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Low-Cost Housing in Hilly Regions: Sustainable Material and Construction Techniques

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Abstract: Housing is a basic human need and play an important role in improving the quality of life and social well-being. In a developing country like India, rapid population growth and urbanization have increased the demand for affordable housing. Housing constitutes a fundamental component of urban infrastructure and plays a significant role in achieving inclusive and sustainable development. The government of India introduced the "Housing for all" initiative to address the housing requirements of economically weaker and low-income groups. However, the increasing cost of land, construction materials, labor, and associated infrastructure has made adequate housing financially inaccessible to a significant section of the population. This study investigates the applicability of sustainable material and costs effective construction techniques for developing affordable housing while maintaining adequate structural performance, durability, thermal comfort and environmental suitability. This paper basically explains how low-cost housing in hilly region uses alternative and locally available materials to reduce overall construction cost while maintaining basic strength and safety. The comparison of the two construction methods with different materials demonstrates that low-cost housing is significantly more cost-effective, costing approximately 69% less than the traditional housing. The study concludes that low-cost housing is a suitable solution for providing affordable homes to low- and middle-income groups in developing countries like India. Proper planning, selection of appropriate materials, quality control, skilled supervision, and awareness of modern construction techniques are essential to ensure the long-term performance and durability of low-cost housing. The finding highlights the potential of integrating locally available resources with cost effective and sustainable construction technologies to develop affordable, resilient, and environmentally responsible housing solution in India.
Keywords: Low-cost housing, Hilly region, Sustainable materials, Construction techniques, Cost effective housing.

I. INTRODUCTION

Low-cost housing in hilly region is an important area of research due to the high construction, difficult terrain, limited accessibility, and vulnerability to natural hazards such as earthquakes and landslides. Conventional construction methods often require expensive material, skilled labor, and transportation, making housing less affordable for local communities. The use of locally available materials, sustainable construction techniques, and cost-effective structural system can significantly reduce construction cost while improving safety and durability. Traditional construction practice, when combined with modern engineering principles, can provide suitable housing solution for hilly areas. This study focuses on analyzing low-cost housing techniques and material suitable for hilly region' with emphasis on affordability, sustainability, seismic safety, and environmental suitability. House or shelter is one of the basic necessities for a human being. Evolution of houses from huts and mud brick houses to G+1, cement plastered, multi-story housing colonies has witnessed a great change in lifestyle and housing needs of individual. The purpose of this study work is to advance knowledge of the complexities pertaining to accessible and affordable housing in India. It will investigate several current solutions, compare various strategies, and investigate the different elements that contribute to the housing shortage. Construction of houses consume significant number of materials and resources such as electricity, fuel, water, sand, cement, steel, wood, bricks, plastics, aluminum and glass. Construction of a house is like any other construction and happens in stages like project initiation, planning, execution, monitoring and control and handing over. As far as energy consumption is concerned, there are many more stages in the service life of a building that are to be considered.

The government of India has introduced several schemes to reduce the shortage of houses for low-income groups (LIG) and economically weaker section (EWS). One of the major schemes is Pradhan Mantri Awas Yojana (PMAY), launched in 2015. Its main aim was to provide affordable and good quality houses with basic facilities such as water supply, sanitation, and electricity to needy families. Housing is said to be affordable to people in hilly region with medium household income as rated by the government by a recognized housing affordability index (Bhatta, 2010).

Affordable housing means a house that a family can comfortably afford according to its income. Affordability is generally measure by comparing the family income with housing expenses. The govt. of India considers factors such as family income, house size, EMI amount, and the ratio of house price to annual income to decide whether a house is affordable.

A. Salient characteristics of traditional settlement and construction in hill regions

Hill settlements in India are usually developed on relatively flatter terrain than surrounding areas which are often considered more stable and less prone to natural hazards like landslides and cloudburst. Oliver, (2006). Traditional settlement in hill region of India is mostly located on southern slopes to have sufficient solar exposure throughout the day and protection from northern cold winds, so that comfortable living condition can be achieved with minimal consumption of energy., Rapoport, (1969). Vernacular building in hilly areas is mostly rectangular in shape and constructed with locally available materials, which are having good climate response. Floor to ceiling height is usually kept between 8 to 9 feet which is low as per contemporary building standards. Symmetrical small window has better seismic response than most of the contemporary building with modern materials in hill settlement of north India. Arya, (2000). Non engineered indigenous construction technique is adopted for construction of building which are developed with local materials, have good climate response, maintain indoor comfort condition and have very good response against earthquakes. UN-Habitat, (2016)

Table.1 Low-cost wall construction techniques used in different hill region

S.no	Construction technique	Material used	Building component	Areas where it is used
1	Mud house	Mud +straw	Floor, wall	Leh Ladakh, Lahaul spiti
2	Dry stone walls	Stone	Wall	Kangra, Chamba
3	Sun dried brick houses	Earth	Wall	Outer Himalayan region
4	Stone house	Natural stone dressed or undressed	Wall	Kashmir Himachal
5	Taaq system	Timber and brick	Wall	Kashmir

Arya et al. (2000)

II. STUDY AREA

Himachal Pradesh was selected as the study area for the present research on low-cost housing construction in hilly areas. The state is located in the northern part of India and forms an important part of the western Himalayan region. Geographically, Himachal Pradesh extends between 30°22′40″ N and 33°12′40″ N latitudes and 75°45′55″ E and 79°04′20″ E longitudes. The state covers an area of approximately 55,673 km² and divided administratively into 12 districts. The elevation varies considerably, from approximately 350 m to 6,975 m above mean sea level, resulting in substantial variation in climate. The state is characterized mountainous landscape comprising the Shivalik hills. According to the census of India 2011, Himachal Pradesh had a population of approximately 68.65 lakh, with an average population density of about 123 persons per km2. A major proportion of the population resides in rural and semi- urban settlements distribution across mountainous terrain. The dispersed nature of settlements, combined with difficult accessibility and limited infrastructure in remote areas, create significant challenges for conventional housing construction. Transportation of construction materials such as cement, steel, bricks and aggregates to remote and high-altitude locations can high altitude locations can substantially increase construction cost. Therefore, the development of economical housing system using locally available materials, local labor and appropriate construction technologies has considered potential for improving housing affordability in the state.

The geographical and climate characteristics of Himachal Pradesh makes the state highly relevant for research on sustainable and low-cost housing. Locally available Materials such as stone, timber, bamboo and other natural or regionally available materials can potentially reduce the construction cost. Himachal Pradesh also receives considerable precipitation, although its distribution varies greatly from one region to other. Areas such as Kangra and Dharamshala receive relatively high rainfall, whereas the higher cold-desert region of Lahaul-spiti receives comparatively low precipitation. Snowfall is an important climatic factor in the higher Himalayan areas influences roof design, structural loading and material selection.

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III. LITERATURE REVIEW

The study of literature includes deep investigation of the research done in past decades aiming to provide low-cost housing and studies the result of the study done by various authors and ultimately provides the future scope of their study. Taur and Devi (2009) This paper aims to point out the various aspects of prefabricated building methodologies for low-cost housing by highlighting the different prefabrication techniques to reduce the cost of construction. Since there is repeated production of similar types of components in precast construction, therefore, it results in faster execution, more productivity and economy in prefabricated construction, the work at site is reduced to minimum, thereby, enhancing the quality of work, reliability and cleanliness. Reddy et al. (2011) studied the suitability of manufactured sand as fine aggregate material. In this study the characteristics of concrete and mortar using M-sand as fine aggregate were determined and compared with that of concrete with river sand. The mortar made with M-sand showed better engineering properties (compressive strength, better workability, bulk density etc.) as compared to that with river sand. The concrete sample was of M20 & M30 grade which gave very satisfactory results when M sand was used in place of river sand. Hence the test program gave a positive aspect on the suitability of M-sand as an alternative to river sand and also helps in the cost reduction for constructional activities. Jadhav et al. (2024) This literature review focuses on evaluating economical housing construction techniques and comparing them with conventional methods. The study considers material such as Porotherm hollow blocks, CSEB, bamboo, straw bales, clay bags, Mangalore tiles, and filler material, along with techniques such as prefabrication, modular construction, rat trap bond masonry, filler slabs, thin joint masonry, and passive solar design. Cost date was collected from different housing projects and evaluated based on construction time, material cost, and overall project cost. The study found that low-cost housing technologies can reduce construction cost by up to 40 %, while also reduce material and labor requirements and shortening construction time. The study concludes that these technologies can provide economical, resource-efficient, and scalable solution for affordable housing. Jain and Bhandari (2023) In this literature study the use of prefabricated components in low-cost housing to reduce construction time and cost and improve quality. The study used precast concrete panels, steel frame, precast beam, column, staircase, lintels and AAC blocks through prefabrication, modular and panel construction techniques. Data were collected from case studies and compared with traditional construction based on time, cost, labor, quality and waste. The results showed 30-50% reduction in construction time, lower labor requirements, better quality control and reduced material wastage. The study concluded that prefabricated is a fast, economical and efficient technique for low cast and mass housing, particularly where rapid construction is required. Perez Fargallo et. al (2018) Author studied indoor thermal comfort in low-cost residential buildings and compared them with traditional housing. The study focused on passive design techniques such as cross ventilation, proper building orientation, thermal mass, roof insulation, courtyard planning and shading devices. Material included mud block, lime plaster, fly ash bricks, thatch and clay tiles. Through field measurements and thermal analysis, the study found that low-cost housing provided better natural cooling, improved ventilation, lower indoor temperature and reduced energy consumption. Vivian et al (2000) The author explained that adequate shelter for all people is one of the pressing challenges faced by the developing countries. India is currently facing a shortage of about 17.6 million houses. The dream of owning a house particularly for low –income and middle-income facilities is becoming a difficult reality. Hence it has become a necessity to adopt cost effective, innovative and environment- friendly housing technologies for the construction of houses and buildings for enabling the common people to construct houses at affordable cost. This paper compares construction cost for the traditional and low-cost housing technologies. Case studies in India are used for the investigation. construction methods of foundation, walling, roofing and lintel are compared. Strength and durability of the structure, stability, safety and mental satisfaction are factors that assume top priority during cost reduction. It is found that about 26.11%and 22.66%of the construction cost can be saved by using low-cost housing technologies in comparison with the traditional construction methods in the case studies for walling and roofing respectively. This proves that using low-cost housing technologies is a cost-effective construction approach for the industry Chougule (2014) The author discusses the use of filler slab as an alternative construction technique to the modern conventional methods. The materials to be used as filler materials should be light weight, inert and inexpensive with a particular size which so as to be can be accommodated within the spacing reinforcement. According to a study conducted by Central building research institute a filler slab with non-autoclaved cellular concrete blocks can be used for sustainable construction. A comparison was made between the filler slab and conventional RC slab which proves that the strength of conventional slab and filler slab is almost equal and hence do not have any strength deformities and can be adopted in place of conventional slab. The filler slab technique is a cost-effective method and saves up to 30% of concrete hence justifying its role as an efficient low-cost construction technique. Gopalan and Venkataraman (2015) according them housing affordability should not be measured only by the purchase price of a house. It should consider different factors such as rental affordability, loan repayment, or EMI affordability, location and transportation costs, living conditions, and total housing expenses.

Warrier et al. (2019) the paper reviews the need, development and technologies related to low-cost housing in India, particularly for EWS and LIG. The author highlights India large housing shortage and explains that meeting housing demand on a large scale can significantly increase the consumption of construction material and energy. Therefore, the study emphasizes the importance of selecting alternative construction materials, innovative building technologies and efficient construction methods that can reduce cost and resource consumption without compromising housing quality. Kumar and Parihar (2025) in their paper a comparative analysis examines the challenges of providing affordable housing to Economically weaker section (EWS) and Low-income groups (LIG) in India. The study compares conventional and innovative construction technologies such as prefabrication, alternative building materials, ferrocement and 3D printing based on cost effectiveness, construction speed, sustainability and scalability, it also reviews government policies such as PMAY, rental housing and land management policies along with financing mechanisms including microfinance and public-private partnerships (PPPs). Doshi (1989) the Aranya low-cost housing project in Indore, designed by Balkrishna Doshi was developed to provide affordable and sustainable housing for low-income groups while improving urban living conditions. The project adopted an incremental housing approach, allowing residents to expand and modify their houses according to their future needs. Khaja et al. (2024) focus on the application of recycled and waste material to develop economical and sustainable housing. Material such as plastic waste, recycled concrete aggregate, scrap metal, fly ash, recycled steel, demolition waste, glass, and rubber are considered as alternative to conventional construction materials. Jagtap et al. (2024) examines the principles of low cost and sustainable housing based on the innovative construction practice of Laurie Baker. The study emphasizes the use of locally available and recycled materials such as stone, mud, laterite, bricks, mortar, terracotta tiles.

IV. RESEARCH METHODOLOGY

This methodology is adopted for the study on construction of low-cost housing in hilly region and compare with this cost to traditional housing. The aim of this paper is to collect, analyze, and interpret data related to construction cost, and materials, aspects of both housing system. The collected information is systematically classified into major parameters, including material type and quantity, construction cost, labour requirements, construction time, maintenance cost, structural performance, thermal performance, environmental impact, and sustainability. The finding is synthesized to identify the most effective and sustainable low-cost housing approaches and to develop recommendations for reducing construction cost while maintaining safety, durability, functionality, comfort and environmental performance. Relevant information is collected through a systematic review of research papers, government reports, technical publication, standards, and selected case studies. The material and construction technologies adopted in traditional and low-cost housing discuss in section A and B.

A. Traditional Housing

Traditional housing common RCC building in hilly region required high cost of construction, material, transportation, and non-availability of proper road. Construction techniques use of conventional method (brick masonry, RCC structure). The design and analysis of traditional building is carried out according to BIS codes.

B. Low-Cost Housing

Reviewing various techniques employed in modifying design and material usage of low -cost housing in hilly region. AAC (autoclaved aerated concrete) blocks are lightweight, precast building material made from fly ash or sand, cement, lime, gypsum, and aluminum powder. They basically reduced the structural dead load and easy to transport. Shaping and cutting AAC can be done with a handsaw. Hollow concrete block is concrete block having a core void area greater than 25 % of the gross area, (Chiluka, S. 2023). The hollow spaces insides the blocks make the masonry lighter and provide good insulating properties against sound, heat, and moisture. Fly ash bricks are manufactured using fly ash, cement, or lime, sand and water, and are produced by mixing, pressing, and curing the material. Compared with traditional clay bricks, fly ash bricks are generally uniform in size, lighter and have good compressive strength and durability. A mud plaster house is a low cost and environmentally friendly building in which the walls are generally constructed using mud blocks, stone, or brick masonry and the wall surface are finished with mud plaster, shown in Figure1.Decorative concrete block incorporates aesthetics into low-cost housing in hilly region by providing visually appealing wall finishes. They can be manufactured by sustainable materials and techniques, reducing environmental impact while improving the architectural appearance of buildings. Light weight concrete blocks are produced using lightweight aggregate such as expanded clay, pumice, or other lightweight materials. They have good thermal and sound insulation properties and reduce the dead load of the structure.

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Brick panel Roofing is a construction technique developed by the central building research institute (CBRI) in Roorkee. It is a cost effective and efficient way to build roofs, and it can save up to 20-25 % in concrete and 25-35 % in total slab cost, (Chilika S. ,2023). Overall, brick panel roofing is a cost effective and efficient way to build roofs, shown in Figure 2.

Figure 1: Mud-plastered house. (Chiluka, S.) 2023

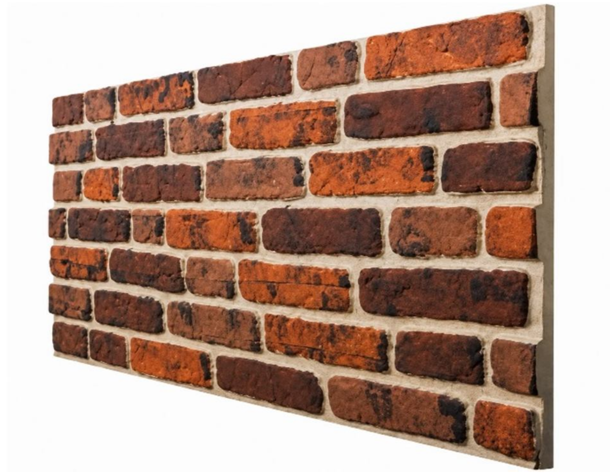

Figure 2: Brick panels. (Chiluka, S.) 2023

Bamboo fiber as a building and reinforcing material, it is basically lightweight, strong, flexible and rapidly renewable material that can be used for structural elements, roofing, reinforcement, and other low-cost building components. Its high strength to weight ratio makes it suitable for structures subjected to wind and earthquake forces, shown in Figure 3. Straw fiber is an agricultural by product that can be used as a sustainable construction material in hilly region. It can be incorporated into thatch roofing, wall panel, boards, and mud-based construction.Various construction techniques like non-erodible mud plaster technology is used to protect mud walls from erosion and water penetration during rainfall. The techniques involve mixing bitumen cutback emulsion with mud mortar and wheat or rice straw and applying it to the wall in 12 mm thickness. Jute and coir fibers are natural fibers that can be mixed with mud plaster to improve its strength, crack resistance, and durability. They are particularly useful in low cost and sustainable housing, shown in Figure 4. Voided filler slab technique is a cost-effective roof construction technique in which lightweight filler materials such as Mangalore tiles or coconut shells replace unnecessary concrete in the tension zone of an RCC slab. This reduces concrete consumption, dead load, construction cost, and carbon emissions. Filler slab can also provide better thermal performance, shown in Figure 5.

Figure 3: Bamboo fiber (Chiluka, S.) 2023

Figure 4: Jute and coir fiber (Chiluka, S.) 2023

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Figure 5: Filler slab (Chiluka, S.) 2023

The proposed low- cost housing project was designed using building plans, elevations, and sections. The design incorporated cost-effective and locally available materials suitable for hilly region. The drawing was used to estimate materials quantities, construction costs, and to compare the proposed housing system with traditional housing. The plan, elevation & section drawings used for this study have been represented in the following Figure 6 & 7.

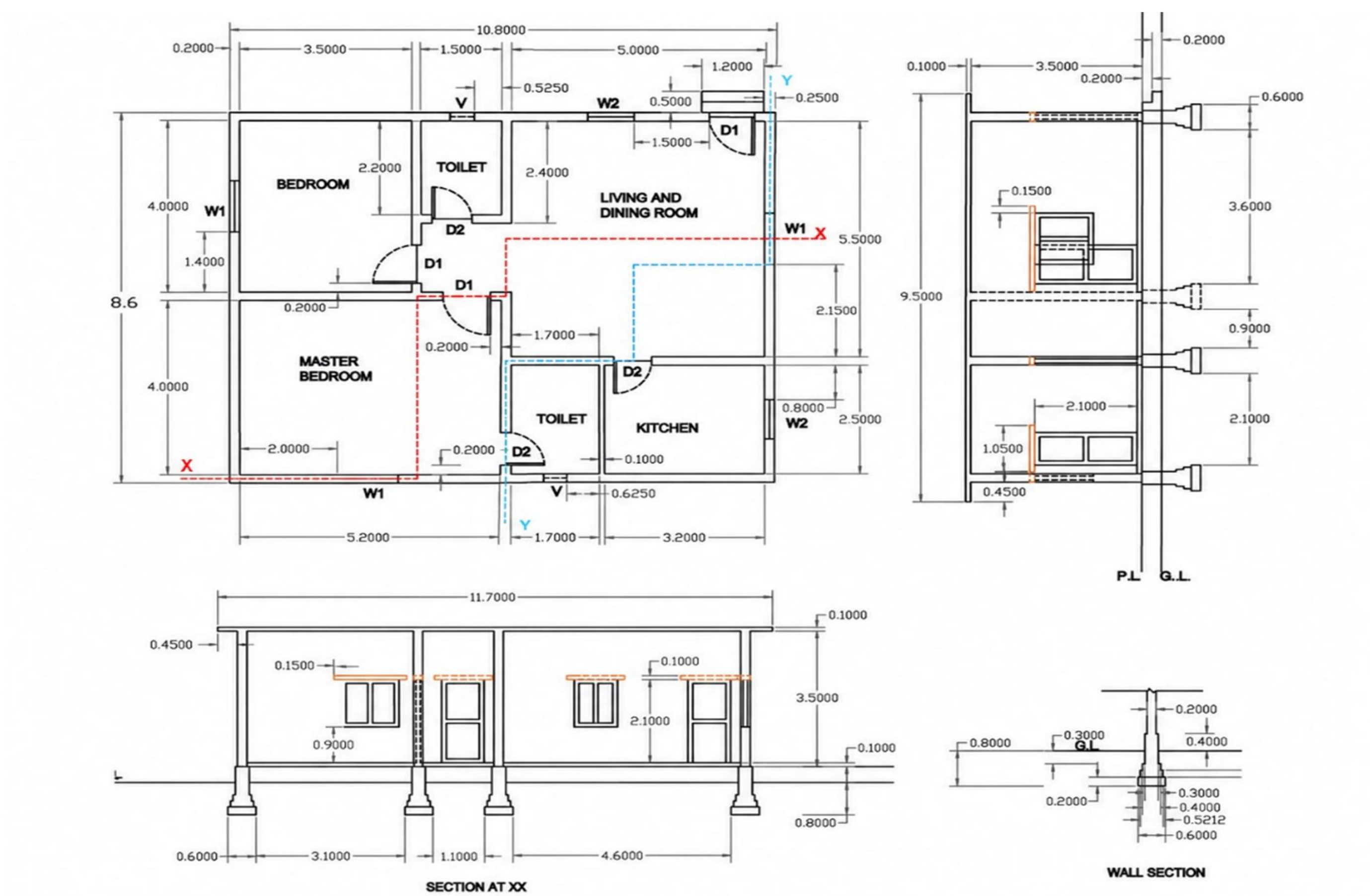

Figure 6: Detailed plan, section at XX, section at YY and wall section of low-cost housing

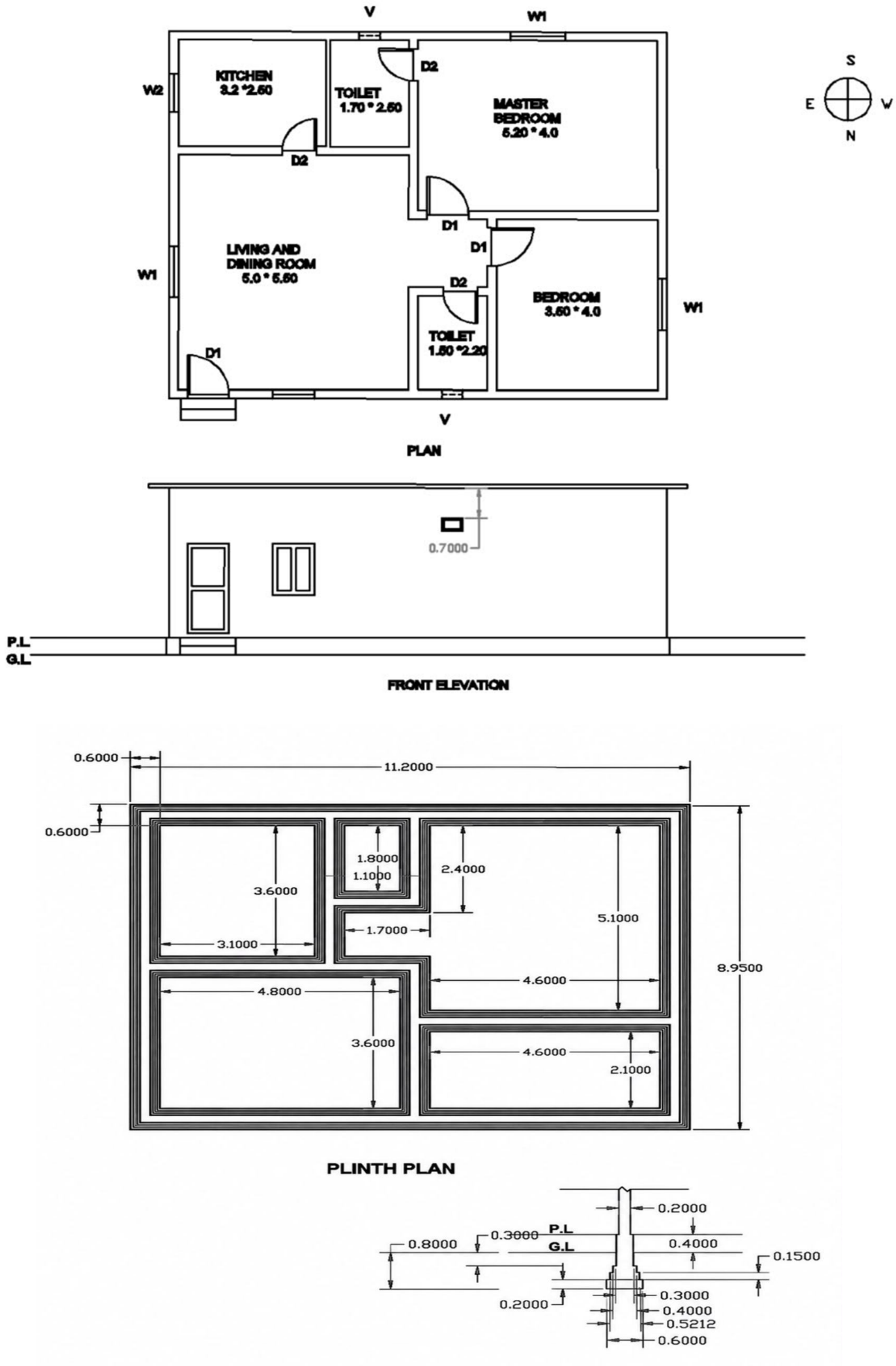

Figure 7. Plan, Elevation and plinth plan of low-cost housing

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The drawing presented in Figure 8, represents a complete 3D architectural presentation of a single-storey low-cost house. It combines the floor plan, 3D views, elevation, and sectional views. The house is designed as a compact 2- bedrooms, living dining room, kitchen, toilets and circulation space. The 3D modelling Autodesk Revit software (academic license) is used to prepare this 3D low-cost housing model. Autodesk Revit provides an efficient method for designing, modelling and documenting of any architectural 3D plan.

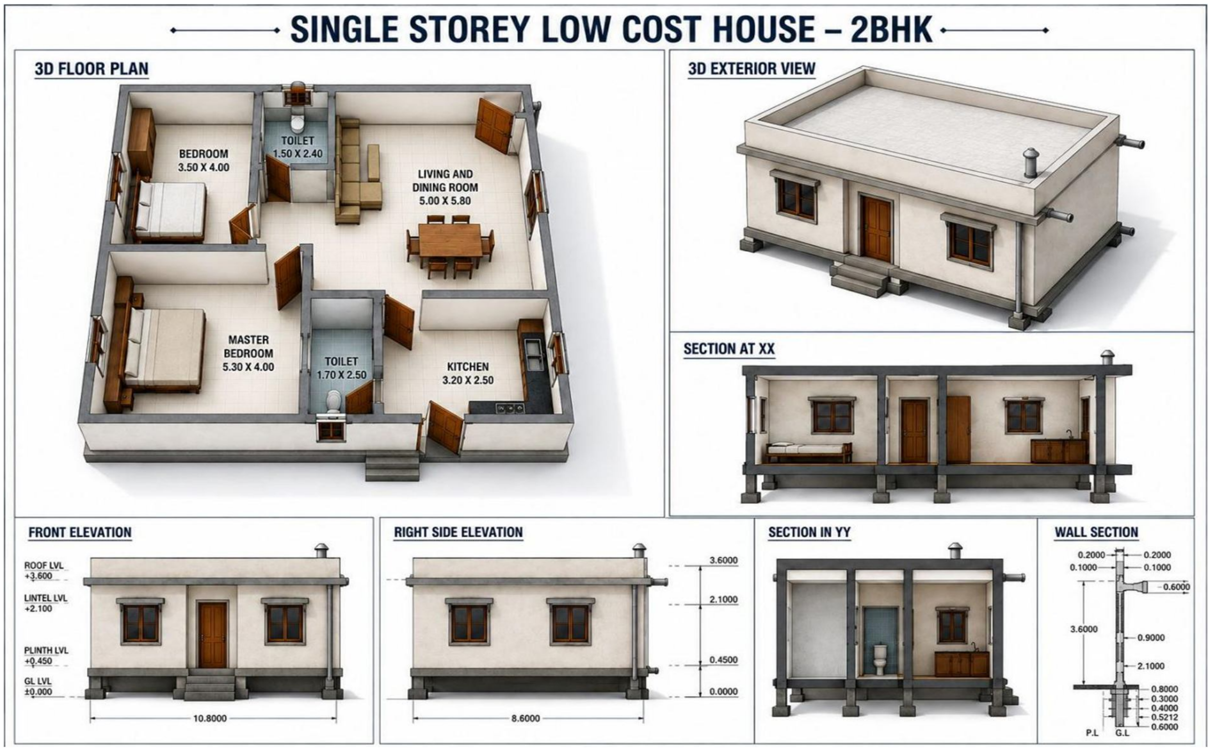

Figure 8. 3D drawings of low-cost housing

For the present study, a 2BHK single story house has been considered for both traditional and low-cost housing measurement & cost estimation purposes. The room dimensions are mentioned below in the table 2.

Table 2. Room dimensions, plan area and plot area

Sr. No.	Room/ Space	Dimensions (m)
1.	Bedroom 1	3.5*4
2.	Master Bedroom	5.3*4
3.	Living/ Dining Room	5*5.8
4.	Kitchen	3.2*2.5
5.	W/C 1	1.7*2.5
6.	W/C 2	1.5*2.2
7.	Total plan area	92.88
8.	Total plot area	111.15 m2

V. RESULTS AND DISCUSSION

The cost estimation was carried out to compare the economic feasibility of traditional and low-cost housing construction. For the traditional housing model, the rates of construction items were considered based on the applicable Himachal Pradesh Public Works Department (HPPWD) Schedule of Rates (SOR), including the relevant material, labor and construction components, abstract of traditional housing mentioned in table 3.

For the proposed low-cost housing model, rates were considered based on prevailing local market rates for locally available and alternative construction materials and low-cost construction techniques. The quantities and basic functional requirements of both housing models were kept comparable to provide a consistent basis for cost comparison. The total estimated cost was then calculated by multiplying the quantities of individual construction items by their respective rates. This approach was adopted to assess the potential cost savings achievable through the use of locally available materials and economical construction techniques in hilly regions, abstract of cost for low-cost housing mentioned in Table 4.

Table 3. Abstract of cost for Traditional Building

Sr. No.	Particular of Work	Quantity	Unit	Rates/Unit	Amount (in Rupees₹)	Remarks
1	Earth Work					
a)	Excavation	19.404	m^3	₹171.40/m^3	3325.85	Excavator (JCB)is used For excavation
b)	Filling	50.622	m^3	₹270.40/m^3	13688.19	The method of filling is Manual
		Total Cost of Earthwork			17015.00	
2	PCC Base of 1:3:6	1.764	m^3	₹5600/m^3	9878.40	PCC base of 100mm thickness M10 Concrete grade is used
3	RCC Work of 1:1:2	52.81	m^3	₹8500/m^3	448885.00	RCC of M20 grade is used
4	Form Work	325.75	m^2	₹300/m^2	97725.00	Plywood is used as Mould for concrete
5	Brick Work	48.3	m^3	₹4800/m^3	231840.00	A-class bricks is used in the wall construction with1:6 mortar
6	Plaster Work of 1:3 of 12mm thickness	411.02	m^2	₹180perm^2	73983.60	12mm thick cement plaster of 1:3
7	White Washing Work (with2 Coats)	356.62	m^2	₹18perm^2	6419.16	White Washing with two coats
8	Paint Work (using Distemper of Two coats)	356.62	m^2	₹65perm^2	23180.30	Paint Work using Distemper with two coats
9	Tiles Work					
	Flooring work (Using tiles)	82.765	m^2	₹650per m^2	53797.25	Flooring with tiles
	On Walls	54.4	m^2	₹700per m^2	38080	Wall tiling (bathroom/ Kitchen glazed tiles)
	Total Tiles Cost				91877.25	
10	Skirting Work	59.8	M	₹180per m	10764.00	Skirting with tiles
11	Cornice Work	69.4	M	₹150per m	10410.00	---------------------
12	Ceiling Work	106.21	m^2	₹550per m^2	58415.50	Wooden ply ceiling work
13	Timber Work					
a)	In frames	0.443	m^3	₹75,000per m^3	33210	
b)	Door1	1	Nos.	₹6,000per each	6000	Panelled door (1.2m× 2.1m)

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c)	Door2	3	Nos.	₹4,800per each	14400	Panelled door (0.9m× 2.1m)
d)	Door3	2	Nos.	₹4,200per each	8400	Panelled door (0.75m× 2.1m)
e)	Window1	1	Nos.	₹5,500per each	5500	Glazed wooden window (1.8m×1.2m)
f)	Window2	7	Nos.	₹4,000per each	28000	Glazed wooden window (1.2m×1.2m)
g)	Ventilator	2	Nos.	₹1,200per each	2400	Glazed ventilator (0.6m ×0.45m)
	Total Timber or Wooden Cost				97910.00	
14	Electrical Work	24	Points	₹1,200per point	28800.00	----------------------
15	Plumbing Work					
a)	Water Supply					
	CPVC Pipes	44	M	₹180	7920.00	----------------------
b)	Fittings					
	Elbows	13	Nos.	₹25/Nos.	325	----------------------
	Tees	5	Nos.	₹40/Nos.	200	----------------------
	Valves	6	Nos.	₹250/Nos.	1500	----------------------
	Unions	6	Nos.	₹50/Nos.	300	----------------------
		Total plumbing work cost			10245.00	
c)	Overhead tank	1	Nos.	₹5,500each	5500.00	Plastic Overhead Water Tank(1000litre)
d)	Sanitary Pipes					
	Soil Pipe (100 mm)	12	M	₹630	7560	------------------------
	Waste Pipe (75 mm)	15	M	₹550	8250	------------------------
	Vent Pipe	6	M	₹180	1080	------------------------
		Total cost of Sanitary Pipes			16890.00	
e)	Manholes& Traps					
	Manholes	2	Nos.	₹6,000 each	12000	Bricks issued in Manhole's construction
	Floor traps	3	Nos.	₹300	900	------------------------
	Gully traps	2	Nos.	₹1,200	2400	------------------------
	Total Plumbing(item no. 15 total) Cost				47935.00	
	Sub Total Cost				₹12,55,038.00	
	Add 3% contingencies				₹37651.00	
	Add 2% work charge establishment				₹25101.00	
	Grand total cost				₹1317790.00	

Table 4. Abstract of cost for low-cost housing

S.no	Particular of work	Quantity	Unit	Rate	Amount	Remarks
1	Excavation In Foundation: - Earth work in excavation by mechanical means (Hydraulic excavator)/manual means over areas (exceeding 30 cm in depth, 1.5 m in width as well as 10 sqm on plan) including getting out and disposal of excavated earth lead up to 50 m and lift up to 1.5 m.	27.21	cum	131.05	3565.87	Excavation by hydraulic excavator
2	Filling available excavated earth (excluding rock) in trenches, plinth, sides of foundations etc. in layers with brick bats, crushed aggregate. not exceeding 20cm in depth, consolidating each deposited layer by ramming and watering, lead up to 50m and lift up to 1.5 m.	6.93	cum	124.05	859.66	Foundation Filling
3	Brick work with common burnt clay modular bricks of class designation 7.5 in foundation and plinth in: Cement Mortar 1:6 (1 cement: 6 coarse sand)	20.58	cum	4610.35	94881.00	Foundation brickwork
4	Autoclaved aerated cement (AAC) blocks work in 200mm thick wall with using polymer modified adhesive mortar 1:5	18.71	cum	1702	31844.42	AAC Work
5	Providing and fixing panelling or panelling and glazing in panelled or panelled and glazed shutters for doors, windows and clerestory windows (Area of opening for panel inserts excluding portion in side groove so rebates to be measured). Panelling for panelled or panelled and glazed shutters 25 mm to 40 mm thick: kiln seasoned wood	19.035	sq.m	5925	112575.00	------------------------
6	Mud Flooring: - Mixture of mud with cow dung and straw in rooms and kitchen	72.2	cum	370	26714.00	Flooring work
7	Casting of slab grade of concrete with M20 1:1.5:3 including centring and shuttering and binding steel or steel bar including bending (mild steel in R.C.C work main bar 12 mm dia. @0.89 kg/m straight bar 24 cm c/c and distribution steel bar 6mm dia. @0.22kg/m.	11.11	cum	7500	83325.00	------------------------
8	Concrete Flooring in washrooms: - Cement concrete flooring 1:2:4 (1 cement: 2 coarse sands: 4 graded stone aggregate) finished with a floating coat of neat cement, including cement slurry, but excluding the cost of nosing of steps etc. complete. 40 mm thick with 20 mm nominal size stone aggregate.	7.55	cum	378.95	2861.07	------------------------
9	White Washing: - White washing with lime to give an even shade in external and internal walls New work (three or more coats)	187.55	sq.m	17.45	3272.74	White washing
10	Paint work in walls					
	External Wall painting with acrylic emulsion paint, having VOC (Volatile Organic Compound) content less than 50 grams/ litre, of approved brand and manufacture, including applying additional coats wherever required, to achieve even shade and colour with two coats.	125.44	sq.m	67.7	8492.28	Paintwork in external walls

	Internal Wall painting with acrylic emulsion paint, having VOC (Volatile Organic Compound) content less than 50 grams/ litre, of approved brand and manufacture, including applying additional coats wherever required, to achieve even shade and colour with one coat.	70.17	sq.m	45.7	3206.75	Paintwork in Internal walls
10	Paintwork in Doors and Windows, ventilators: - Painting wood work with Deluxe Multi Surface Paint of required shade. Two or more coat applied @ 0.90 litre/10 sqm over an under coat of primer applied @0.75 litre/10 sqm of approved brand and manufacture.	11.52	sq.m	94.3	1086.34	------------------------
11	ELECTRIFICATION					
a)	Providing and fixing, wiring point for light with 3/.029 T.R.S. wire fixed on 16 mm (5/8") teak wood battens with brass clips, nails Bakelite switch, teak wood switch board wooden blocks making holes and making them good, whole painted 2 coats, including supplying of all materials	6	Nos.	50	300.00	ELECTRIFICATION
c)	Supplying and fixing tube light fittings 1.2 m (4) long 40 watts including tube, choke, starter, etc., complete	3	Nos.	125	375.00	------------------------
b)	Main switch board including 3-way distribution board and 15 Amps. 250 volts I.S.D.P.	1	Nos.	90	90.00	------------------------
d)	Supply of light bulbs	5	Nos.	100	500.00	------------------------
e)	Supplying and fixing of sub-main of 7/029 T.R.S. wire	100	meter	5	500.00	------------------------
	LABOUR					
	Electrician for installation of electrical wiring	1	Nos.	500	500.00	------------------------
12	SANITARY WORKS					
a)	Providing and fixing Stainless Steel A ISI 304 (18/8) kitchen sink as per IS:13983 within. brackets and stainless-steel l plug 40mm, including painting of fittings and brackets, cutting and making good the walls wherever required: 470x420mmbowl depth178	1	Nos.	2257.6	2257.60	------------------------
b)	Providing and fixing P.V.C. low level flushing cistern with manually controlled device (handle lever) conforming to IS: 7231, with all fittings and fixtures com- plate. 10 Liter capacity.	2	Nos.	443.95	887.90	------------------------
c)	Providing and fixing solid plastic seat with lid for pedestal type W.C. pan complete: black plastic sheet with lid	2	Nos.	225.3	450.60	------------------------
d)	Providing and fixing G.I. inlet connection for flush pipe connecting with W.C. pan	2	Nos.	58.05	116.10	------------------------
e)	Providing and fixing P.V.C. waste pipe for sink or wash basin including P.V.C. waste fittings complete 32mm dia. pipe	1	Nos.	87.7	87.70	------------------------
f)	Providing and fixing soil, waste and vent pipes:	1	Nos.	979.8	979.80	------------------------
13	WATER SUPPLY WORKS					

	Providing and fixing Polyethylene Aluminium Polyethylene-AL- PE Composite Pressure Pipes conforming to IS- 15450, U.V.stabilized with carbon black having thermal stability for hot & Coldwater supply, capable to with stand temperature up to 80°C, including all special fittings of composite material (engineering plastic blend and brass inserts wherever required) e.g. elbows, tees, reducers ,couplers & connectors etc., with clamps at 1.00 meter spacing. 1216 meter with 16 mm dia.	2	Nos.	191	382.00	------------------------
	providing and fixing brass bib cock of approved quality.	3	Nos.	201.06	604.06	------------------------
	Providing and fixing brass ferrule with C. I. mouth cover.	2	Nos.	295.15	590.30	------------------------
	Providing and fixing rectangular high density polyethylene water storage loft tank with cover, conforming to ISI: 12701, colour of opaque white or as approved by Engineer-in-charge. The rate includes making necessary holes for inlet, outlet & over flow pipes. The base support i/c fittings & fixtures for tank shall be paid separately.	1000	per Liter	5.8	5800.00	------------------------
	Fitter for fitting the water supply system	2	per day	750	1500.00	------------------------
				TOTAL = 388605.186 Approx. = 388606		
					Add 3% of contingencies	₹11661
					Add 2% of Work Charge	₹7780
					TOTAL COST	₹408047

Table 5. presents a comparative analysis of low-cost housing and traditional housing based on cost, strength and construction materials. The comparison indicates that the estimated cost of low-cost housing ₹ 4,08,047, whereas the corresponding cost of traditional housing is ₹ 13,17,790. Thus, the low-cost housing approach provides a substantial reduction in construction cost while maintaining adequate strength. The use of materials such as AAC blocks and mud in low-cost housing further contributes to reducing material consumption and overall expenditure.

Table 5. Comparative Table

Parameter	Low-cost housing	Traditional housing
Cost	₹4,08,047	₹13,17,790
Strength	Adequate	High
Material	AAC blocks, mud	Cement, sand

The bar chart represents construction cost of the low-cost housing was ₹4,08,047, compared with ₹13,17,790 for the traditional housing, showing a cost reduction of approximately 69%. The findings demonstrate that low-cost housing is considerably more economical than conventional housing.

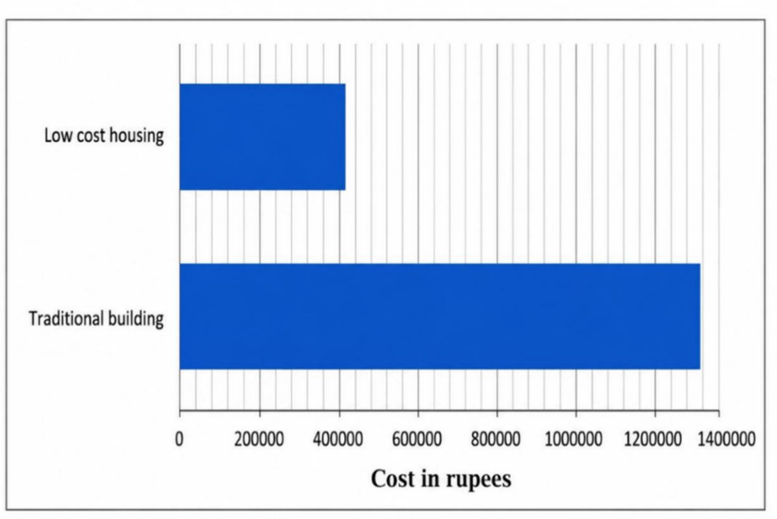

Figure.9 Bar chart representing cost comparison between low cost and traditional housing

VI. CONCLUSION

The study concludes that low-cost housing technologies can provide an economical, sustainable, and context specific alternative to conventional housing in hilly region. The analysis shows that selection of locally available material, lightweight construction systems, appropriate building techniques, and passive design approaches can reduce construction costs while maintaining adequate strength, durability, thermal comfort, and environmental performance. The comparison the propose 2BHK low- cost housing with conventional housing demonstrates a significant difference in construction cost. The estimated cost of the low-cost housing was ₹4,08,047, whereas the conventional housing cost approximately ₹13,17,790, resulting in a cost reduction of about 69%. This indicates the considerable economic potential of low-cost construction techniques for low-income and economically weaker communities. However, cost reduction should not the only criterion for selecting a housing technology, particularly in hilly region where building is exposed to earthquake, landslides, difficult terrain, transportation constraints, and climatic variations. The study therefore emphasizes that material selection and technology should be evaluated with respect to structural safety, local climate, availability of sources, skilled labor, maintenance requirement, thermal comfort and sustainability. Techniques such as AAC blocks construction, mud-based construction, filler slab system, bamboo, locally available stone, and other resource efficient material have potential to reduce material consumption, dead load and over all construction expenditure. Cooperatives should be formed to support low-cost housing by using locally available materials and reducing the need to transport materials from distant places. This can lower transportation and material costs and may reduce the total construction cost by about 20-30%.

VII. ACKNOWLEDGMENT

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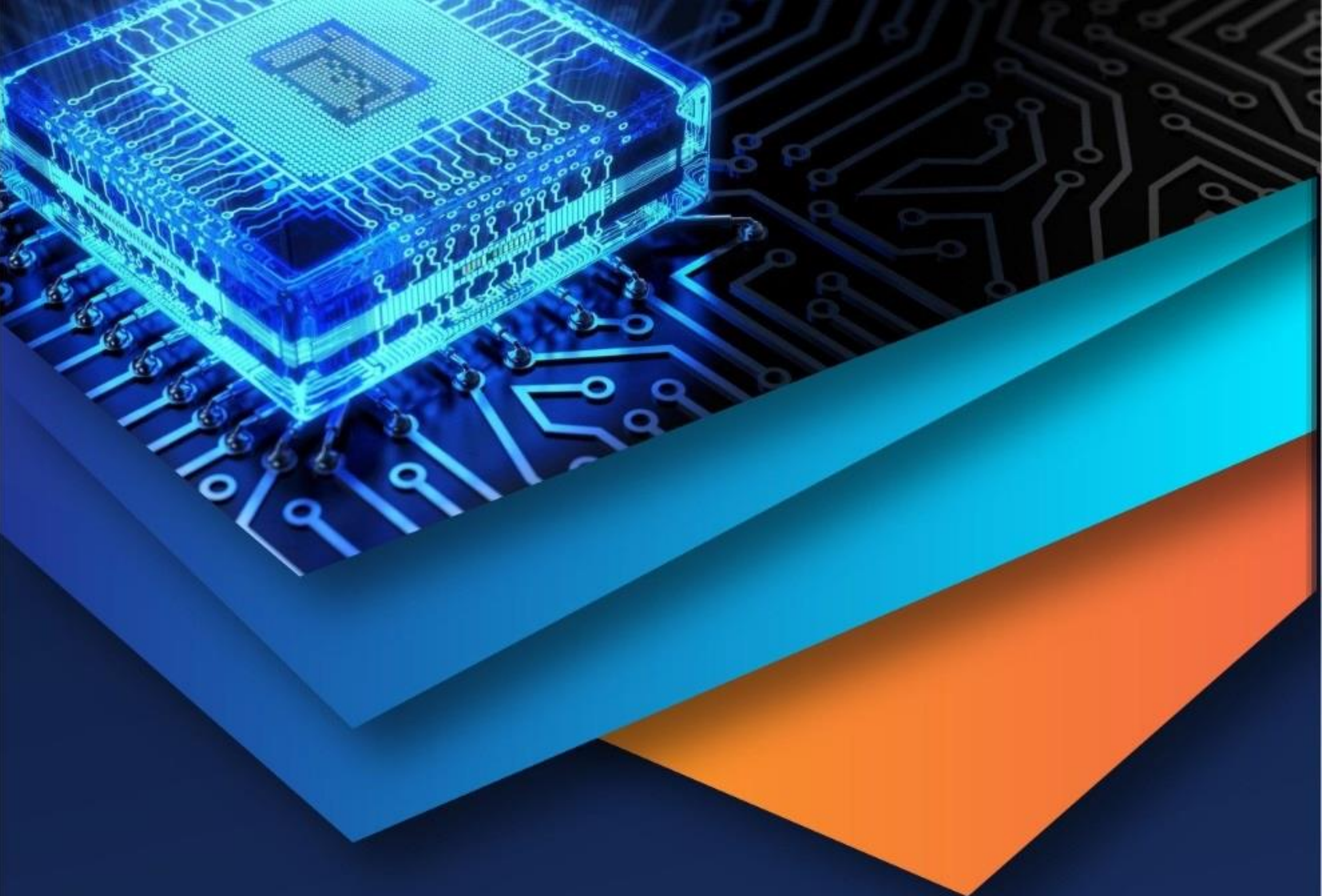
REFERENCES

[1] Bhatta, Analysis of Urban Growth and Sprawl from Remote Sensing Data. Springer, Berlin, Germany 2010.
[2] Oliver, P. Built to Meet Needs: Cultural Issues in Vernacular Architecture. Architectural Press, Oxford, U.K (2006)
[3] Rapoport, A. House Form and Culture. Prentice-Hall, Englewood Cliffs, NJ, USA (1969).
[4] Arya, A. S. Guidelines for Earthquake Resistant Non-Engineered Construction. Building Materials and Technology Promotion Council (BMTPC), Government of India. (2000)
[5] Government of Himachal Pradesh, “Himachal Pradesh at a Glance,” Government of Himachal Pradesh, Shimla, India.
[6] Government of Himachal Pradesh, Department of Revenue, “Geography and Climate of Himachal Pradesh,” Government of Himachal Pradesh, Shimla, India.

[7] Office of the Registrar General & Census Commissioner, India, Census of India 2011: Primary Census Abstract, Himachal Pradesh, Ministry of Home Affairs, Government of India 2011.
[8] Government of Himachal Pradesh, Department of Economics and Statistics, Statistical Abstract of Himachal Pradesh, Shimla, India.
[9] Himachal Pradesh State Disaster Management Authority, State Disaster Management Plan: Himachal Pradesh, Government of Himachal Pradesh, Shimla, India.
[10] [10] Himachal Pradesh State Disaster Management Authority, “Landslide Hazard in Himachal Pradesh,” Government of Himachal Pradesh, Shimla, India.
[11] Department of Agriculture, Government of Himachal Pradesh, “Agro-Climatic Zones of Himachal Pradesh,” Government of Himachal Pradesh, Shimla, India.
[12] India Meteorological Department, Climate of Himachal Pradesh, Ministry of Earth Sciences, Government of India.
[13] Bureau of Indian Standards, IS 1893 (Part 1): 2016, Criteria for Earthquake Resistant Design of Structures, India: BIS, 2016.
[14] Bureau of Indian Standards, IS 4326: 2013, Earthquake Resistant Design and Construction of Buildings—Code of Practice, India: BIS, 2013.
[15] Bureau of Indian Standards, IS 13827: 1993, Improving Earthquake Resistance of Earthen Buildings—Guidelines, India: BIS, 1993.
[16] Bureau of Indian Standards, IS 13828: 1993, Improving Earthquake Resistance of Low Strength Masonry Buildings—Guidelines, New Delhi, India: BIS, 1993.
[17] Ministry of Housing and Urban Affairs, Government of India, Pradhan Mantri Awas Yojana—Housing for All (Urban), New Delhi, India.
[18] Building Materials & Technology Promotion Council, Vulnerability Atlas of India, Ministry of Housing and Urban Affairs, Government of India, New Delhi, India.
[19] UN-Habitat, United Nations Human Settlements Programmed. Urbanization and Development: Emerging Futures. United Nations Human Settlements Programmed, Nairobi, Kenya, 2016.
[20] V. Devi and R. Taur, “Low-cost housing,” in Proceedings of ACSGE-2009, BITS Pilani, India, pp. 25–27, oct 2009.
[21] B. V. V. Reddy, “Suitability of M-Sand as Fine Aggregate in Mortars and Concrete,” CSIR Project Report, Project No. CP 6597/0505/11-330, July 2011.
[22] A. A. Jadhav, S. S. Patil, and S. Kadam, “Cost Analysis of Affordable Housing Technologies,” 2024.
[23] S. Jain and H. Bhandari, “An Affordable Housing with Prefabricated Construction Technology in India: An Approach to Sustainable Supply,” ECS Transactions, vol. 107, no. 1, pp. 8513–8520, Doi: 10.1149/10701.8513ecst, 2022.
[24] A. Perez-Fargallo, J. A. Pulido-Arcas, C. Rubio-Bellido, M. Trebilcock, B. Piderit, and S. Attia, “Development of a new adaptive comfort model for low-income housing in the central-south of Chile,” Energy and Buildings, vol. 178, pp. 94–106, doi: 10.1016/j.enbuild.2018.08.030, 2018.
[25] Vivian et al., “Low-cost housing,” 2000.
[26] A. D. Chougule et al., “Filler Slab as an Alternative Construction Technique for Sustainable and Low-Cost Housing,” 2014.
[27] K. Gopalan and M. Venkataraman, “Affordable Housing: Policy and Practice in India,” IIMB Management Review, vol. 27, no. 2, pp. 129–140, doi: 10.1016/j.iimb.2015.03.003,2015.
[28] A. Ganga Warrier, P. Tadepalli, and S. Palaniappan, “Low-cost housing in India: A review,” IOP Conference Series: Earth and Environmental Science, vol. 294, no. 1, Art. no. 012092, doi: 10.1088/1755-1315/294/1/012092, 2019
[29] K. Kumar and S. Parihar, “Affordable and Low-Cost Housing Solution in India: A Comparative Analysis,” 2025.
[30] B. V. Doshi, Aranya Low-Cost Housing Project, Indore, India, 1989.
[31] M. A. Qadri Syed Khaja, “Recycled Materials and Sustainable, Innovative, Affordable Housing (SIAH): Investigating the Current Status, Progress, and Way Forward,” Journal of Architectural Engineering Technology, vol. 13, no. 4, Art. no. 1000402, doi: 10.4172/2168-9717.1000402, 2024
[32] S. Sawadatkar, A. Jagtap, K. Tikhe, and P. Mohare, “Sustainable Architectural Design Using Laurie Baker’s Method for Building Construction,” E3S Web of Conferences, vol. 559, Art. no. 04051, doi: 10.1051/e3sconf/202455904051, 2024.
[33] Chiluka, S. Evaluating the Effectiveness of Low-Cost Housing Methods in India. Journal of Civil and Construction Engineering, 9(2), 29–46, 2023.
[34] Government of India, Pradhan Mantri Awas Yojana (PMAY): Housing for All, Ministry of Housing and Urban Affairs, Government of India, 2015.
[35] Bureau of Indian Standards, IS 456:2000: Plain and Reinforced Concrete—Code of Practice, New Delhi, India: BIS, 2000.
[36] Bureau of Indian Standards, IS 1893 (Part 1):2016: Criteria for Earthquake Resistant Design of Structures—Part 1: General Provisions and Buildings, New Delhi, India: BIS, 2016.
[37] Bureau of Indian Standards, IS 800:2007: General Construction in Steel—Code of Practice, New Delhi, India: BIS, 2007.
[38] Bureau of Indian Standards, IS 13920:2016: Ductile Design and Detailing of Reinforced Concrete Structures Subjected to Seismic Forces—Code of Practice, New Delhi, India: BIS, 2016.
[39] Building Materials and Technology Promotion Council (BMTPC), Compendium of Prospective Emerging Technologies for Mass Housing, Ministry of Housing and Urban Affairs, Government of India, New Delhi, India.
[40] S. Navaratnam, T. Ngo, T. Gunawardena, and D. Henderson, “Performance review of prefabricated building system and future research in Australia,” Buildings, vol. 9, no. 2, Art. no. 38, 2019.
[41] J. L. Suarez, L. Gosselin, and N. Lehoux, “Analysis of value creation in social housing construction in remote communities—Application to Nunavik, Canada,” Built Environment Project and Asset Management, vol. 13, pp. 493–508, 2023



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