**International Journal of Technology Engineering Arts Mathematics Science**
Special Issue 1, August 2023, pp. 66-72
ISSN: 2583-1224,

# Collaborative Approach for Inclusive Design in Communal Senior Living: Integration of Architecture and Mechanical Engineering

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**Article Information**

***Article history:***

Received Jun 10, 2023
Accepted Dec 10, 2023

**ABSTRACT**

This paper explores the significance of collaboration between architecture and mechanical engineering in designing communal senior living spaces. The study identifies the key parameters governing the architectural design of such facilities in India, which encompass Autonomy and Accessibility, Social Inclusion, Safety and Security, Adaptability, and General Wellbeing. Among the various building systems, the research highlights the dominant influence of the Heating, Ventilation, and Air-Conditioning (HVAC) system in communal senior living facilities, particularly in relation to the concept of 'Healthy Ageing'. It identifies suitable parameters for designing an HVAC system in such settings, including Thermal comfort, Indoor air quality, Ventilation, Ease of control, Safety and Accessibility for maintenance. To achieve the primary objective of creating comfortable, and healthy living environments for the elderly, the architectural design strategies must integrate these mechanical systems. This paper emphasizes the importance of collaboration between architecture and mechanical engineering, showcasing successful implementations and providing valuable insights into influential factors encompassing economic, social, and cultural aspects. Moreover, the paper underscores the need for understanding the specific needs of the senior user group and creating responsive built environments tailored to their requirements.

**KEYWORDS:** Communal Senior Living; Inclusive Design; Healthy Ageing; HVAC system design; Responsive Architecture.

## 1. INTRODUCTION

The senior citizen demographic has undergone drastic changes globally. The built environment must respond to the same with compassionate living solutions. The transforming social, economic, technological and demographic challenges must be addressed by the built environment. Increasing life expectancy and decreasing fertility rates have resulted in an increment in the senior population percentage. This has garnered the attention of many countries.

Following the 2016 UN General Assembly, India also began to formulate an inclusive set of national policies delineated statewise. The 2011 census report and the reports by UNFPA state that the levels and growth of this demographic shift are more prominent in South India [1], [2]. Various policies pertaining to the living arrangements of the different economic classes of senior citizens has been taken into consideration. The demand for senior accommodations is higher in the urban areas, due to the changes in the traditional support structures and family systems.

The built environment for the senior citizen demographic must respond to their transforming demands. Various models for senior living have emerged worldwide, which allow seniors to maintain their independence and opt for flexible living options. Communal senior living is one of the highly opted arrangement amongst the demographic sector. HVAC (Heating, Ventilation, and Air Conditioning) system designed for senior living is focussed in this study as it acts as the most influential among all building systems when the user group includes the elderly. Elderly demography exhibits a demand for unique comfort requirements and specific health considerations. A crucial role is played by HVAC systems in the maintenance of a comfortable indoor environment which promotes aspects of healthy ageing. The senior demographic require a precise control of temperature and humidity levels considering their physiological and psychosocial demands. A well designed HVAC system directly or indirectly impacts several parameters of Healthy Ageing. However, there is a significant research gap in integrating architecture and HVAC design to address this objective effectively.

## 2.METHODOLOGY

The primary approach adopted in addressing the objective of this study is literature review and analysis of existing studies and research on communal senior living and HVAC systems for the elderly. Insights on the definition of "elderly", social gerontology perspectives, the concept of healthy aging, communal senior living models, and the compatibility of HVAC systems for the elderly have all been drawn by reviewing reported literature and basing recommendations from the drawn inferences from the review. By presenting a comprehensive understanding through this primary literature review, the collaboration between the architecture and mechanical engineering towards the betterment of elderly is emphasized.

## 3. LITERATURE REVIEW AND ANALYSIS

### 3.1. DEFINING THE USER GROUP

The term 'Elderly' is conventionally defined as a person of age 60 years or more. Social gerontologists define elderly using four dimensions: chronological, biological, social and psychological [3], [4]. Subsequent studies contributed to a holistic viewpoint towards defining 'Ageing'. Initial approaches focussed on chronological definition of life expectancy [5]–[7]. It changed as a result of the transformations of the social, economic and cultural spheres of the society.

The definition of 'Healthy Ageing' accommodates the perception of the elderly and the influence of 'Quality of Life (QOL)' parameters. The perception of elderly who experience functional limitations, their culture, values, expectations and standard of living were also considered i.e. physical, psychological and social needs [8], [9].

