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Editorial

Tadeja Zupančič

This edition of Architecture Papers of the Faculty of Architecture and Design STU represents a multifaceted trigger for a vivid discussion about the quality of architectural research. It presents some holistic, socially and culturally oriented research approaches. It also showcases how technical specialists within the wider domain address specific issues, relevant to architecture as a field of knowledge. Is that architectural research as well? My answer is a conditional yes: if/when contextualised into the holistic spectrum of multi-perspective views, deriving from interdisciplinary discussions. As a member of the EAAE Council (European Association of Architectural Education) I am referring to the updated EAAE Charter on Architectural Research (EAAE): *'… research in architecture encompasses knowledge production through design projects, artefacts and design processes, as well as research about and for design.'* In this issue, we can find research about and for design. It is coming from different professional profiles, working in a disciplinary way.

As an architect I am searching for holistic approaches to the research theme and/or problem selecting, addressing and discussing. I hold to the integral research tradition in architecture. I believe in the power of convergent thinking, a characteristic of designers, overcoming contemporary knowledge fragmentation and dispersion, able to master *'wicked problems, open-ended processes, resilience and risk.'* (CA^2RE) I have difficulty understanding the research without comprehensive contextualisation. When researchers talk or write about design from a singular point of view, without the evidence of being able to create a distant view, except from the same direction as their singularity of view, I doubt this kind of research is highly relevant for architecture as a culturally rooted field of knowledge, that primarily contributes to the cultural development. Sometimes people use the term design for any issue relevant to the design process, without the ability to immerse into the design thinking and doing. I think a meaningful contribution to architectural knowledge requires a multiple view approach, future orientation, or at least a discussion about the potential future relevance of the work, as well as hybrid methods, dependent on research topics, strategies employed and developed.

The speed of publication production works against the opportunity to immerse into the worlds of other researchers. Writing the editorial is more than a discussion about the themes available. It is more than making an artificial framework imposed for classification at the level of abstraction that fits all and none of the contents. In the case of open issues, this is a tempting way out. Though I think an editorial could, in the future, become a critical meta-reflection on the originality (of knowledge contribution), relevance (of themes, problems, approaches, research strategies) and rigour (of aims or questions or hypotheses and methods employed), I am leaving this critical reflection to the readers.

In the article about the small-scale housing estates in Budapest, from the period between 1945 and 1960, the main idea is to confirm the hypothesis about the persistence of a small housing estate as a housing form, that *'withstands political and architectural changes, adapting to and continuing to meet their requirements'*. This is examined from various perspectives. The post-occupancy evaluation of numerous social housing units in Oran, Algeria, is another example of a research approached from various angles to gain perspective. The focus is on the social dimensions and, more specifically, on the impact of social actions on the traces of socially ignorant architectural ideas. Dealing with some cases in Oran cannot be generalised to the whole Algerian context, yet on the other hand, it cannot be limited to the context of a specific city or state.

The remaining three articles represent a singular perspective view very close to the specific issues dealt with. They promise some insights into *'enhancing visual comfort in staircases'* through *'comprehensive analysis and design recommendations'*, ideas for *'…optimising daylighting and passive indoor thermal comfort in single-banked office buildings in the temperate dry climate of Nigeria'* and the study about weight and structural considerations of potential green roof growth-media compositions for the Nigerian building industry.

To conclude, I would like to point out some contemporary changes in research assessment guidelines. They may reduce the time-related pressure on all those involved: authors, reviewers, editors… The evidence of these changes is, for instance, the CoARA agreement (CoARA). Having enough time, researchers might rethink the context of potential relevance in a specific research. What are the communities of research relevance in each case? Multiple views and contextual anchors within the same article could help to reach the relevant audiences. Multi-, trans-, cross-disciplinary attempts seem promising in that direction, where architectural convergent thinking may glue the contemporary knowledge fragmentations.

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Socialist in content, national in form: Small-scale housing estates in Budapest between 1945 and 1960

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Abstract:
In the second half of the 20th century, solving the housing crisis became a significant social issue and political task throughout Europe, particularly in the countries of the Eastern Bloc. Although due to its quantity, prefabricated large mass housing estates became overrepresented, dozens of smaller, experimental, and diverse mass housing forms also emerged. It is hypothesized, that these small housing estates, due to their scale and quality, are urban planning projects that were realized across political, economic, and architectural changes. To demonstrate their adaptability, this paper presents the small housing estates built in one of the capitals of the Eastern Bloc countries—Budapest—during the most turbulent one-and-a-half decades of the socialist era (1945–1960). The research consists of three main parts: (1) Hungarian politics and housing policy, (2) Budapest's urban policy, and (3) a brief presentation of the urban planning and architectural aspects of Budapest's small housing estates. The result of the research is the creation of a complete small housing estates portfolio, illustrated archive articles, archival plans, and photographs. It becomes evident that although the times from World War II to the consolidation of power saw vastly different political eras, directives, and ideals realized, along with various architectural styles and housing policies, the small housing estate as an urban planning product was able to adapt and survive. Moreover, it is a valuable architectural, housing, and urban planning imprint of the era, the only mass housing form realized in numerous examples in Budapest.

Keywords: post-war, socialist realism, socialist modern, Budapest, housing estate

INTRODUCTION

It is well-known that in 20th-century Europe, the tool for addressing housing poverty became the construction of (large-scale) mass housing estates (Glendinning, 2021). These buildings took various forms from Portugal to Sweden, and from Serbia to Israel in the post-war decades (Rodrigues et al., 2023). In the case of state-socialist countries, where housing ceased to be a commodity, housing enjoyed priority politically and ideologically (Tsenkova, Polanska, 2014). The result of this is also widely acknowledged: the emergence of monotonous, grey, ten-storey pre-fabricated panel buildings on the outskirts of cities, which began to resemble ghettos (Hess et al., 2018).

The criticisms levelled at large housing estates (HEs) considered the solution would be reducing scale: in small housing estates (Szelényi, Konrád, 1969). Due to their scale, they can be designed with diverse architectural and urban forms, making these architectural projects become part of the urban fabric (Klein, Bauer, 2023). In Hungary, the popularity (or the promotion) of small HEs dates back to the 1970s (Szabó, 1978), but their presence is not limited to this era at all. In fact, in Budapest, smaller housing estates could be found from the end of the 19th century (e.g., railway worker settlements—Bene, Szabó, 2023) through the early 20th century (e.g., temporary slums—Umbrai, 2008) to contemporary residential complexes (Erő, 2004). In my doctoral dissertation, I present an architectural and urban planning examination of all the small HEs built in Budapest during the state socialist era (104 in total). This publication, that individually presents the state socialist small housing estates planned until 1960 in Budapest (22 in total) (Fig. 1) is part of that larger, comprehensive research.

The period between 1945 and 1960 is unique because Hungary's housing policy was characterized by immaturity, rough ideas, a lack of resources, and frequent political directive changes (Kocsis, 2009). In this dysfunctional system, alongside reconstructions, new socialist cities, and private family house constructions, only the construction of small HEs can be considered a relevant urban planning project. 60% of the 37 HEs built in Budapest between 1945 and 1960 were small-scale (Fig. 1). The map clearly shows that while these smaller interventions were scattered across a wide area of the city, the medium and large HEs served sort of a model, clustered in a few focus areas. This dispersion further emphasizes the uniqueness and independence of the small HEs. My hypothesis is that the small housing estate is a persistent urban form that withstands political and architectural changes, adapting to and continuing to meet their requirements.

This research focuses on the 22 small HEs in Budapest, which can be referred to not only as the socialist ideals of the time but also as successful and realized precursors of later solutions (large HEs) addressing the housing crisis. Some HEs of the era are well-known to the Hungarian public due to their low numbers and exciting architectural (and political) backgrounds. However, this research sheds light on the small HEs that have been left out of the existing literary canon. My goal, besides illustrating the political and housing policy changes through these small HEs, is to highlight the diversity, adaptability, and resilience of this urban form. I believe that due to their scale, exemplary urban planning and architectural situations have emerged in the case of Budapest's small HEs, making them worthy of international attention.

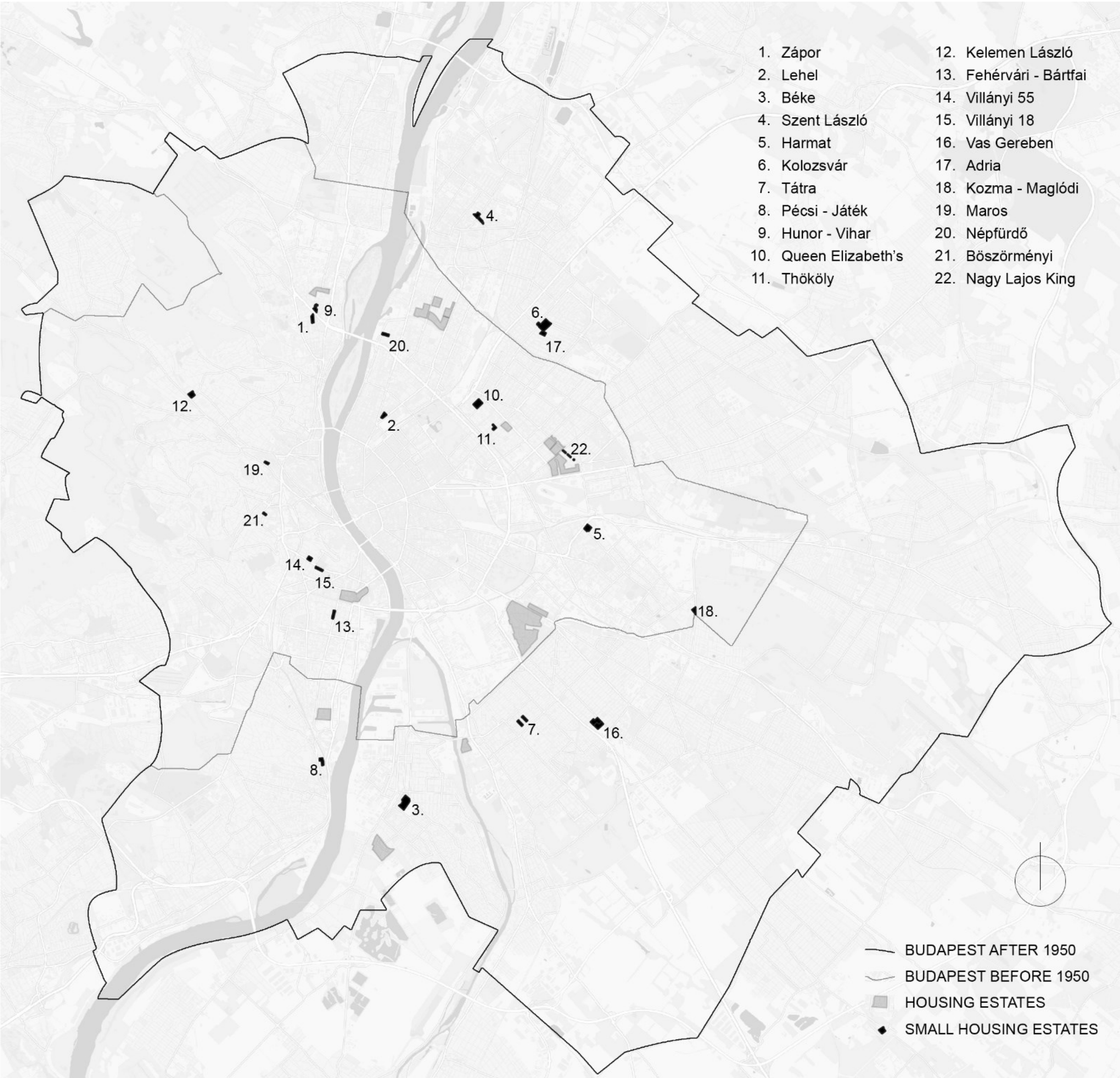

Fig. 1. Map of the 50s housing estates in Budapest, Hungary. (Source: Author, 2024)

METHODOLOGY

The paper consists of three main parts: (1) Hungarian politics and housing policy, (2) Budapest's urban policy, and (3) a brief presentation of the urban planning and architectural aspects of Budapest's small HEs. The descriptions of housing and urban policy are mainly summaries and reorganizations of domestic contemporary (post-regime change) literature, and to a lesser extent, the context is supported by archival documents and laws. Despite the length restrictions, all the 22 small HEs built in Budapest between 1945 and 1960 are presented with brief architectural or urban planning descriptions and a picture each. The materials used for the varied presentation of each small HE include original architectural plans from the Budapest City Archives, archival official documents, publications from archival professional journals, archival maps and satellite images, contemporary literature, my own site visits, and photographs taken at that time.

To accurately define the case studies, it is necessary to define the term "small housing estate" first. After reviewing various domestic and international literary classifications, the 1971 law provides the most precise definition in this regard. I supplemented this with definitions from other researchers to obtain the most logical and consistent definition. I consider a small housing estate to be a group consisting of at least 90 apartments, spread over a contiguous area, comprising a minimum of 3 separate multi-storey, multi-apartment buildings (4/1971 decree). Additionally, it is important that these estates are distinct from their surroundings (Ferkai, 2005), have unified urban and architectural plans (Körner, Nagy, 2006), and consist of no more than 500 apartments (Egedy, 2000). The case studies presented in the publication are all located within the administrative boundaries of (Greater) Budapest and were either completed no earlier than 1950 or their planning commenced no later than 1960.

HUNGARIAN HOUSING POLICY

Following World War II, Hungary came under Soviet occupation. During the transitional period between 1945 and 1948, the dismantling of democratic frameworks and the multiparty system, already severely affected before, took place. In 1948, the dictatorship became formalized, characterized by unrestrained terror under the leadership of Mátyás Rákosi (Gyarmati, 2021). The end of this era was marked by the 1956 Hungarian Revolution and the subsequent arrival of Russian tanks crushing the streets of Budapest. Following this, state socialist politics consolidated until the regime change of 1989–1990. The first decade of the regime underwent turbulent power struggles; political, and socio-economic changes, which also had a hard impact on the architecture of the 1950s. Just as we can divide the 10–15 years following the war into three periods in the political arena - (1) the formation of state socialism, (2) Rákosi dictatorship, (3) consolidation - so too can we apply this triad to architecture. Although the temporal boundaries of each period (style) may blur, we can speak of (1) post-war modern architecture, (2) socialist realism, and (3) socialist modern architecture.

Transitional period

In the aftermath of World War II, the bureaucracy concerning architecture did not undergo significant changes, and political directives did not become mandatory. Architects had two prominent tasks: firstly, to continue pre-war projects and plans (e.g. defining the principles of urban development in the capital based on the 1940 plan), and secondly, to mitigate and address the damage caused by the war (e.g. regulation 2481/1945 concerning restoration works that could be carried out without permits). Between 1945 and 1949, the focus was on the restoration of the housing stock (Saád, 1985), and only a negligible number of new —mostly prestigious—buildings were constructed (such as the People's Stadium, and the bus terminal). For instance, out of the 4469 new apartments in Budapest in 1949, only 250 were newly built (the rest were created by redistributing existing apartments) (Preisich, 1998). The newly constructed buildings were characterized by modern spatial forms, minimalist design tools, and puritan material usage. These components align with the progressive (and inherently leftist) architectural trends of the early 20th century while also fitting well with the intellectual emptiness, material poverty, and emotional distress prevalent in the post-war period.

Rákosi dictatorship

From 1948 onwards, politics demanded increasing influence in architectural and housing fields. In 1948, the first state Design Institutes were established, which expanded the next years, and architects could only find financial and existential security within this system (Keller, 2012). Due to forced industrialization, housing issues were sidelined (Kocsis, 2009). This occurred despite the dire state of housing in Hungary: in 1949, only 10% of apartments had bathrooms, and 12.6% had indoor toilets (KSH, 1950). The state saw the solution to increasing its power by taking crucial control of the housing market, leading to nationalization (regulation 6000/1948 and 4/1952). With the regulation of rent (12840/1948), property maintenance and construction became unprofitable, leading to the gradual physical and then social decay of older buildings.

In 1951, within the framework of the Great Architectural Debate, organized by the Agitation and Propaganda Department, two renowned architects of the era argued in favour of the desirable architectural style for socialism (cosmopolitan modern and socialist realism). Dictator Rákosi followed the debate with great interest, as a result of which socialist realism became the dominant architectural style in Hungary, marking the formal beginning of style terror. The absurdity of the debate was later characterized by one of the two key participant: "There was neither Debate nor Great nor was it exclusively Architectural" (Perényi, 1984). Architects were required to use socialist realist forms within Design Institutes (Kuslits, 2013).

The slogan of the style became "socialist in content, national in form," following Stalinist principles. Typically framed urban forms, inner courtyards, 3–4 storeys, classicizing façades, high-pitched roofs characterize the style. From the outside, the buildings appear palatial, part of a complex urban composition. However, apartments hidden behind ornate façades, arcades, and corridors are modest, and sometimes even have reduced comfort (i.e., shared bathroom) (Prakfalvi, Szűcs, 2010). Despite being a style dictated by the regime, socialist realism was not the only style, given the structural issues and modernism continued alongside (Honvári, 2006). While the decorative façades of socialist realist buildings may seem anachronistic, their floor plans and spatial arrangements often adhere to modern principles, transcending political boundaries.

Consolidation

After the Hungarian Revolution (1956), the building of a softer dictatorship began in the second half of the decade, called goulash communism. However, because of the transition, the end of the Stalinist era in Hungary occurs only at the beginning of the 60s (Rainer, 2003). This boundary is reinforced by the 15-year plan (1960), which redefined the housing policy of the following decades, envisioning and realizing the construction of one million new homes. After 1956, welfare measures became a priority (thanks to Soviet political initiative), and the budget for housing construction increased several times over (Körner, Nagy, 2006). The State's involvement in housing construction increased steadily, reaching a 50:50 ratio of private and state-built constructions by the end of the decade (Preisich, 1998).

To address the housing crisis promptly, standard designs, mass HEs, and small and reduced-comfort apartments were planned and built (Rákosi et al., 1956). Architects were given the opportunity to work within freer theoretical and formal frameworks (Simon, 2013). Both on an urban planning and architectural scale, we can observe the incorporation of modern and traditional principles. In addition to state projects, as a sign of consolidation, the government facilitated the construction of private homes

(35/1957) and condominiums built by the state bank (OTP), which were offered as inherited properties. Furthermore, cooperative buildings organized based on territorial or workplace criteria emerged (Csizmady, 2008). In addition to the construction of new private apartments, the 27/1959 (V.7.) government decree, in contrast to the decrees on nationalization, facilitated privatization and the alienation of condominium properties.

CITY POLICY OF BUDAPEST

Post-war Budapest architecture was distinctly shaped by two national trends: reconstruction efforts and the continuation of pre-war plans. In 1945, the principles of urban development for the capital were determined based on plans from 1940 (Fabó, Nagy, 2023). This involved defining housing construction along a north-south axis and assigning residential functions to Buda and city functions to Pest. Due to excessive centralization, the creation of sub-centres was proposed. The most ambitious urban plan of the time was the creation of Greater Budapest, where the administrative boundaries of the city were expanded to encompass the surrounding agglomeration (Szekeres, 1996). As a result, the population doubled, and the existing 14 districts expanded to 22.

The concept was conceived in the first decade of the 20th century, but the political environment did not allow for its implementation until the 1940s. The plan for Greater Budapest, completed in 1948, came into effect in 1950. Since then, the boundaries of Budapest have remained constant, making this year a cornerstone in the city's history. After the war, the informal population of the city continuously increased, despite the fact that until 1953, families belonging to the middle class were being relocated from major cities, especially from Budapest (Hantó, 2009). The number of newly built apartments continuously decreased, reaching its minimum by 1953 (Preisich, 1998). By this time, the housing situation in the capital had become critical, which became a source of social tension.

With the onset of consolidation, the State's involvement drastically increased, and between 1956 and 1960, one-third of new apartments were built in the HEs schemes. These HEs were constructed in the most suitable parts of the city, where minimal demolition and infrastructural development were required. This often meant the transitional zone between pre-1950 Budapest and the attached areas. Most HEs were of small or medium size, offering diverse (experimental) or traditional architectural designs, and due to their location, they represented higher quality compared to their later counterparts (Csizmady, 2008). Larger apartments were mainly built in the inner city and on the Buda side, reflecting the existing prestige of their surroundings (Keller, 2012). Even if the HEs had different prestige levels than their environment, their small scale allowed them to adapt and integrate over the decades (Bene, 2023).

SMALL HOUSING ESTATES

Post-war

Only 5 small HEs bear the marks of post-war modern architecture in Budapest. All of them are located in the working-class areas of the city; moreover, two of them are situated in the newly annexed districts, serving as new sub-centres. Each development comprises freestanding minimalist or modern architectural slabs and cubes surrounded by open space. The first small HE was built in Buda, on Zápor Street (1949–1951) (Fig. 2.). The development, consisting of two three-storey slab houses and three seven-storey towers, faced strong criticism, particularly for its outdated and poor design (external corridors, no elevator) (Gerle, 1950). The first realized initiative aimed at providing housing for (best) workers was the construction of the Lehel Square HE (1949–1951) (Prakfalvi, 2009) (Fig. 3.). This investment, located close to the downtown, comprised a total of four (out of which 3 were identical) five-storey slabs. Although the two-bedroom apartments were showcased as a positive example even to foreign politicians, 90% of the residents wanted to move out after the first winter due to the unreasonably high heating costs and other technical issues.

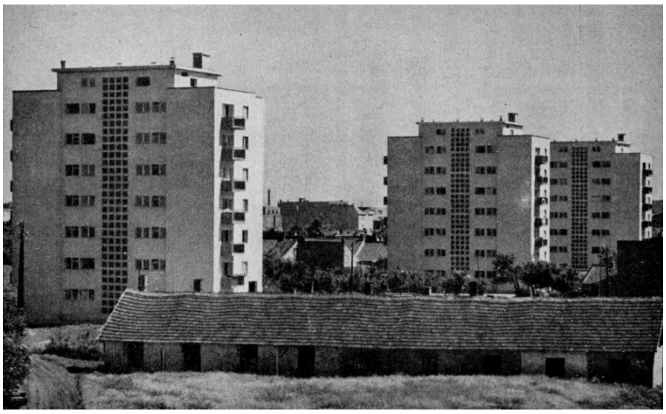

Fig. 2. Archive photo of the Zápor Street small HE. (Source: Gerle, 1950)

Fig. 3. Archive photo of the Lehel Square small HE (Photo: Ráth László, FSZEK, around 1950. (Source: Prakfalvi, 2009)

Fig. 4. Aerial view of the Béke Square small HE in 1963. (Photo: MHSZ, 1963)

Other HEs for (the best) workers were built in the newly annexed areas of Újpest and Csepel. Since both the new northern district of the city (Újpest) and the island tip in the southern part of Budapest (Csepel) were predominantly inhabited by workers even before socialism, it was appropriate to build model HEs there. Furthermore, Csepel was planned to be developed into a new socialist city, with its first project being the construction of a sub-centre, called Béke Square (1951–1955) (Preisich, 1948). The buildings clustered around the church consist of two-storey cubes and three-storey slabs with outdoor corridors (Fig. 4.). These slabs became standardized due to their affordability and were adapted in Salgótarján and Pécs as well (Vámossy, 2016). These slabs can also be found in the aforementioned example in Újpest, also in a new sub-centre situation.

Fig. 5. Archive photo of the Szent László Sqaure small HE from 1959. (Photo: Sándor György, 1959)

Alongside these buildings in Szent László Square, other standardized plans for cubes and slabs were implemented. Despite the identical standardized plans and target residents, what connects these two locations is that different architectural styles were used to finish the HEs. In Csepel, 9 modern and 3 socialist realist slabs were built, and alongside 8 modern and 2 socialist realist cubes were erected. Besides the differences in floor plans and façade styles, it is noteworthy that - unlike the modern buildings - the socialist realist buildings have their own gardens and plots. At the Szent László Square HE, four buildings were constructed at the end of the 1950s, blending socialist realism and modernism (Bene, 1959). Following the line of the street, they are situated on private plots but feature flat roofs, pillar frames, and ribbon windows. Surprisingly, beautiful sgraffito adornments decorate them (MÉ, 1959) (Fig. 5.).

The best example of the mixture of different styles within one development is the Harmat Street HE in Kőbánya (1950–1954). Two different Design Institutes were commissioned to design it even before the era of style dictatorship. One of them planned a representative building next to the main road, while the other planned 6 slab houses for the space behind this building (Preisich, 1955). Due to this duality of having one design plan yet designing and constructing contrasting buildings, they became total opposites of each other (Fig. 6.). While the 6 slabs organized around the square represent a puritan (even meagre) modernism, the representative building stands as one of Budapest's outstanding socialist realist legacies: with arcades, columns, towers, and the piano nobile. The contradictory nature of these developments might have been created by the different political biases and embeddedness of the Design Institutes.

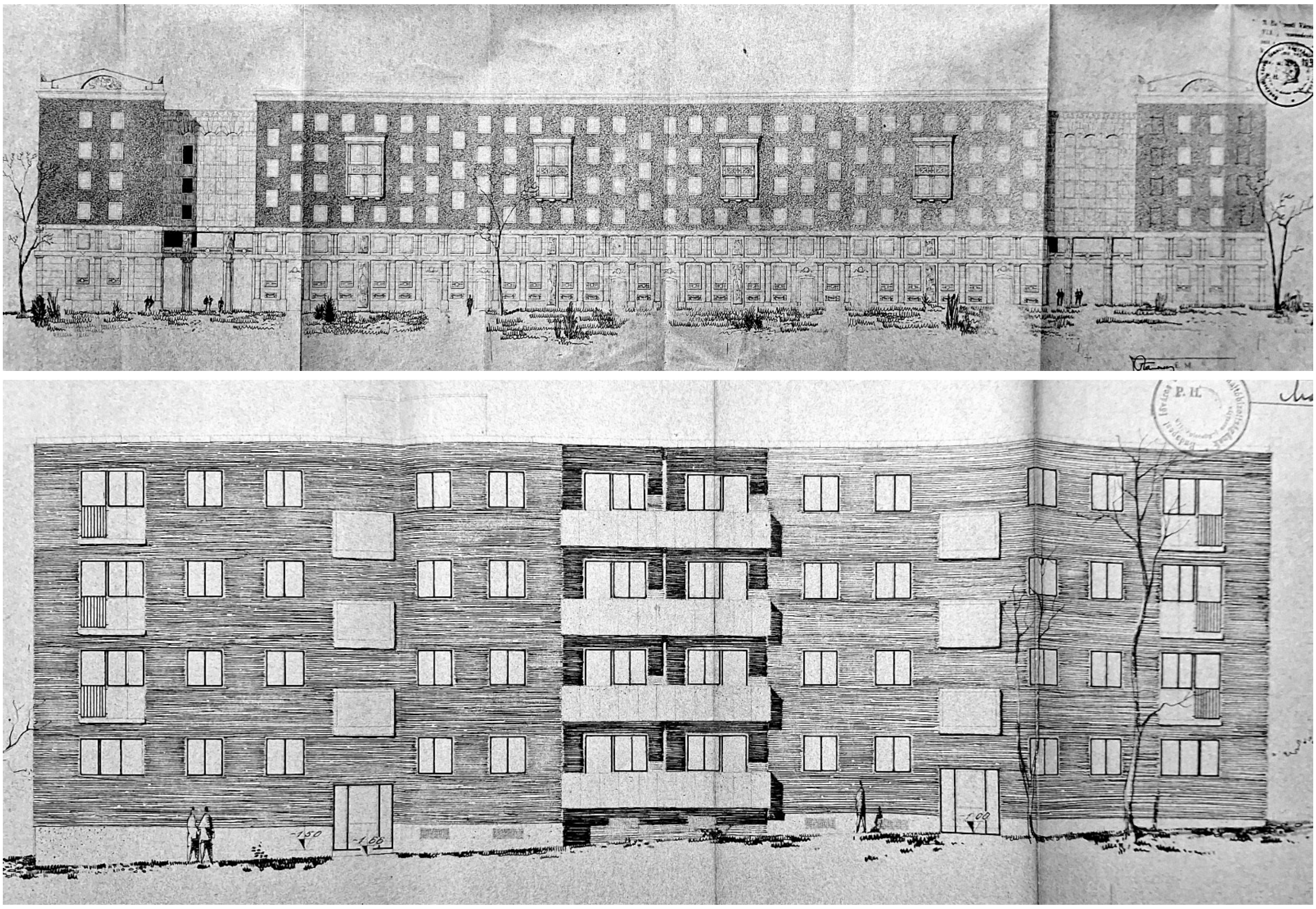

Fig. 6. 1950's plans for the façades of the Harmat Street small HE. (Source: BUVÁTI, LAKÓTERV, 1951)

Socialist realism

The number of investments has doubled compared to the previous era, and in many cases, the scale has also increased. The locations of these 10 projects are less explicitly tied to industry and the working class, but the dominance of the outer skirt remains. Development of the sub-centres continued as a pattern, while on the other hand, densification of high-prestige neighbourhoods in Buda is evident. Apart from the mandatory socialist realist façade design, the case studies are not uniform in terms of scale, layout, density, and land ownership. A great example of the development of new sub-centres is the Kolozsvár Street HE, consisting of 440 apartments (1953–1956), which includes kindergarten, nursery, and services within its buildings (Rátonyi, 2013).

The open and permeable framed urban form, consisting of six square-shaped blocks, is both space and mass-oriented (Fig. 7.). Thanks to well-proportioned public spaces and buildings, a unified and pleasant urban composition has emerged, with a green park strip running through the centre adorned with sculptures. The precisely planned public space network reminiscent of French gardens and the anachronistic façades disguise the small, dark, and poorly oriented apartments behind them. The Tátra Square HE in Pesterzsébet can be considered less successful. The two-storey buildings with minimal decoration form the boundaries of one side of a 100 × 200 metre central park.

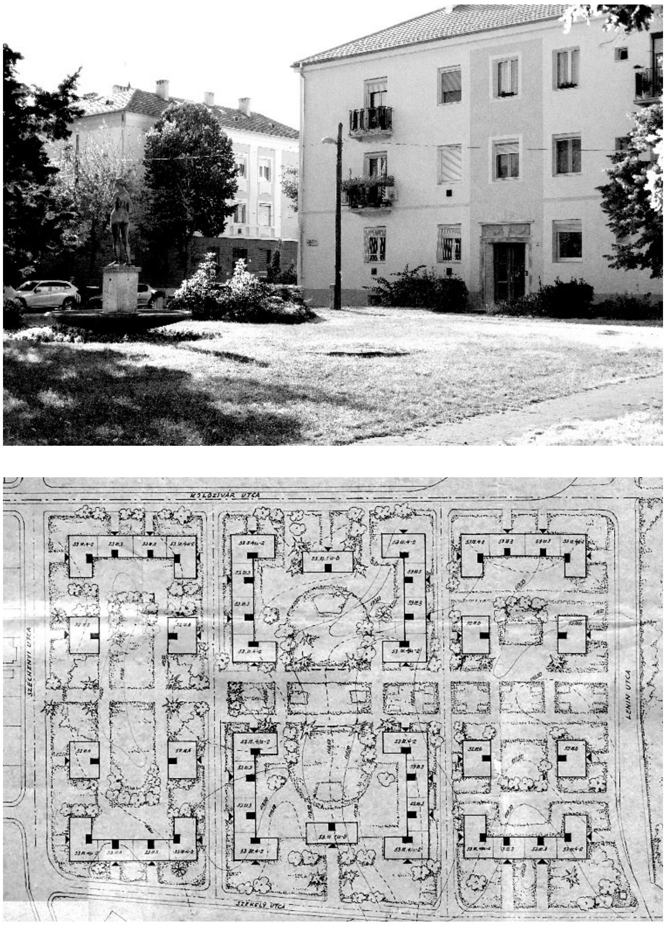

Fig. 7. Photo of the main public space and the master plan of the Kolozsvár Street small HE. (Source: Rátonyi, 2013)

On the other side of the two rows of buildings, away from the street line, smaller parks were created. This abundance of open space, combined with a lack of function resulted in poorly proportioned areas (Fig. 8.). Although the HE fits well into the already established urban fabric of the district in the plans, in reality, it turned into a disjointed no man's land. The least successful socialist realist housing estate is located in the centre of Budafok on Pécsi – Játék Street (1957–1958) (Tarnai, 2023). The 9 slabs, defying the urbanistic principles of socialist realism, are arranged barracks-style, in single rows. The houses consist of one-room apartments without bathroom (Fig. 9.). Due to the intended community (workers) and the minimal budget allocated for construction, the façades of the buildings also exhibit the puritanical simplicity not typical of socialist realism.

Fig. 8. Urban wasteland in the Tárta Square small HE. (Photo: Author, 2023)

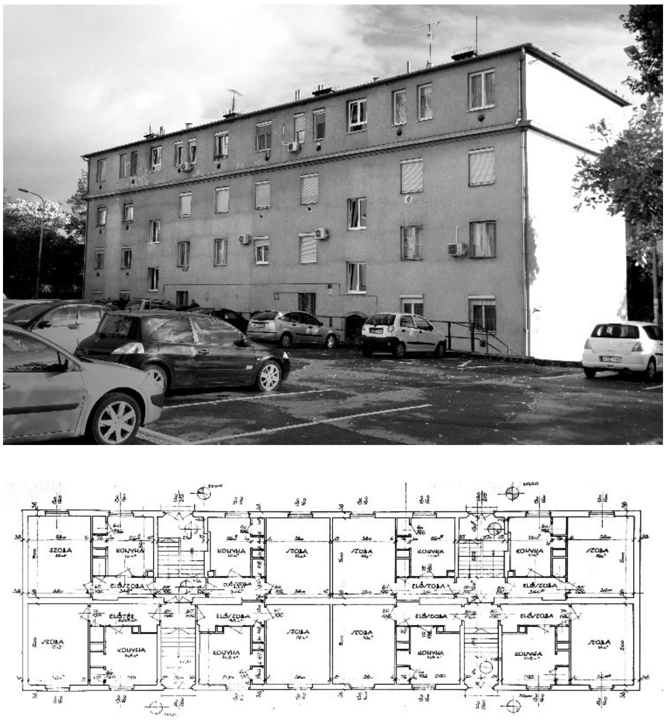

Fig. 9. Façade and floorplan of the Pécsi - Játék Street small HE. (Top photo: Author, 2023; source below: BUVÁTI, 1965)

One of the most excitingly designed HEs can be considered the Hunor – Vihar Street project in Óbuda (1954–1956). The façades of the buildings evoke the restrained ornamentation of Nordic realism, and their layout following the street line fits well into their surroundings (Fig. 10.). Moreover, the construction consisting of four-storey buildings exhibits unexpected sensitivity: when connecting to a lower neighbouring building, it steps down by one floor. The uniqueness of the housing estate lies in the fact that out of the four buildings, two have their own enclosed gardens, while the other two hover in the public space. This duality can also be observed in Budapest's most famous socialist realist housing estate, located on Queen Elizabeth's Road in Zugló (1954–1957).

Half of the 24 two-storey cube houses are located on private plots, although fences were only erected around them after the regime change (MÉ, 1954). The popularity of the development is owed to its high-quality public space system, spacious three-room apartments, and good community (Fig. 11.). The buildings feature prominent entrances, French balconies, and delicate decorations, but their placement and form follow modern principles. Its success is indicated by the fact that a new HE based on this sample plan was built on Thököly Road just one street away (1956–1960). Although there were no changes in the floor plans, the façades became quieter, decorations were omitted, and the entrance received a modern design (Fig. 12.). The entire HE is organized around a common courtyard, which is enclosed. HEs built on private land became characteristic, especially in the wealthier areas of the Buda hillsides.

The Kelemen László Street also features the aforementioned cube house sample plan (1952–1956) (Fig.13.), where 8 such buildings were arranged in a chequered pattern and fenced off (Csordás, 1955). The other projects in Buda returned to framed-row construction following the street line. On the corner of Fehérvári Road and Bártfai Street, on either side, tree three-storey, low-key decorated slab houses were built, symmetrically on shared plots, with shops along the ground floor (Fig. 14.). Later on, one of the plots (probably around the turn of the 1960s), the composition was expanded with two more slab houses, but in a more modern way.

Lastly, the "luxury" housing estates near the Gellért Hill must be mentioned (1953–1955). At 55 Villányi Road, the slab house sample plans from 1953 were placed in a symmetrical composition (Bakay, 2012) (Fig. 15.). The eight houses are organized around two courtyards, and between them— strengthening the symmetry—there is a decorative pool, statue, and pergola. Taking into account the slope of the terrain, the higher buildings have fewer floors. At 18 Villányi Road, a more open-framed construction was created, with setback courtyard-like front yards. Out of the five completed buildings, three are aligned with the street line, and their ground-floor wings open onto the sidewalk with retail spaces (Fig. 16.). Compared to the previous ones, denser construction, and more detailed façades can be observed, giving this elite housing estate a distinctly urban character. Nevertheless, the architectural details of the Villányi Road HEs were strongly criticized by professionals (Abai, 1955).

Fig. 10. The Hunor - Vihar Street small HE during its construction. (Photo: UVATERV, 1956)

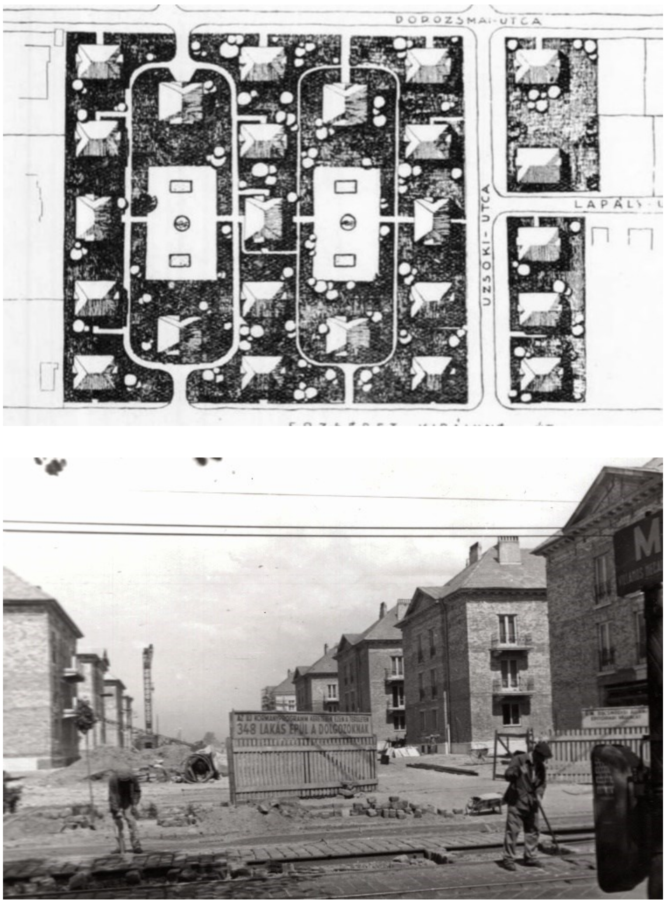

Fig. 11. The Queen Elizabeth's Road small HE master plan and during its construction. (Top source: MÉ, 1954; photo below: József Samodai, 1955)

Fig. 12. The Thököly Road small HE nowadays. (Photo: Author, 2023)

Fig. 13. Sample plan of the Kelemen László Street small. (Source: Csordás, 1955)

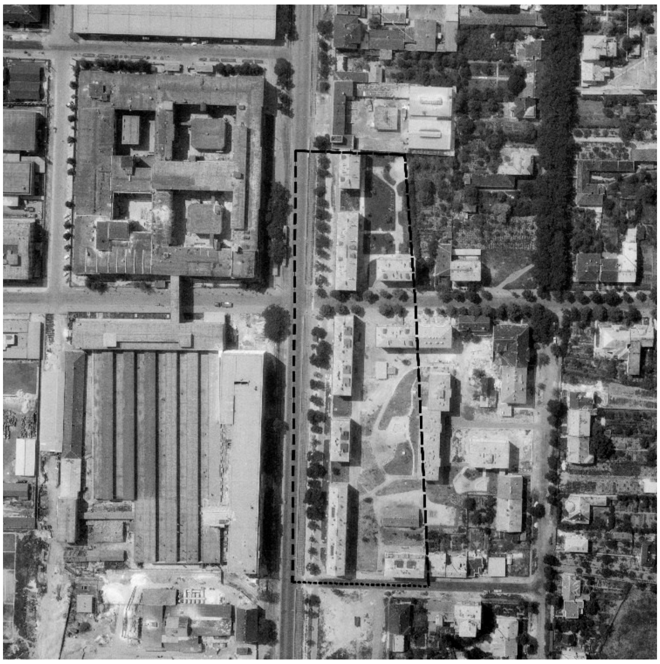

Fig. 14. Aerial view of the Fehérvári Road – Bártfai Street small HE in 1963. (Photo: FÖMI, 1963)

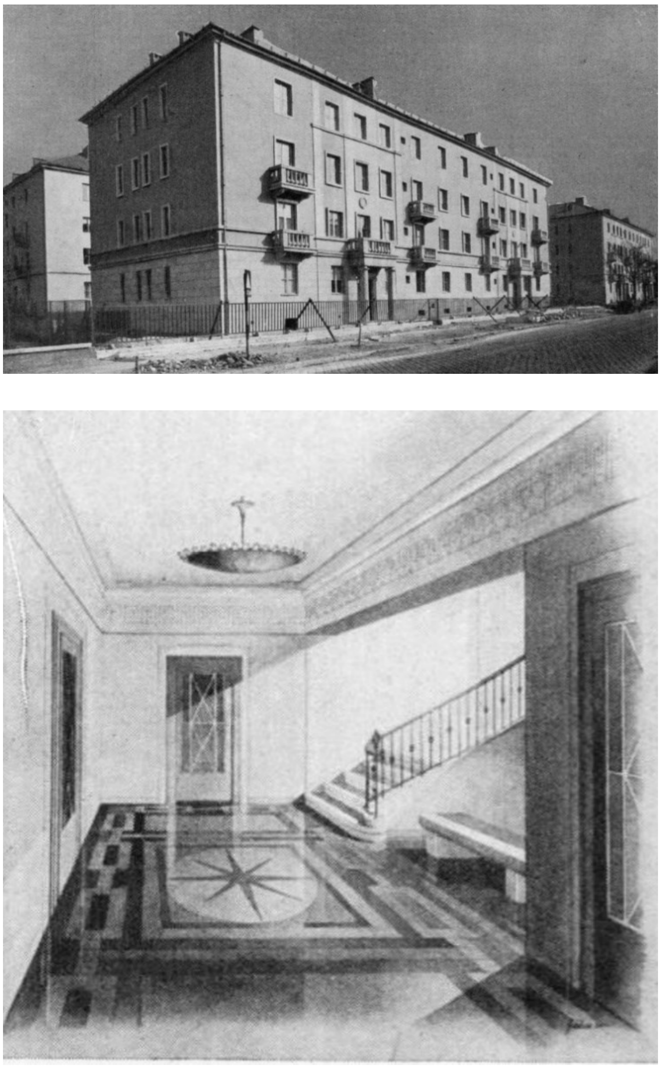

Fig. 15. The 55 Villányi Road small HE in- and outdoor. (Source: Abai, 1955)

Fig. 16. Street view of the 18 Villányi Road small HE. (Photo: Author, 2023)

Socialist modern

In the late 1950s, the architecture bears witness to liberation with the creation of 7 socialist modern HEs in Budapest. With their mixed architectural-urbanistic designs and high quality, they mark the real end of stylistic tyranny. Except for one, all of them were built on enclosed private plots. This indicates that instead of prioritizing the formation of centres and urban compositions, the emphasis shifted towards filling existing larger gaps in the city. The spatial focus is once again placed on the working-class neighbourhoods of Pest. The largest small HE was also realized in an outer working-class district (Kispest), on Vas Gereben Street (1958–1964). Spanning across 7 hectares, this development comprises 21 two and three-storey slab and cube houses, as well as a school and kindergarten. The diverse standard designs are organized around open space courtyards in some cases, while in others they are arranged in rows. You could find both inside and outdoor corridors, high-pitched and flat-roofed buildings. Its architecture is refined yet not monotonous (with prominent staircases, diverse transition spaces, and alternating brick and panel façades) (Fig. 17.).

Fig. 17. Outdoor corridors in the Vasgereben Street small HE. (Photo: Author, 2023)

Adjacent to the socialist realist HE on Kolozsvár Street, another development was erected on Adria Street, consisting of 10 two-storey, pitched-roof houses on a common plot (Fig. 18.). These buildings, each containing 12 one-and-a-half-room apartments with balconies, surround a high-quality inner courtyard featuring a garden pond and playground. While the exact date of this project is unknown (between 1945 and 1960), its construction and architecture suggest it belongs to this era. Similarly, the HE on

Kozma and Maglódi Road built on a triangular-shaped plot, is not precisely dated (between 1945 and 1960). In the 1960s, a cube house was added to the repetitive composition of slab houses in this development. The layout is slightly more fortunate as one row deviates from this system owing to the triangular plot. Its landscaping is well-crafted, with individual apartments featuring unique floor plans (35–60 m^2) and tasteful modern façades, rivalling the luxury properties of the Buda Hills in the representativeness of its main entrance (Fig. 19.). Given its peculiar location (bordering a forest, cemetery, and prison), as well as its architectural quality, it is one of the most unusual small HEs in Budapest.

Fig. 18. Façade detail of the Adria Street small HE. (Photo: Author, 2023)

Similarly, unique location and high architectural quality characterize the houses on Maros Street overlooking Városmajor Park in Buda (1958). The four five-storey buildings are perpendicular to the street and the park on separate plots (MÉ, 1959). With its rastered glass brick staircases, slender corner balconies, and point-like small windows appearing on the façades, as well as its diverse apartment sizes, it represents high architectural standards, although the enclosed nature of the façades facing the park remains questionable (Fig. 20.).

The Népfürdő Street HE facing the Danube (1959–1961) is considered outstanding not so much for its architectural qualities but rather for its urban planning aspects. The plot is surrounded by sports fields, a beach, and a pre-war colony. Facing the Danube, the building adopts the parapet height and roof design of the colony's buildings, but as it turns into smaller streets, this accommodating attitude diminishes. A modern flat-roofed slab connects with an additional staircase to the Danube-facing building, creating a closed-corner block. However, the development then becomes scattered, with standard cube houses alternating within the block or along the street front (Fig. 21.).

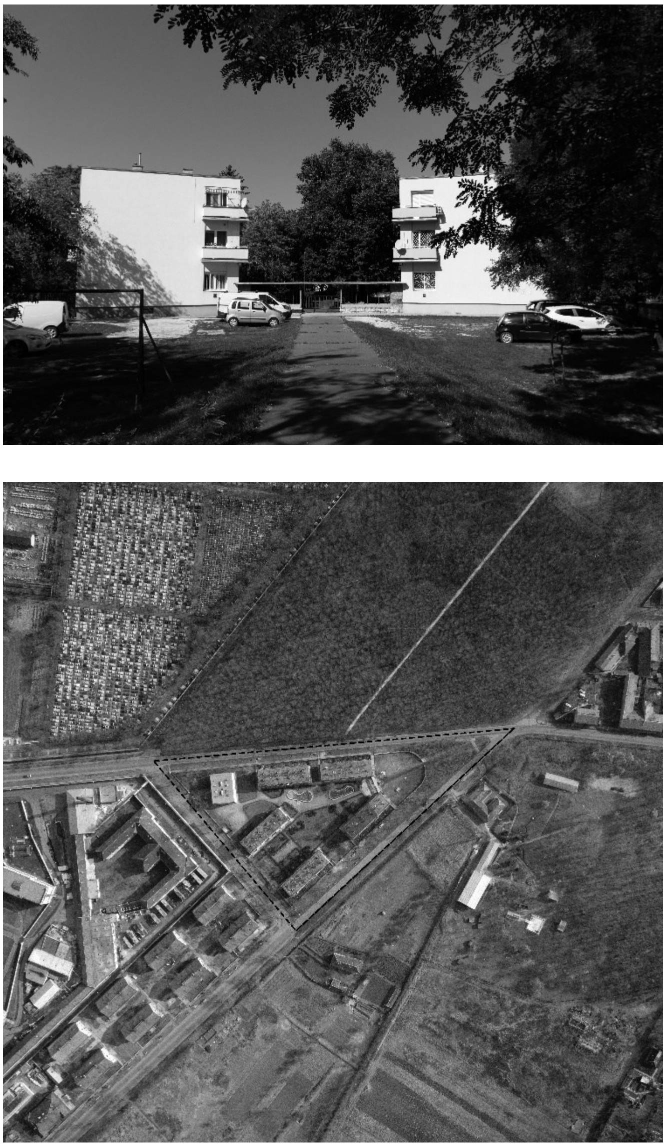

Fig. 19. Aerial view of the Kozma - Maglódi Road small HE in 1973 and its main entrance nowadays. (Photo: top – Author, 2023; below: FÖMI, 1973)

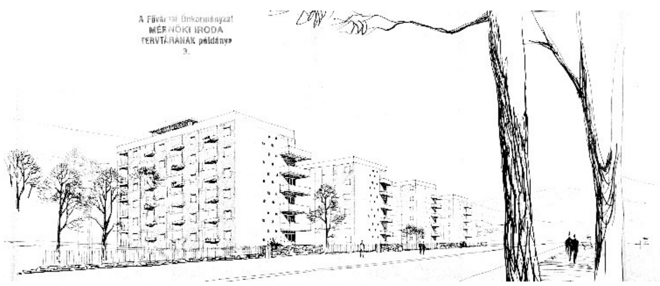

Fig. 20. Visual design of the Maros Street small HE in 1958. (Source: IPARTERV, 1958)

The lyrical development balances well between traditional and modern building approaches. The Böszörményi Road HE (1957–1960) fits best with the existing built environment. In a central part of Buda, within one block, you can find grand bourgeois villas, four-storey, densely built tenement houses, and a more complex, colony-like ensemble of buildings. The socialist modern housing estate balances well between these various characters:

while facing the main road, it features a five-storey, closed section; towards the side streets, it opens up green areas, flanked by building blocks maintaining the height of neighbouring structures (Fig. 22.). The interior of the block is filled with a repetition of the main street's front building twice. The density of the plot, the spatial positioning and height of the buildings, and their pitched roof design resulted in a housing estate that seamlessly blends into its surroundings.

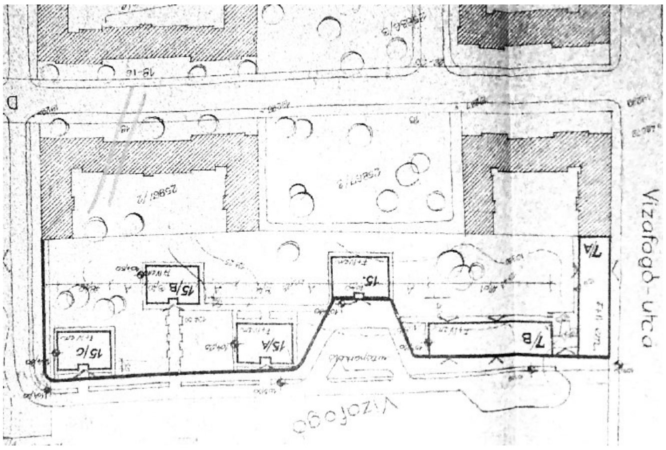

Fig. 21. Master plan of the Népfürdő Street small HE from 1959. (Source: BUVÁTI, 1959)

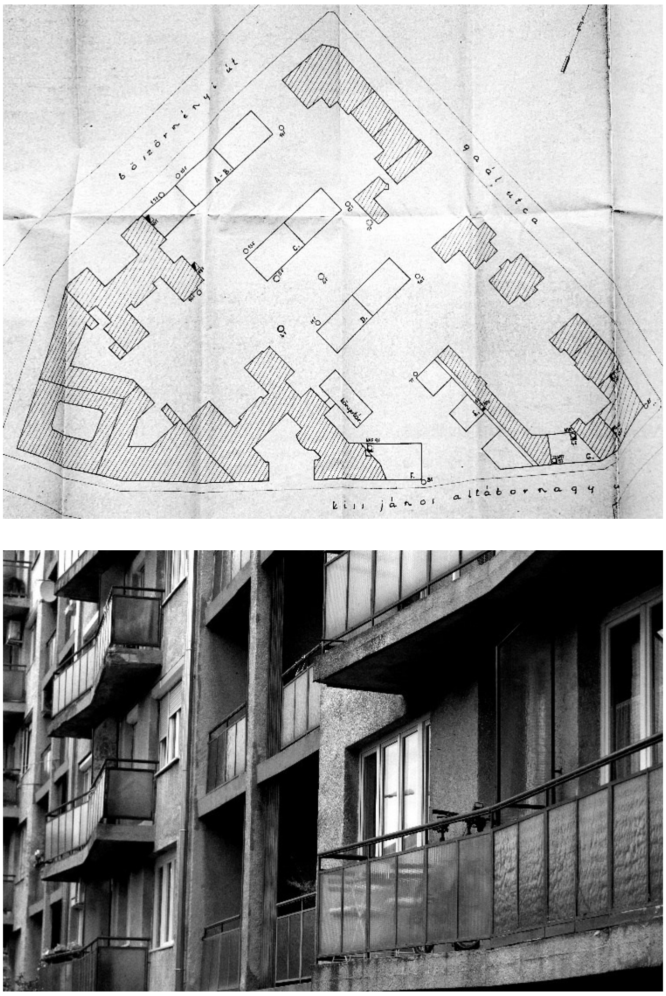

Fig. 22. 1959's master plan of the Böszörményi Road small HE and its façade detail nowadays. (Top source: ÉM, 1959; photo below: Author, 2023)

The Nagy Lajos King Road HE is also an excellent example of integration, although it is nestled into a suburban environment rather than an urban one (1959–1961). Several smaller and larger HEs are linked to one of Budapest's new representative boulevards. However, historically, this area had a suburban atmosphere with family homes and semi-detached houses. This housing estate bridged this dual character by erecting eight identical buildings on eight different private plots. Referencing the semi-detached environment, the buildings are freestanding and distinctly divided into two parts, connected by staircases, while their contemporary material use, appearance, and two- to three-storey height evoke the character of the representative main road (Fig. 23.).

Fig. 23. Street view of the Nagy Lajos King Road small HE. (Photo: Author, 2023)

CONCLUSION

After outlining the housing policy in Hungary and Budapest between 1945 and 1960, the research presents the small HEs built during in Budapest this period based on urban planning and architectural considerations. The small-scale housing estates can be divided into three groups, corresponding to political—(1) transition period, (2) Rákosi dictatorship, (3) consolidation; and architectural—(1) post-war, (2) socialist realism, (3) socialist modern—changes. During the establishment of state socialism, the post-war small HEs were mostly implemented in the centres of working-class neighbourhoods. The buildings adhered to modern architectural and urban planning principles, but the quality of their construction was poor. During the harshest years of state socialism, the style terror of socialist realism prevailed. The target audience of the small HEs built during this period was more diverse: alongside elite HEs hiding behind decorative façades with statues and fountains on private plots, there were also barracks-like estates consisting of one-room apartments with reduced comfort. During the years of consolidation, socialist modern small HEs represented consistently high quality, perhaps due to their placement on private plots. They featured diverse architecture and urban form.

Overall, it can be stated that these small HEs were built in diverse styles, architectural quality, layout, and budget, catering to both the party elite and the working class. Given this universality, they provide an excellent layer of housing and city policy in Budapest of the 1945–1960 period. Over the years, there has been an improvement in the architectural and construction quality of the buildings, with the emphasis shifting from developments floating in public spaces to private plot constructions. Except for the downtown area, small HEs can be found in all areas of Budapest, which demonstrates their success. Examining the individual small HEs, it can be concluded that the research hypothesis has been confirmed, namely that a small housing estate is a persistent urban form that withstands political and architectural changes, adapting to and continuing to meet their requirements. Focusing on the 22 small HEs built in Budapest built between 1945 and 1960, the paper highlights the diversity of their inhabitants, the adaptability of their architecture style, and the resilience of their urban form.

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Framework for optimising daylighting and passive indoor thermal comfort in single-banked office buildings in the temperate dry climate of Nigeria

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Abstract:
Many researchers have differed on the optimum values of Daylighting and Passive Indoor Thermal Comfort (DPITC) determinants in tropical climates. The study is aimed at developing a framework for optimising DPITC in singled-banked office buildings, during the activity period (8 a.m. to 5 p.m.), in the temperate dry climate of Nigeria. It was achieved by evaluating the effects of orientation, window-to-wall ratio (WWR), R-values of external wall insulation material, and shading devices on DPITC. A quantitative research design using an explorative design approach was employed in the study as well as an experimental research strategy through simulation method to optimise DPITC. The study used the Federal Secretariat building of Nigeria as a prototype of a single-banked office building. The Google SketchUp Pro 2022 and OpenStudio 3.3.0 simulation tools were used to evaluate the prototype building from January to December 2023. The data generated was analysed using relevant statistical tools (MANOVA, ANOVA, column charts, graphs, and tables). The findings revealed that the best WWR for daylighting and passive indoor thermal comfort are 20% and 15% respectively, while the compromise value was 20%. It was also noted that the R-value of the external wall insulation material does not affect the daylighting of an office building but affects the passive indoor thermal comfort, where the optimum R-value was of 3.26 m2·K/W. The mathematical model was developed as $A = 224.58 - 1254.84WWR + 102.87PF - 4.11R$ … ….1 where A is orientation, WWR window-to-wall ratio, PF projection factor, and R is the R-value of the external wall materials.

Keywords: daylighting, daylight autonomy, operative temperature, single-banked office building, thermal comfort

INTRODUCTION

Attaining adequate passive indoor environmental comfort particularly in multi-storey office buildings is critical to the success of a sustainable office building. It is crucial to take daylighting and passive indoor thermal comfort into account in their interactions (Zulkarnain et al., 2021; Zoure, Genovese, 2022) in tropical countries like Nigeria to avoid environmental pandemonium. For example, when a single comfort factor is considered independently, such as maximising the use of daylight when solar radiation levels are high, it may lead to an increase in indoor temperatures and cause thermal discomfort (Nasrollahzadeh, 2021). Recent studies conducted by Wang et al. (2024) and Chinazzo et al. (2019) indicated that there is a positive correlation between thermal comfort and the amount of daylight in a room. American National Standards Institute (ANSI) and American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE) Standard 55 (2020), as well as the International Organisation for Standardization (ISO) 7730 (2005) defined thermal comfort as the condition of mind that expresses satisfaction with the thermal environment. Daylighting is defined by Xue et al. (2014) as the people's satisfaction with the visual environment.

A study conducted by Zulkarnain et al. (2021) shows that daylighting is one of the elements that directly connects a building to its external surroundings and there are three types of daylight that can enter a building (Mohamed et al., 2020), these are: direct sunlight, diffused skylight, and light reflected from surrounding objects. Liu et al. (2023) noted that, the most significant type is the direct sunlight which enters the room through the openings. Researchers have indicated a number of factors affecting daylight performance as well as thermal comfort such as building orientation, type of window, and type of glass (Galal, 2018; Anthony et al., 2020). Another important factor is building spatial layout as observed by Musa (2023), Sasu et al. (2016), and St Clair (2009). Many studies in the tropics were able to predict daylight and thermal comfort but of conflicting values due to the failure to consider building spatial layout. For example: Mahmoudi Saber et al. (2015) findings were on the mixed-used buildings not tied to the basic building classification; Hakim et al. (2021) results were more aligning to single-banked buildings even though were silent on the building layout classification; while that of Salem Bahdad et al. (2022) did not consider a number of variables such as WWR, R-values of the materials as well as building layout. In addition to that, a study by Zhang and Ji (2022) have added a concept of energy without considering the building spatial layout, while Fan et al. (2023) findings were more applicable to open-plan office buildings than to other building layout classification though did not refer to the building layout.

This study aims at developing a framework of optimising daylighting and passive indoor thermal comfort (DPITC) in single-banked office buildings in the temperate dry climate of Nigeria. It was achieved by exploring the effects of window-to-wall ratio (WWR), orientation, overhang projection factor, and R-values of the exterior wall component of single-banked office buildings on DPITC in the temperate dry climate of Nigeria. These brought about the following research questions:

i. To what extent does the orientation (azimuth) affect DPITC of mid-rise office buildings?

ii. To what extent does the WWR affect DPITC of mid-rise office buildings?

iii. To what extent does the projection factor of a horizontal shading device affect the DPITC of mid-rise office buildings?

iv. To what extent do the R-values of the exterior wall component affect the DPITC of mid-rise office buildings?

Moreover, these also raised the following hypotheses: hypothesis (H_I) states that the effects of mean values of DPITC are significantly different for at least one of the azimuths in a single-banked office building in the temperate dry climate of Nigeria; hypothesis (H_2) states that the mean effects of DPITC are significantly different for at least one of the WWR in a single-banked building in the temperate dry climate of Nigeria; hypothesis (H_3) states that the mean effects of DPITC are significantly different for at least one of the overhang projection factors in a single-banked building in the temperate dry climate of Nigeria.

CONCEPT OF A FRAMEWORK

There are generally two types of frameworks: theoretical and conceptual frameworks as noted by Ravitch and Riggan (2017), and Kivunja (2018). Optimisation framework as defined by Al-Ansari and Alherbawi (2020) is the optimum technology that treats each waste type into useful products. The word "optimisation" in this research simply means to make the indoor environment of the office buildings as comfortable as it can be in the temperate dry climate of Nigeria. Sukreet and Kensek (2014) outlined four different types of optimisation in architectural education, which include: parametric analysis; genetic algorithms; multi-objective optimisation; and passive optimisation techniques. Passive optimisation is the process by which an expert designer generates a large number of design possibilities, typically with the use of simulation software, to meet optimisation standards. Sukreet and Kensek (2014) have critiqued the process of developing three or more building options, comparing them cognitively to past experiences, and then using intuition to choose the best one. Coello (2005) observed that a multi-objective algorithm is more traditionally associated with engineering and scientific fields. Parametric analysis is the process of changing the values of a particular variable until a maximum or minimum result is obtained which indicates the best solution. The research has adopted the parametric method of optimisation for achieving the study goal.

The climate type is a fundamental factor in optimising DPITC. A basic classification of climate can be of two categories based on different historical periods: classical and modern. The ancient Greeks used reasoning to categorise climate during the classical era. The creation and spread of weather recording equipment in the middle of the 19th century is credited with giving rise to modern climate classification. Although many different modern climate classifications have been developed, they may all be broadly divided into two categories: genetic climate classifications and empiric classifications (Arnfield, 2016; Ritter, 2019). The study has adopted the empiric climate classifications as widely adopted for all practical applications as concluded by Djamila (2018). Most climate classifications that are based on human comfort have their origin in Atkinson's (1953) climate classification (Koenigsberger et al., 2013) as shown by Musa (2022). The study has adopted Mobolade and Pourvahidi's (2020) climate classification based on the fact that it factored temperature, relative humidity, mean radiant temperature, and wind velocity in its method of classification. It also considered the gradual transition from one climatic zone to another as shown by Musa (2022).

MATERIALS, DATA AND METHODS

An experimental research strategy using a simulation method was employed through an exploratory design approach and quantitative research design. A non-convenience probability sampling technique was used in selecting the Federal Secretariat as an example of a single-banked office building as illustrated in Fig. 1. It was chosen for this study because its prototype is replicated all over Nigeria. The prototype was then modelled in Google SketchUp Pro 2022, Radiance from the OpenStudio 3.3.0 simulation tools.

Fig. 1. Federal Secretariat Abuja Nigeria. (Photo: Authors, 2024)

The window parameters used in the simulation were as follows: 3 mm thick glass as the window material of 0.331 solar transmittance at normal incidence; 0.6189 front side solar reflectance at normal incidence; 0.44 visible transmittance at normal incidence; 0.51 front side visible reflectance at normal incidence; and 0.0133 W/Mk conductivity. The simulation was from January to December 2023 on the hypothetical sites devoid of surrounding buildings and trees, in Jalingo, Minna, and Abuja, using the various range of values of WWR (15-40%), azimuths ($0–270^0$), overhang projection factor (0.35–0.6), and R-values ($1.04–4.16m^2·K/W$) and their corresponding mean values of Daylight Autonomy (DA), Useful Daylight Illuminance ($UDI_{100-3000}$), Spatial Daylight Autonomy ($_SDA$), Operative Temperature (OT), and Relative Humidity (RH) was recorded. The methods used in conducting the research was based on the Kamel and Memari (2018), and IEA (2022) procedures. Based on these documents, the following steps were followed:

i. A prototype of Nigerian Federal Secretariat building was modelled in Google SketchUp 2017;

ii. In order to simulate daylight, EnergyPlus weather (EPW) was used as the type of weather file;

iii. SketchUp plugging known as OpenStudio was used to set weather files of Abuja, from weather Analytic;

iv. Radiance measure in OpenStudio was used for daylight;

v. Run period from January to December of 2023 was selected from Simulation settings;

vi. Simulation button was pressed for the final analysis.

Data generated were then analysed using the MANOVA statistical tool with a significance value of 0.05, bar charts, graphs, and tables. Regression analysis was also used to establish the relationship between the four variables in a single-banked office building for DPITC in the temperate dry climate of Nigeria.

RESULTS AND DISCUSSION

The results are presented based on the research questions earlier raised in this paper: To what extent does the azimuth angle affect DPITC of mid-rise office buildings in the temperate dry climate of Nigeria? The simulations of a single-banked office building with a WWR of 8.8%, and R-value of 2.08 m^2K/W was done, and the results are presented in Tab. 4.1 and 4.2. It was noted that three out of eleven conditions have fulfilled the benchmarks as put forward by Illuminating Engineering Society (IES, 2022) which recommended a DA of 60% of the work plane illuminance; $UDI_{100-3000}$ of 80%, and $_SDA$ of 75% in office space. It has also been observed that, as the azimuth angle increases the DA increases but UDI decreases. When the daylight indicators were ranked, it showed that a building oriented at zero degrees has the better daylighting as shown in Table 4.2. The finding is in agreement with the Anumah and Anumah (2007). The simulation results of the effects of building orientation on operative temperature and relative humidity are presented in Tab. 4.3.

Tab. 4.1. Simulation results of the effects of orientation on DA, $_SD$, and UDI in mid-rise office buildings, in the temperate dry climate of Nigeria.

Azimuth	0^0	11.5^0	22.5^0	45^0	67.5^0	90^0
DA	73	73	73	75	76	76
$_SDA$	97.5	97.4	97.4	97.7	97.5	97.5
UDI	81	80	79	74	69	67

(Source: Authors, 2024)

Tab. 4.2. Ranking of the daylight comfort metrics on building orientation.

Azimuth	DA	SDA	UDI	Daylight Comfort	Remark
0	3rd	2nd	1st	1st	0^0 is the best orientation to achieve daylighting
11.5	3rd	3rd	2nd	2nd	
22.5	3rd	3rd	3rd	4th	
45	2nd	1st	5th	6th	
67.5	1st	2nd	6th	8th	
90	1st	2nd	7th	9th	
112.5	1st	8th	6th	11th	
135	2nd	4th	5th	7th	
157.5	3rd	5th	3rd	5th	
180	3rd	6th	1st	3rd	
270	4th	7th	4th	10th	

(Source: Authors, 2024)

Tab. 4.3. Ranking of thermal comfort indicators for building orientation.

Azimuth	Operative temperature	Rank	Relative humidity	Rank
11.5	30.2825	1	64.125	1
0	30.32	2	63.85	2
22.5	30.37375	5	63.7375	3
45	30.77	4	63.125	4
67.5	31.13	5	62.6	5
90	31.295	6	59.7625	6

(Source: Authors, 2024)

Tab. 4.4. Ranking of the orientation for DPITC.

Azimuth	DA	SDA	UDI	Daylight Comfort	Thermal Comfort	DPITC	Remark
0	3rd	2nd	1st	1st	2nd	1st	11.5^0 is the most appropriate due to the effects of wind direction in the tropics.
11.5	3rd	3rd	2nd	2nd	1st	1st	
22.5	3rd	3rd	3rd	4th	3rd	2nd	
45	2nd	1st	5th	6th	4th	3rd	
67.5	1st	2nd	6th	8th	5th	4th	
90	1st	2nd	7th	9th	6th	5th	
112.5	1st	8th	6th	11th			
135	2nd	4th	5th	7th			
157.5	3rd	5th	3rd	5th			
180	3rd	6th	1st	3rd			
270	4th	7th	4th	10th			

(Source: Authors, 2024)

The result showed that 11.5^0 azimuth is the most appropriate orientation for better operative temperature and relative humidity. When values of daylight metrics and thermal comfort indicators were ranked together as indicated in Tab. 4.4. 11.5^0 was found to be the most appropriate for DPITC due to the direction of air circulation at 45^0 as observed by Szokolay (2008).

Hypothesis testing 1

H_{01}: There is no significant difference in DPITC among the mid-rise office buildings with different azimuth angles in the temperate dry climate of Nigeria.

One-way MANOVA was used to test if the effect of azimuth angle differs from one another significantly in one or more of the DPITC variables and a statistically significant difference was obtained, $F (25, 210) = 3.640$, $p < .00001$; Pillai's $\Lambda = 1.512$, partial $\eta 2 = 0.302$. Hence since there were more than two (2) levels of the independent variable, there was a need to determine where the differences truly came from, which brought about the need for a post-hoc test. A series of one-way ANOVAs on each of the DPITC variables was conducted as a follow-up test to the MANOVA. The results turned out to be statistically significant in all the five DPITC variables: DA *(F (5, 42) = 14.645; p < .000; partial η2 = 0.635),* UDI *(F (5, 42) = 419.750; p < .0000; partial η2 =0 .980),* ${}_S$DA *(F (5, 42) = 3.267; p < .014; partial η2 = 0.280),* mean annual operative temperature ($F (5, 42) = 10.776$; $p < .000$; partial $\eta^2 = .562$), and mean annual relative humidity ($F (5, 42) = 2.857$; $p < .026$; partial $\eta^2 = 0 .254$).

A series of post-hoc analyses using Fisher's LSD were conducted to examine individual mean differences comparison across the azimuth angles and DPITC variables. The results revealed that: except for azimuth 45^0, all DA were statistically significant with one another for all values that were greater than 22.5^0 but less than 45^0; except for the relationship between azimuth 0^0 and 11.5^0, all UDI values were statistically significant to one another; and finally, except for the relationship between azimuth 22.5^0 and 45^0, 67.5^0 and 90^0, all ${}_S$DA values were not statistically significant to one another. That means all azimuth angles that are within 45^0 are not statistically significant to one another, while those that are not within the same 45^0 are statistically significant to one another. For example, 0^0, 11.5^0, and 22.5^0 are not significant to one another, while they are significant with 45, 67.5^0, and 90^0. The reverse is also true. For the relative humidity, it shows that, except azimuth 90^0 which was statistically significant to all others, all the average annual relative humidity values were not statistically significant to one another.

To what extent does the WWR affect DPITC in mid-rise office buildings in the temperate dry climate of Nigeria? The simulations of a single-banked office building, with an R-value of 2.08 m^2K/W and a constant Azimuth angle of 11.5^0 were done and the results are presented in Tabs. 4.5, 4.6, and 4.7. To evaluate the most appropriate WWR for optimum daylighting, the rank and percentile were used, and the results showed that 20% is the optimum value of WWR for daylighting in the temperate dry climate of Nigeria, which has complied with Shebl (2007) and ASHRAE 90.1 (Goel et al. 2014). However, it is contrary to the 2012 International Energy Conservation Code (IEA, 2019) which recommends a different value of 30% (Makela et al., 2011).

The simulation results of the effects of WWR on operative temperature and relative humidity are presented in Tabs. 4.6 and 4.7. The results showed that while relative humidity has met the condition recommended by ASHRAE Standard 55 (2020) as shown in Tab. 4.7, none of the operative temperatures met with the ANSI/ASHRAE Standard 55 (2020) as indicated in Tab. 4.6. The rank and percentile were used to reveal the best WWR for minimum operative temperature and maximum relative humidity and 15% was found to be the most appropriate WWR for better operative temperature as well as relative humidity as indicated in Tab. 4.8. When the values of daylight metrics and thermal comfort indicators were ranked together as indicated in Table 4.8, 20% WWR was found to be the most appropriate for DPITC. The finding has confirmed that of Budhiyanto (2017).

Tab. 4.5. Simulation results for the effects of WWR on DA, ${}_S$DA and UDI in a mid-rise office building, in the temperate dry climate of Nigeria.

WWR	0.15	0.195	0.200	0.220	0.240	0.300	0.400
DA	71	80	80	81	82	84	84
UDI	82	79	79	77	75	68	53
${}_S$DA	94.04	95.64	95.71	96.25	96.39	96.93	97.5

(Source: Authors, 2024)

Tab. 4.6. Simulation results for the effects of WWR on the operative temperature of the prototype mid-rise office building, in the temperate dry climate of Nigeria.

	WWR						
	0.15	0.195	0.2	0.22	0.24	0.3	0.4
Room	Average RH	Average RH	Average RH	Average RH	Average RH	Average RH	Average RH
102	27.3	29.3	29.3	29.54	29.9	30.74	28.46
202	31.47	32.19	32.43	32.55	32.79	33.63	33.63
302	31.83	32.43	32.43	32.91	33.15	33.87	33.63
402	31.95	32.43	32.67	32.91	33.15	33.87	33.87
502	31.95	32.43	32.91	32.67	33.39	34.11	34.35
602	31.71	32.67	33.15	32.79	33.63	34.11	33.87
702	31.95	32.79	32.55	32.91	33.15	34.11	33.87
802	32.07	32.43	32.43	32.91	33.15	34.35	33.99
Average	31.27875	32.08375	32.23375	32.39875	32.78875	33.59875	33.20875

(Source: Authors, 2024)

Tab. 4.7. Simulation results of the effects of WWR on the relative humidity in the temperate dry climate of Nigeria.

	WWR						
	0.15	0.195	0.2	0.22	0.24	0.3	0.4
Office	Average RH	Average RH	Average RH	Average RH	Average RH	Average RH	Average RH
102	65.25	65.25	65.5	65.25	65.5	65.25	62.5
202	61.5	60.5	60.1	60.25	59.5	59	52.3
302	62.1	60.1	60.25	59.58	59.5	59	52.2
402	56.3	54	54	54	54	54	50.5
502	59.5	57.75	57.75	57.75	57.5	56	53.3
602	56.3	54.5	54	54.5	54.25	56	52.1
702	59.2	57.75	57	57.25	57.25	56	53.3
802	60.5	60.25	60.25	60.1	60.5	58	55.2
Average	60.08125	58.7625	58.60625	58.585	58.5	57.91	53.925

(Source: Authors, 2024)

Tab. 4.8. Ranking of the WWR for DPITC.

WWR	DA	UDI	sDA	Daylight Comfort	Thermal Comfort	DPITC	Remark
15	5th	1st	7th	6th	1st	4th	
19.5	4th	2nd	6th	2nd	2nd	2nd	
20	4th	2nd	5th	1st	3rd	1st	
22	3rd	3rd	4th	3rd	4th	3rd	20% is the most appropriate WWR for DPITC.
24	2nd	4th	3rd	4th	5th	5th	
30	1st	5th	2nd	5th	6th	6th	
40	1st	6th	1st	7th	6th	7th	

(Source: Authors, 2024)

Hypothesis testing 2

H2: It states that the mean effects of DPITC are significantly different for at least one of the WWRs in a single-banked building in the temperate dry climate of Nigeria.

The one-way MANOVA was used to test if the mid-rise office buildings with different WWRs differ from each other significantly in one or more DPITC variables. It was tested and a statistically significant difference was obtained, $F(30, 210) = 8.634$, $p < .0000$; Pillai's $\Lambda = 2.761$, partial $\eta2 = 0.552$ A Series of one-way ANOVA's on each of the DPITC variables was conducted as a follow-up test to the MANOVA. The results turn out to be statistically significant in all the DA *($F(6, 42) = 59.39$; $p < .0000$; partial $\eta2 = 0.895$)*, UDI *($F(6, 42) = 271.793$; $p < .0000$; partial $\eta2 = 0.975$)*, and sDA *($F(6, 42) = 66.778$; $p < .0000$; partial $\eta2 = 0.905$)*. The other two were not, because they have fallen out of the span of -2 to +2 as the acceptable values for skewness and kurtosis, as specified by George and Mallery (2010).

A series of post-hoc analysis using Fisher's LSD were performed to examine individual mean differences comparison across all the seven different WWR and five DPITC variables. The results revealed that, for DA, UDI, and sDA, all WWRs were statistically significant with one another, and the opposite was also true for operative temperature and relative humidity because they were nonparametric data. A Kruskal-Wallis test was therefore used to compare the effects of WWR on operative temperature having fallen out the span of -2 to +2 as the acceptable values for skewness and kurtosis, as specified by George and Mallery (2010). It showed a statistically significant difference in operative temperature score among the different WWR, $\chi2(5) = 29.62$, $p = 0.0000$, with a mean rank Operative temperature of 9.75 for 0.15 WWR, 16.69 for 0.195 WWR, 22.63 for 0.2 WWR, 26.94 for 0.22 WWR, 33.94 for 0.24 WWR, 45.13 for 0.3, and 42.44 for 0.4 WWR.

To what extent does the shading device affect the DPITC of mid-rise office buildings in the temperate dry climate of Nigeria? The simulations of a single-banked office building, with an R-value of 2.08 m^2K/W, azimuth angle of 11.5^0, a shade offset value of 0.3, and WWR of 20%, were done and the results are presented in Fig. 2. The finding showed that the optimum projection factor for daylighting in mid-rise office buildings in the temperate dry climate is 0.35 followed by 0.45/0.5, and lastly 0.6 as indicated in Fig. 3. The simulation results showing the effects of the projection factor on thermal comfort show that, while relative humidity has met with the recommended values given by ASHRAE Standard 55 (2020), none of the operative temperatures has met the ANSI/ASHRAE Standard 55 (2020) as shown in Fig. 4.

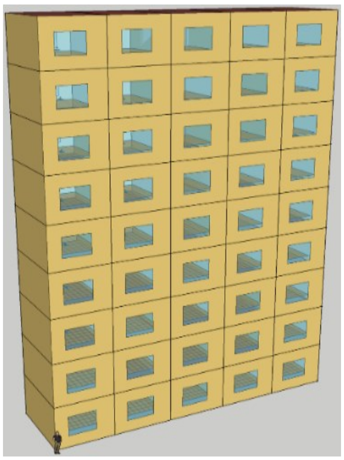

Fig. 2. Simulation of Federal Secretariat Abuja. (Source: Authors, 2024)

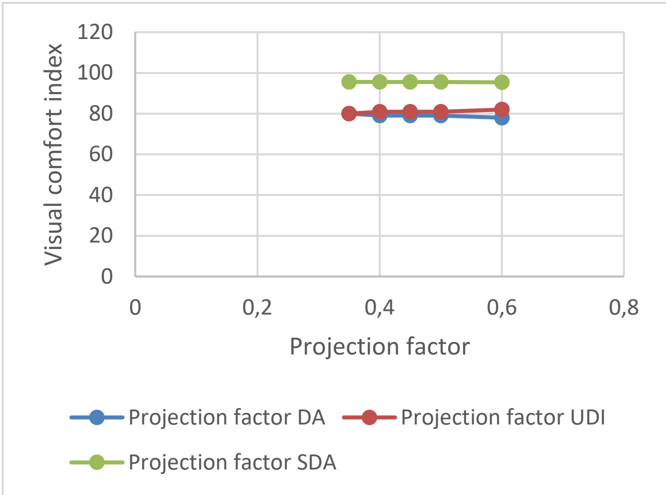

Fig. 3. Projection factor for optimum daylighting in a single-banked office building in temperate dry climate of Nigeria. (Source: Authors, 2024)

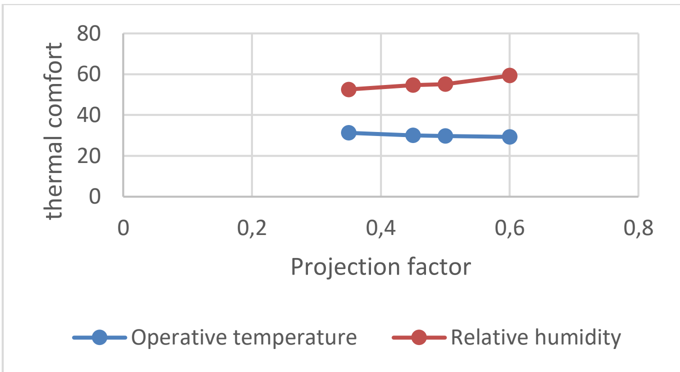

Fig. 4. Projection factor for minimum operative temperature and relative humidity in a single-banked office building. (Source: Authors, 2024)

To reveal the appropriate projection factor for minimum operative temperature and maximum relative humidity, the rank and percentile were used, and the results were obtained as presented in Fig. 4. The result showed that 0.6 was the most appropriate projection factor for better operative temperature as well as relative humidity. When the values of daylight metrics and thermal comfort indicators were ranked together as indicated in Tab. 4.9. 0.5 and 0.6 projection factors were found to be the most appropriate for DPITC. The finding was almost in conformity with that of Hien and Istiadji (2003), who discovered 0.55 as the most effective shading coefficient for passive indoor comfort.

Tab. 4.9. Ranking of the projection factor (PF) for DPITC.

Projection factors	DA	UDI	sDA	Daylight comfort	Thermal comfort	DPITC	Remark
0.35	1st	3rd	1st	1st	4th	4th	0.5 and 0.6 are the most appropriate PFs for DPITC but a level of significance is required to resolve it.
0.45	2nd	2nd	2nd	2nd	3rd	3rd	
0.5	2nd	2nd	2nd	2nd	2nd	1st	
0.6	3rd	1st	3rd	3rd	1st	1st	

(Source: Authors, 2024)

Hypothesis Testing 3

H03: There is no significant difference in DPITC between mid-rise office buildings with different projection factors of shading devices in the temperate dry climate of Nigeria.

The MANOVA test was conducted to test if there would be one or more differences between PF and DPITC variables and a statistically significant difference was obtained, F (20, 116) = 2.487, $p < .001$; Pillai's Λ = 1.200, partial η2 = 0.300. A homogeneity for variance assumptions was tested for all the five DPITC variables before conducting a series of tests between the subject effects. Based on a series of Levene's F tests, it was considered satisfactory. A series of one-way ANOVAs on each of the five DPITC variables was conducted as a follow-up test to the MANOVA. The results turned out to be statistically significant in all the DA *(F (4, 30) = 3.265; p < .025; partial η2 =0 .303)*, UDI *(F (4, 30) = 10.466; p < .0000; partial η2 = 0.583)*, SDA *(F (4, 30) = 4.500; p < .006; partial η2 = .375) and Operative temperature (F (4, 30) = 2.843; p < .041; partial η2 = 0.275).*

A series of post-hoc analysis using Fisher's LSD were performed to examine individual mean differences comparison across all the five different PF and five DPITC variables. The results showed that 0.5 and 0.6 have almost equal statistically significant differences with others, and therefore 0.5 PF is chosen for economic reasons. For example, the mean scores for UDI were statistically significantly different between 0.6 PF and 0.35 PF (p < .05), 0.6 PF and 0.4 PF (p < .05), 0.6 PF and 0.45 PF (p < .05), 0.6 PF and 0.5PF (p < .05), and 0.6 PF and 0.6 PF (p < .05); while the mean scores for UDI were statistically significantly different between 0.5 PF and 0.35PF (p < .05), 0.5 PF and 0.4PF (p < .05), 0.5 PF and 0.5PF (p < .05), and 0.5 PF and 0.6PF (p < .05), but not between 0.5 PF and 0.45PF (p < .249). The result has also revealed that UDI responds to PF more than the other four variables.

To what extent do the R-values of the exterior wall insulation material affect DPITC of mid-rise office buildings in the temperate dry climate of Nigeria? The simulations of a single-banked office building, with an azimuth angle of 11.5⁰, a shade offset value of 0.3, an overhang projection factor of 0.5, and WWR of 20% were done and the results are presented in Tab. 4.10. The findings have shown that all four conditions were the same and, therefore, the R-value of external wall insulation material does not affect the daylighting of an office building as indicated in Tab. 4.10. The simulation results of the effect of R-values of external wall insulation material on thermal comfort are presented in Fig. 5. The results have shown that only one of the operative temperatures has met the ANSI/ASHRAE Standard 55 (2020) (whose R=4.16). It has also been observed that as the R-value of external wall insulation materials increases the thermal comfort also increases.

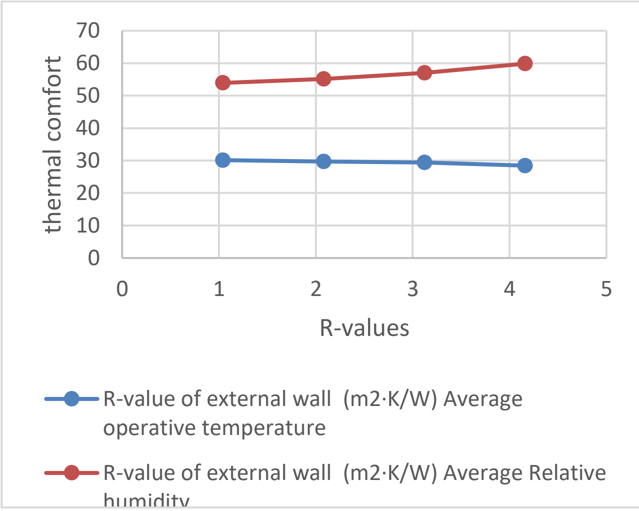

Fig. 5. R-values of external wall materials for minimum Operative temperature and Relative humidity in a single-banked office building. (Source: Authors, 2024)

To reveal the appropriate R-value of external wall insulation material for the mean value of operative temperature and relative humidity, the rank and percentile were used, and the result showed that, as the R-value increases, the thermal comfort also increases as indicated in Figure 4.10. Correlation equations: - *RH = 1.8882R + 51.569,* and *T = -0.5106R + 30.77* (where *RH is relative humidity, R is* R-value, and T is operative temperature*)* for relative humidity and operative temperature revealed the most appropriate R-value for better operative temperature as well as relative humidity was 3.26 m2·K/W. When the values of daylight metrics and thermal comfort indicators were ranked together, 3.26 m2·K/W was found to be the most optimised R-value for DPITC as indicated in Tab. 4.11. The result conformed with that of ANSI/ASHRAE/IES Standard 90.1 (2010 and 2017 editions) which recommended a minimum range of R-value of 1.0–2.7 (m2·K/W) for non-residential buildings but contrary to that of Energy Conservation Building Code (2014), which recommended the optimum R-value of 3.7 (m^2·K/W) as the optimum for non-residential buildings.

Tab. 4.10. Ranking of the DA, sDA, and UDI against the R-value of external wall insulation materials.

R-value of the external wall (m2·K/W)	DA	RANK	UDI	Rank	sDA	Rank	Daylight rank
1.04	79	1	81	1st	95.5	1	1
2.08	79	1	81	1st	95.5	1	1
3.12	79	1	81	1st	95.5	1	1
4.16	79	1	81	1st	95.5	1	1

(Source: Authors, 2024)

Tab. 4.11. Ranking of the R-values for DPITC. Remark: 3.26 m2·K/W is the most appropriate R-Value of the external wall for DPITC in the temperate dry climate of Nigeria.

R-Value of external insulated wall material (m2·K/W)	DA	UDI	sDA	Daylight Comfort	Thermal Comfort	DPITC

1.04	1	1	1	1	4	4
2.08	1	1	1	1	3	3
3.12	1	1	1	1	2	2
4.16	1	1	1	1	1	1

(Source: Authors, 2024)

Hypothesis testing 4

The homogeneity of variance-covariance matrices was tested using Box's Test of Equality of Covariance Matrices and Box's M value obtained is 3.494 with a p-value of .963, which was interpreted as non-significant based on Huberty and Petosky's (2000) guidelines. Therefore, the covariance matrices of the dependent variables were equal across groups for MANOVA. The one-way MANOVA was tested, and a statistically significant difference was obtained, $F (3, 28) = 3.168$, $p < .040$; Roy's Largest Root $\Lambda = .339$, partial $\eta 2 = .253$. A homogeneity for variance assumptions was tested for all thermal comfort variables before conducting a series of tests between the subject effects. Based on a series of Levene's F tests, it was considered satisfactory. A series of one-way ANOVAs on each of the two thermal comfort variables was conducted as a follow-up test to the MANOVA. The results turned out to be statistically significant in all the Average Annual Operative Temperature *($F (3, 28) = 3.014$; $p < .047$; partial $\eta 2 = .244$) and Average Annual Relative Humidity ($F (3, 28) = 2.936$; $p < .051$; partial $\eta 2 = .239$).* A series of post-hoc analyses using Fisher's LSD was performed to examine individual mean differences comparison across all the two different R-values and four thermal comfort variables. The result revealed that there is a statistically significant difference in the relationship between 4.16 and 2.08/ 1.08 for Average Annual Relative Humidity than in any other ones and between 4.16 and 2.08 in Average Annual Operative Temperature.

Mathematical models

These were applied to develop a relationship between the optimised DPITC determinants for single-banked office buildings in the temperate dry climatic zone of Nigeria. The mathematical model is limited to office buildings with horizontal shading devices, for it is more effective than the vertical in the tropics as observed by Al-Tamimi (2011) and Kim et al. (2013). The framework was used to obtain four more optimised DPITC values in each type of office building as indicated in Tab. 4.12 for single-banked office buildings. It was used to carry out the multiple regression to investigate whether the optimised values of WWR, projection factor, and R-value of external wall material could significantly predict different optimised azimuth angles for DPITC in single-banked office buildings in a temperate dry climate of Nigeria. The results of the regression indicated that the model explained 99.9% of the variance and that the model was a significant predictor of azimuths, $F(3,1) = 4700.8$, $p = .010721$. The WWR, projection factor (PF), and R-value of external wall materials (R) contributed significantly to the model ($B = -1254.84$, $p=0.010872$), ($B = 102.8743$, $p=0.017526$), and ($B = -4.10695$, $p=0.044915$), respectively.

Tab. 4.12. Five sets of optimised values of DPITC in single-banked office buildings in a temperate dry climate.

S/NO	Azimuth	WWR	PF	R-value
1	11.5	0.2	0.5	3.26
2	22.5	0.2	0.6	3.12
3	35	0.15	0.07	2.08
4	45	0.15	0.25	4.16
5	12.5	0.2	0.5	3.1

(Source: Authors, 2024)

$$Y = C + M1X1 + M2X2 + M3X3 \ldots\ldots .4.1$$

The 4.1 formula was used to develop the model from regression results as follows:

Azimuth (A)= 224.5802 + (-1254.84 x WWR) + (102.8743 X Projection Factor) + (-4.10695 x R-Value)

A= 224.58 - 1254.84WWR + 102.87PF - 4.11R…….4.2

SI Units: A= (0); R= (m^2.K/W); C= (0); M1= (0); M2= (0); and M3=(0 W/m^2.K).

DISCUSSION AND CONCLUSION

The research has found out that, for a building to have optimum passive indoor thermal and adequate daylight, the values of azimuth, WWR, overhang projection factor and R-value of the external wall materials must comply with the following equation: A= 224.58 - 1254.84WWR + 102.87PF - 4.11R…….4.2 for example, if a building is oriented along recommended azimuth of 11.5^0 then its WWR, overhang projection factor and R-value of the external wall materials must be 20%, 0.5 and 3.26 m2·K/W respectively. The findings have confirmed the observation of Ochedi and Taki (2022) that no single orientation is suitable for all buildings in a climate zone.

The result has explained the reasons why there are many differences in WWR, R-value, orientation and overhang projection factors by various researchers. For example, since Al-Tamimi, (2011), Anumah and Anumah (2017), Odunfa et al. (2018), Shebl (2007), and ASHRAE 90.1 (Goel et al. 2014) used similar azimuths, R-value and shadings, they recommended similar WWR. However, 2012 International Energy Conservation Code (IEA, 2019) recommended different WWR for it used different values of azimuth, shadings, and R-value of external wall material. Another important factor is the building spatial layout which may be the reason ANSI/ASHRAE/IES Standard 90.1 (2010 and 2017 editions) recommended a minimum range of R-value between 1.0 to 2.7 (m2·K/W) for non-residential buildings contrary to that of Energy Conservation Building Code (Bureau of Energy, 2017), which recommends 3.7 (m2·K/W).

Therefore, the architects and other building professionals should not mix the values of building considerations from different researchers for each might have used different determinants. Typical example are Kandar et al. (2011) and SOLID GREEN (2017) who used different building spatial layout and arrived at their different values.

Framework validation

It is very important to engage the users in the validation of any framework, as noted by Fan et al. (2023). There are various ways of validating a model which include: an expert assessment validation and the examination of framework output for reasonableness under a variety of settings of the input parameters.

Examination of framework output under a variety of settings of the input parameters

This involved changing the values of one of the framework concepts such as WWR, R-values, or PF, which may affect the values of other concepts, to achieve the optimum passive thermal and daylighting of an office building.

Testing the values given by the Building Code of Australia (BCA) and Australia's guide to environmentally sustainable homes (AGESH)

The study tested the values given by BCA and AGESH, which recommend the optimum WWR as 19%, orientation as 11^0NE, minimum R-values as 2.8 m2.K/W, and projection factor as 0.35. The result complied with $A = 224.58 - 1254.84WWR + 102.87PF - 4.11R$.

Testing the values given by ASHRAE standards

The study tested the values given by ASHRAE, which recommended the optimum value of WWR as 20%, minimum R-values as 2.68 m^2.K/W, and projection factor as 0.5 (except if WWR was greater than 30%). The result complied with $A = 224.58 - 1254.84WWR + 102.87PF - 4.11R$ and McGee (2013) findings, proposed an optimum orientation of up to 15° NE.

Testing the values given by the International Energy Conservation Code (IECC)

The study tested the values given by IECC which recommended 30% as the maximum WWR, 3.52 m^2.K/W as the maximum value of R, 15^0 optimum azimuth angle, and 0.6 as the projection factor. The result complied with $A = 224.58 - 1254.84WWR + 102.87PF - 4.11R$.

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Weight and structural considerations of potential green roof growth: Media compositions for the Nigerian building industry

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Abstract:
The principal objective of this paper was to assess the physical properties and weight or structural implications of some potential green roof growth media compositions practicable for use in the Nigerian built environment. The study carried out an essential selection of material constituents of growth media blends mixed in a 3:1:1 ratio of natural stone-based gravels, soil and compost respectively. Six substrate blends based on laterite stones, ory and empirical field evaluation methods. The results revealed that the granite-based blend is the heaviest sample with 1,713.30 kg/m³ in its saturated state, while the lightest in weight is the pumice blend with 869.30 kg/m³ which is 50.7% less than the granite blend. The heaviest and the lightest outlined models were subsequently subjected to a weight analysis on a proposed reinforced concrete flat-roofed structure. The results showed that all the extensive green roof samples fall within the IBC stipulated range. The heaviest granite substrate obtained a design load of 0.951 kN/m², while the lightest pumice blend recorded a design load of 0.576 kN/m². Hence, it stands to offer an optimum alternative in green roof retrofitting projects for existing flat-roofed buildings. The study, therefore, submits that all samples evaluated involve readily available materials in the studied area and can be used with respect to their characteristic properties as presented in this study. It also serves as a reference point for all stakeholders in the research and building construction industry in Nigeria and beyond.

Keywords:
green roof, growth-media composition, substrate weight, lightweight construction

INTRODUCTION

Green roof technology is still in its incipient and exploratory stage in the Nigerian built environment industry. Therefore, there is limited knowledge on the weight and structural implication of using green roof on buildings which is one of the most challenging aspects of using such a system both in new and retrofitted projects. The dismal level of knowledge and patronage the system suffers locally is evidently attributed to a lack of common awareness of its numerous benefits, limited basic technical knowledge, and the characteristic high initial and maintenance cost of the system (Ezema et al., 2015; Salihu, 2018). However, most importantly, the green roof system is typically associated with challenges that involve its characteristic weight and the implication it has on the supporting roof system. It is therefore regarded as the most critical and challenging aspect of a green roof project which if not duly considered can lead to the partial and/or ultimate failure of the support roof owing to the excessive loading as a result of the weight of the green roof system (Schweitzer, Erell, 2014; Dvorak, 2011). Although such a weight is grossly due to the build-up of the vegetation and several green roof components, the major element that primarily determines its weight is the growth medium, which is a blend of soil and the hard-core material that ensures stability and plant development capacity of the system (Vijayaraghavan, 2016).

According to the American Society for Testing and Materials (ASTM E2400, 2019); and Forschungsgesellschaft Landschaftsentwicklung Landschaftsbau (FLL) standards (2008); the growing media must functionally sustain plant life with minimum input and maintenance, and must also be locally available, possess good drainage capability, good water and nutrient-holding capacity and most importantly, it must be lightweight in nature in its saturated form to avoid failure of the main roof system of the building. Therefore, in light of this problem, this research is primarily focussed on investigating the weight attributes and their subsequent structural implication on some locally obtained growth media materials in order to obtain the categorical implication of using them as local substrate blends practicable for both new and retrofitting projects, and applying them on either lightweight or heavyweight roof systems predominantly found in the local building industry.

Although the International Building Code (ICC, 2018) has stipulated that green roofs are computed as live loads calculated on the basis of saturation of the soil and shall be within the range of

0.958kN/m², studies have shown that values and attributes of green roofs are location-specific and each scheme must therefore be considered as a distinct case from one setting to another (Decruz et al., 2014). The National Building Code (Federal Ministry of Housing and Urban Development Nigeria, 2006), has made provision for structural applications of various categories of predominantly used roof systems like the reinforced concrete flat roofs and different assortments of timber and steel trussed roof systems on both single and multi-storey buildings; however, no section of the building code has been found to regulate the live-load implications of using the green roof system. This study hence becomes a necessary platform for evaluating the weight implication of the outlined potential green roof growth-media compositions in Nigeria for subsequent reference and plausible adoption.

To attain categorical deductions on the efficacy of using the potential growth media with respect to their inherent weight and subsequent physical impact on the supporting roof; some outlined research questions were put forward to achieve the primary objective of the study. The research questions are:

1. What are the commonest and practicable green roof growth-media constituents attainable in the local built environment industry?
2. What is the weight and structural impact of the outlined growth media models?
3. What is the level of compliance of the prospective growth media with respect to established green roof codes and guidelines?

Mapped to the research questions, the research objectives therefore are:

1. To perform a critical selection of the potential growing media feasible for local adoption,
2. To subject the outlined growth media models to relevant evaluation and structural analysis,
3. To assess the level of compliance of the prospective growth media with respect to established green roof codes and guidelines.

LITERATURE REVIEW

Green roof benefits and major components

As shown in Fig. 1, the major components of a green roof system include; the plants, an engineered growing medium, a filter layer to contain roots and growing medium, a drainage layer, a waterproofing membrane and the main roof structure (Rakotondramiarana et al., 2015).

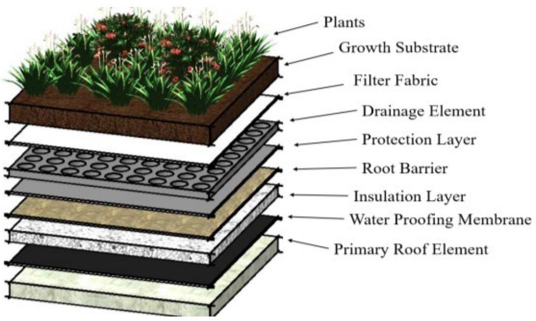

Fig. 1. Schematic diagram of the layered structure of a typical green roof system. (Source: Vijayaraghavan, 2016)

Generally, green roofs can be categorised as extensive and intensive systems depending primarily on their thickness. The extensive system has a thickness of less than 300 mm deep growing media and requires minimal irrigation with a robust low-growing plant and ground cover species on a gently sloping support roof (Berardi et al., 2013). Extensive green roofs are designed to be lighter in weight, relatively cheap, but not open to recreational use and require minimum maintenance (Lyons, 2010). On the other hand, the intensive green roof has the depth of growing media of more than 300 mm, it is generally designed to accept recreational activity and to include the widest range of vegetation from grass to shrubs and semi-mature trees (Berardi et al., 2013). They are largely limited to flat roofs in park-like areas accessible to the public that require intense maintenance needs (Getter, Rowe, 2006). When elements of both extensive and intensive categories are present in any given system, they are considered to be semi-intensive green roofs (Raji et al., 2015).

Green roofs are perceived as an effective contribution to addressing several environmental problems at the building and urban levels. In addition to the creation of a pleasant environment, green roof systems fundamentally offer numerous benefits in comparison to conventional roof installations. The roof system facilitates storm water retention to minimise flooding, noise and air pollution, mitigation of urban heat islands on a macro scale, and provides protection from temperature extremes thus helping to reduce energy requirements for cooling the building interior spaces (Speak, 2013; Collins, 2016; Sutton, 2015; Suszanowicz, Wiecek, 2019). On a more physical scale, the roof system offers economic benefits that facilitate increasing the life expectancy of building's roofs by protecting them from physical damage, and improving the economy of space as it allows for the creation of utilisable commercial and recreational roof gardens and terraced areas on rooftops (Castleton et al. 2010; Lyons, 2010).

Weight and structural challenges of the green roof substrate

Typically, green roof substrate is composed of different ratios of stone-based gravel, soil and organic material; however, the most crucial constituent of the growth media that is responsible for its gross weight is the stone-based hard-core material (Chenot et al. 2017). In the case of a wrong choice of substrate, the consequences are compaction, imbalances between water and air, suffocation of the root apparatus, increased weight, reduction in drainage, and the alteration of nutrients (Cascone, 2019).

The weight of the substrate is one of the most critical domains of knowledge for establishing a long-term design and construction of green roofs (Grant, 2007). This involves the dead load, which is the final constructed weight of all built elements and all components associated with the green roof assembly; the live load, which is the weight of people and any mobile equipment; and there is also the transient load, which is that of moving, rolling or short-term loads, including wind and seismic activity (Cascone, 2019). According to IBC (ICC, 2018); and FLL (2008), an accessible green roof must have minimal capacity to support 4.79 kN/m², whereas non-occupied roofs shall be designed for live loads of 0.958 kN/m² under saturated conditions. The ASTM International (ASTM E2400, 2019) also provided a weight limitation for green roof systems to be 8.1 kg/0.09 m² for extensive green roof systems. A more applicable range for a regular extensive green roof was, however, submitted in studies by Ahmed and Alibaba (2016), and Chenani et al. (2015), which submitted that a green roof of 100 mm thickness can optimally weigh from 73 kg/m² to 122 kg/m². For the intensive green roof, however; Ahmed and Alibaba (2016) submitted that the roof must be designed to support a weight range of 171–391 kg/m².

Green roof substrates should be characterised by low dry and wet bulk densities, as they represent the main load on the roof-bearing structure, especially in old buildings where the roofs were not built to accommodate green roof systems (Wilkinson, Feitosa, 2015). One of the key approaches for decreasing the weight of the substrate is to utilise low-density inorganic materials; this is because the lower the density of the substrate, the thicker the substrate can be constructed so that a larger variety of vegetation can be planted (Cascone, 2019). The stone-based material being the largest contributor to green roof weight that constitutes more than 60% of the system weight becomes the major point of concern. In view of this, numerous studies have been carried out to achieve minimum density with thicker substrates. An example of this is a study that shows that the bulk density of perlite was stated to be 9.4 times less than that of conventional garden soil (Wilkinson, Feitosa, 2015).

As categorically stated in the structural perspective by Grant, (2007); the biggest challenge for green roof installation is the load-bearing capacity of the primary roof system upon which the growth media rests. However, bigger challenges are faced when dealing with older buildings that are subject to retrofitting and remodelling, as this may require costly structural reinforcement which evidently makes the projects excessively expensive (Wilkinson, Feitosa, 2015). The solution thus remains that if the weight of the green roof is limited to a bearable minimum, the need for structural reinforcement is also consequently reduced.

MATERIAL AND METHODS

The approach adopted for the study involves laboratory procedures and field observation of its experimental segment. Subsequently, some load analysis was conducted in an effort to establish clear-cut information on the structural implications of using the outlined growth media blends in the Nigerian built environment industry. Therefore, the dependent variables for the study, are the composite blends of the primary media constituents that include the stone-based gravels, soil and compost. The independent variables on the other hand are the growth media weight and its impact on the support roof. All the results were successively subjected to a test for compliance with the established codes and guidelines relevant to the study.

Material selection for the growth media

Tab. 1. Selected gravels for the study. (Source: Authors' fieldwork, 2023)

Type	Origin	Qualities	Mix
1. Granite	Igneous	Strong and heavy	3:1:1
2. River gravel	Location dependent	Available and very durable	3:1:1
3. Laterite stones	Igneous	Soft, easy to crush, good WHC	3:1:1
4. Sandstone	Sedimentary rock	Low in strength and weight	3:1:1
5. Debris	Composite	Readily available, cuts down embodied energy use	3:1:1
6. Pumice	Igneous	Light in weight, not readily available	3:1:1

According to studies carried out within the context of the study, the most available natural stones used for gravel in the building industry are laterite stones, sandstone, granite and river gravel (Kolawole et al., 2019; Njoku et al., 2020). Specific to the mandate of the study and also used for similar lightweight requirements, other types of stones considered are pumice, shale and limestone (Tangbo et al., 2021; Momoh et al., 2018). Within the tenet of purposeful sampling using lightweight and availability as the primary criteria, all the stated stones were collected. In tune with the avocation of recycling contained within the environmentally sustainable ethics in the building industry, a blend of recycled debris from a typical building site was also considered. Tab. 1 shows the origin, qualities and mix ratios for the selected growth media blends for the study. As observed in the recommendations from the FLL (2008), the study adopted the use of locally available loamy soil and compost from animal farm deposits available in the study area in a ratio of 3:1:1 respectively.

Laboratory exercise

The apparatus used in the laboratory was a 100 kg weighing machine, calibrated cylindrical plastic jars, and a scoop as shown in Fig. 2. The sampled growing media blends were measured in a metal measuring container of 400 * 150 * 230 (0.138 m³) in size, and 4.2 kg in weight. Therefore, the multiplying factor to obtain a cubic meter was = 72.463 m³. The test was conducted by collecting the stones and crushing them into gravels of appropriate sizes. Dry samples of compost and soil were then collected in their natural forms and mixed with the gravel. The volume of water required to saturate each mixture was measured using the calibrated jars, and the weighing machine was set to the zero point and used to measure the six samples batched in the steel measuring box. