be judged subjectively.

### 2.6 Finish Quality (SA)

**Definition:** Choice of methods and materials greatly affect the workmanship quality and thus the ultimately the finish quality of construction. So while evaluating the

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technologies of construction, one shall take into account the desired quality of finishes also. Finish quality includes bulging and waving of surfaces, hollowness, surface cracking, thick plastering requirements etc. Broadly the different aspects of finish quality are classified into:

#### 2.6.1 Exterior Finish Quality (TA)

**Definition:** It refers to the finish quality of exterior surfaces (both horizontal and vertical) including exposed concrete surface, masonry, glazing and claddings, different types of sidings, brick exteriors and stuccos etc. obtained using the adoption of housing technology. The term exterior finish quality deals with issues like surface cracking, spalling, bulging and waving of exterior surfaces, hollowing, dampness, and other anomalies etc. Following criteria are to be used to evaluate the attribute:

- Quality of finish obtained in terms of high, medium, low.
- Requirement of finishes.
- Compatibility with surface finishes such as putty, paint etc.

#### 2.6.2 Interior Finish Quality (TA)

**Definition:** It refers to the finish quality of interior surfaces (both horizontal and vertical) obtained using the adoption of housing technology. The term interior finish quality deals with issues like surface cracking, bulging and waving of interior surfaces, hollowing, dampness, and other anomalies etc. Following considerations are to be used to evaluate the attribute:

- Quality of finish obtained in terms of high, medium, low.
- Requirement of finishes.
- Compatibility with surface finishes such as putty, paint etc

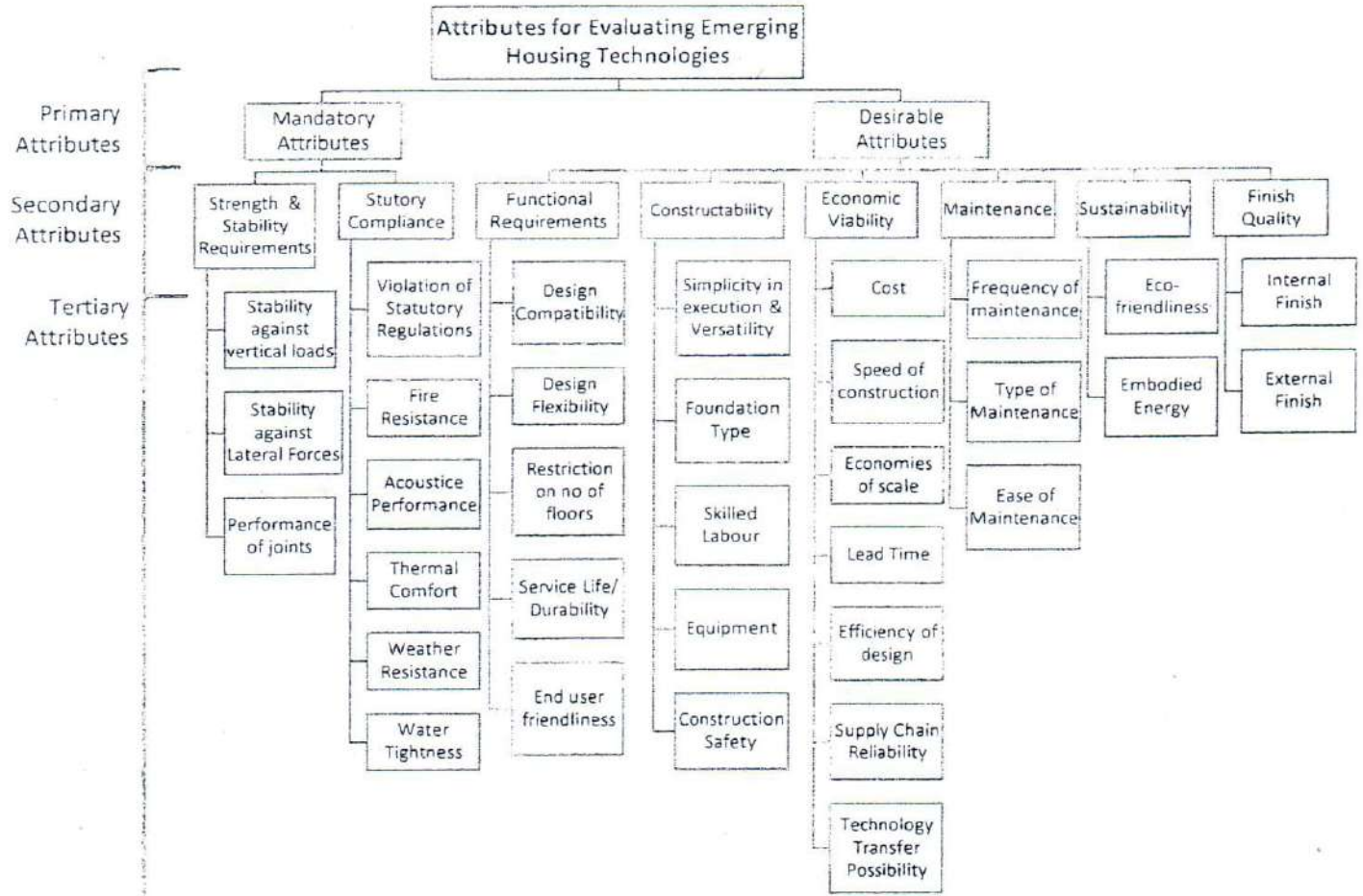
### 3 Summary & Conclusions

The key outcome of this research work is an efficient and yet "easy-to- implement" set of attributes which will also serve as a Decision Support System (DSS) for the emerging technologies of housing. This set of identified and defined attributes will aid the Indian Real Estate developers to select the most appropriate method of residential building construction from the perspective of affordability and sustainability.

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# 5 Appendix B – List of Attributes



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