Physical environment and social environment is highly influenced by the built environment. The study by Ball et al. establishes that the elderly prefer to engage in activities that help them maintain their sense of independence, autonomy and control of their environments and choices [10]. In the study by Mitchell and Kemp, the facilities that gave their residents choices and flexibility scored higher in the QOL measurement [11].

The other influential components included privacy, universal design features and the opportunities for social interaction. These studies help identify the major factors that impact the QOL of the elderly population, i.e. Autonomy and accessibility, Social inclusion, Safety and security, Adaptability, and General wellbeing [10], [11].

### 3.2. COMMUNAL SENIOR LIVING

The percentage of elders living alone or with a partner or spouse has increased to 27.2% by 2013. Between 2014 - 2018 an increase of 69% was reported in the number of residents checking into old age homes.

Primary reasons stated for the choice of living arrangement are reported to be a preference for 'end of life' living with people of similar age group, isolation and loneliness, lack of rapport with neighbours and insecurity due to declining health. The higher percentage of this subsection is reported to be having higher education and living alone or with their spouses and capable of performing activities of daily life (ADL) with little or no assistance. But, a considerable number of elderly suffer from two or more chronic diseases and feel they need special care in terms of diet care, exercise routines and mental health services [12], [13].

The concept of senior housing has evolved over time, with different models developing in different regions. In Europe, the idea of elderly care as charity led to the establishment of poorhouses and workhouses in the 1800s. Nursing homes later became a popular option. In North America, a similar trend occurred, with a shift from poor relief systems to large-scale medical aid institutions [14]. After World War II, institutionalized living models for seniors began to change. In both Europe and North America, the focus shifted to developing alternative senior housing solutions, such as age-in-place options and co-housing [15].

The Asia Pacific region saw a rise in its aging population due to socio-economic progress and international migration. Countries like China, Japan, and Singapore started developing community aging facilities and upgrading existing communities. Japan introduced long-term care insurance and incorporated age-friendly housing, while China capitalized on economic growth to develop large-scale senior living communities [16], [17]. Malaysia and Turkey also implemented measures for elderly care and age-friendly accommodation [9], [16].

Contemporary senior living models have emerged globally, driven by technological advancements and research. The industry now focuses on choice, variety, adaptability, and control. Assisted living residences cater to seniors who need assistance but not intensive medical care. Independent living apartments target relatively healthy seniors, while continuing-care retirement communities offer a range of services and care levels. These communal senior living models aim to address specific concerns of seniors, majorly aiming to promote healthy ageing through the design of the built environment.

Communal senior living facilities focusses on elderly who need assistance with ADL or IADL, but do not need the intense medical assistance. Elderly without major infirmity, people investing for their old age and elderly looking to downsize post-retirement are the major target group. Individual units usually comprise of Apartments or separate houses with a minimal kitchen facility. These communal living models include facilities such as Social activities, transportation, meal preparation and housekeeping. Health care services are not included; however, some facilities provide a la carte services with a private sponsor. These models adhere to various types of sponsors and ownership types, such as Profit based i.e. small family-care homes or small board-and-care facilities developed on conventional real estate housing development, Non-profit based i.e. affordable housing designs and services using reimbursement, subsidies etc and Public model consisting of subsidised living units.

The major program components include 3 major zones i.e. Residential, Communal shared spaces and Support spaces. Residential zones include variety in dwelling unit sizes and designs. Typical unit consists of Bedroom, bathroom, living room, kitchenette. Communal shared spaces include Connecting spaces, common dining, library, activity areas, cafe, wellness centre, outdoor spaces and the like. Support spaces will include the zones earmarked for security, building mechanical systems etc. Upcoming Trends in the aforesaid include Affordable models, generic community-based services rather than facility-based programs, adaptable or flexible units, demography specific models [17], [18]. Another important form community living includes the Continuing-care retirement community (CCRC). The focus here shifts towards elderly that require intensive medical care and continued assistance. Intensive healthcare, dining services, housekeeping scheduled transportation, emergency call monitoring, healthcare, assisted living, dementia care, and long term care is included in the aforesaid model and hence includes Residential units of mixed sizes and types, nursing homes, common areas and support areas [17].

### 3.3. COMPATABILITY OF HVAC SYSTEMS FOR ELDERLY

In general, seniors are more likely be sensitive to both heat and cold as they age, due to the natural deterioration of the body's temperature regulation [19]. In addition, they are more likely to have respiratory, circulatory, and mobility ailments that causes difficulty in physically accessing the temperature and ventilation controls and devices, as well as maintaining them. As per World Health Organization data, elderly people spend 95% of their time indoors, highlighting the importance of creating a comfortable and safe indoor environment for their well-being [20]. This objective has gained increased focus since COVID-19 pandemic and associated lockdowns [21].

Though multiple studies have been conducted on the thermal comfort of elderly in warm and humid climatic conditions [22]–[24], very few studies have been reported for elderly in Indian context. Sudarsanam and Kannama recently conducted a detailed analysis on the thermal comfort of elderly in residences of warm and humid climates during summers in India [25]. The analysis inferred that the comfort temperature for elderly occupants was 30 °C, with a comfort range of 28.5 °C to 31.5 °C. This range was observed to be much narrower compared to younger individuals in residences under similar conditions. Male elderly participants had a higher neutral temperature, influenced by their clothing adjustments. Probit analysis indicated that 90% of the elderly felt comfortable within an operative temperature range of 26.9 °C to 30.9 °C. Preferred adaptive behavioral actions for comfort by male elderly included clothing adjustments and cold showers, while female elderly stated additionally about adaptive cooking durations and tying up their hair to overcome thermal discomfort. Other adaptive actions such as opening of opening/closing of windows/doors were not done frequently over security concerns. It was also observed that because of physical disabilities and ailments, elderly people were not able to take advantage of adaptive opportunities such as moving to elevated places to acquire fresh air and keep themselves thermally comfortable or watering the terrace floor. Detailed analyses of suitable thermal comfort conditions for elderly in India are to be conducted. Thermal discomfort and improper ventilation would lead to uncontrolled temperature control resulting in falling hazard due to heat syncope [26], [27].

In a communal living space, both the individual units as well as common areas are to be designed such that the General Wellbeing of the elderly are not affected due to thermal discomfort and poor indoor air quality (IAQ). When poor IAQ is discussed, it is required to consider ‘sick building syndrome’, which is a term used to describe indoor air pollution where pollutants in the air such as natural dust mites, dander, mold spores, bacteria, viruses, and gasses from paints, cleaning products, and other household items such as cigarettes become concentrated due to lack of proper ventilation [28]. The presence of asthma, other lung diseases, compromised immune systems, and other common health issues observed within the elderly further complicates the situation. Generally, the ventilation systems installed are addressing the requirements of normal adults. But the same conditions are not applicable for the elderly. Though air quality index (AQI) of below 50 is acceptable for normal adults, WHO recommends AQI below 25 for the elderly. This can be ensured by increasing the average air change per hour (ACH) from general value of 6 to 8 for the elderly [29], [30].

Similarly, centralized ventilation and cooling systems employed in communal spaces have their vents overhead. However, drafts from overhead vents can potentially affect the Safety and Wellbeing of elderly. Such drafts may lead to physical ailments such as muscle stiffness, joint pain, or increased respiratory symptoms [31]. In certain cases, drafts can even aggravate conditions such as arthritis or respiratory issues like asthma or chronic bronchitis and cause dizziness. To avoid these Safety hazards, vents can be installed deflectors and diffusers to disperse the overhead airflow while implementing auxiliary airflow vents at floor level as well. While discussing the Safety of the elderly, factors that require additional focus are alerts/alarm systems, acoustic discomfort and overall physical hazard introduced by the HVAC systems.

The general alert mechanisms employed in these systems are blinker based and in cases of emergencies, there are warning acoustic alarms. However, most elderly are prone to some degree of visual impairment due to ailments such as colour blindness, cataract, glaucoma, etc. Alert mechanisms in HVAC range from simple filter change to hazardous voltage fluctuation issues or gas leaks. Additionally, sudden high volume alarms tend to disorient the elderly rather than alerting them of the potential hazard. In order to effectively alert the elderly towards the hazard, the system should contain multisensory alert system with inbuilt capability to communicate the hazard to external emergency response authorities. This system would be very effective in communal spaces, wherein a central monitoring and response console can be implemented which is in communication with these devices. Adapting smart technology within HVAC systems is of primary importance [32]. Additionally, exposed heating and cooling surfaces such as radiators pose serious burn risk and tissue damage. Alternatively, radiant heating and cooling mechanisms within the walls, floors and ceiling would ensure Safety of the occupants while also providing uniform temperature distribution within spaces. When the heating and cooling is done through temperature-controlled surfaces (most often the floor in individual units) through thermal radiation, they are far more comfortable for seniors with circulation problems to their extremities, than the radiators [33]. They require very low maintenance and are 15% more energy efficient. The radiant ceiling cooling panel system is superior to traditional air conditioning system in both aspects of economy and thermal comfort. The system would provide a better indoor thermal environment, more uniform indoor air distribution, no unpleasant feeling of air draught and do not cause undue noise vibration either.

While addressing the Safety and Wellbeing of the occupants, care should be taken to ensure their Autonomy and Accessibility. While employing high-efficiency filters on outdoor air handling units to guarantee sufficient ventilation, the filters on indoor devices should be easily accessible and replaceable with minimum efforts. Corrugated cardboard-based air filters for such indoor devices are proposed as being very easy to shape and mount on or replace in existing ventilation systems [34]. Similarly, the exhaust hoods should be simple to maintain with easily accessible filters for removal and cleaning as well as accessible switches. In the case of control systems such as thermostats, light switches and temperature gauges, the outlet wall height of not more than 120 cm to be maintained from the floor [35]. Thermostats and other controls can be pre-programmed or controlled through smart technology for further convenience [36]. The control indications should be legible and perceivable with multiple senses by the elderly. By employing cascaded outdoor unit with Variable Refrigerant Flow (VRF) modules, smooth functioning of the indoor systems is ensured even if any outdoor unit needs to be shut down for maintenance. VRF modules are capable of handling the resulting changes in cooling load. Through this mechanism, the privacy and autonomy of the elderly is also assured. Even with smart technology and Internet of Things (IoT), the encryption should be such that the online privacy of the elderly is protected [37].

While most of the identified issues and suggested recommendations are focused on the indoor spaces within individual units of communal living, the common areas that promote Social Inclusion are of equivalent importance as well. The indoor ventilation systems in the common areas such as recreational rooms, library, lounges, etc. are to be equipped with Demand Controlled Ventilation (DCV). By implementing this system, the ventilation is controlled depending upon the occupancy level and pollutant concentration [38]. While implementing DCV, the feedback control needs to address the specific IAQ levels required for the elderly [39]. By these HVAC design strategies, the parameters of Healthy Ageing are assured in the communal living space.

## 4. COMMENTARY ON ARCHITECTURAL INTERVENTION

The architectural design of the communal senior living facility must be moulded to accommodate the custom designed HVAC system. The design must aim to ensure seamless integration of the system while supporting its optimal functionality and efficiency.

Appropriate spatial integration through the macro level layout design is the main approach. Provision of sufficient space to accommodate the main and supplementary equipment as well as inclusion of strategically planned access points for maintenance and repair is essential. The planning must incorporate the zoning and ductwork requirements of the system. The ventilation network of the building must include strategic placement of fenestration, vents, exhaust etc. to enhance the proper circulation of air. The sizes and placement of the same must consider the age friendly design requirements. The design of common spaces must integrate the control systems of HVAC with the overall building automation system. The design must assist the regular monitoring and maintenance of the system. The planning must ensure the application of universal design principles at all levels. The design of the building envelope should aim to provide adequate insulation and minimize air infiltration and leakage. The inclusion of relevant acoustic design strategies will ensure quality and comfort in the indoor environment. Collaboration between architects and mechanical engineers is crucial at each phase to optimize the overall building performance and achieve favourable outcomes while designing for the elderly demographic.

Furthermore, HVAC systems that allow for individual control and customization provide a sense of autonomy and empowerment for elderly residents. Elderly individuals often have varying comfort preferences and specific needs. HVAC systems that allow for adjustable temperature settings, zone control, and other customization options empower residents to regulate their immediate environment according to their preferences. This level of control contributes to overall satisfaction and well-being. Comfort and safety are paramount for the elderly. Maintaining appropriate indoor temperatures and ventilation is critical for their well-being. Extreme temperatures can increase the risk of heat-related illnesses or hypothermia, particularly for those with limited mobility or compromised health. A well-designed HVAC system ensures a consistent and comfortable temperature range, reducing the risk of discomfort, heat stress, or cold-related health issues.

Lastly, noise reduction is essential for the well-being and quality of life for elderly individuals. HVAC systems that incorporate noise-reducing technologies and proper installation techniques help minimize operational noise levels, ensuring a quieter and more peaceful living environment for seniors.

## 5. CONCLUSION

Architecture plays a significant role in the care for ageing as its impact ranges from individual to community level. It is not a solitary solution however, and it engages collaboration with other sectors to perform the aforesaid. The paper prioritizes the parameters of autonomy, inclusion and choice for the elderly while devising the design strategies that incorporate the design demands of architecture and mechanical engineering. The research seeks to incorporate the elements of physical and psychosocial well-being of the users while providing an environment that ensures the standards of institutional care. The research initiates a conversation on changing paradigms of communal senior living and enhancing the quality of life within it through the seamless collaboration of architectural and mechanical engineering domains.

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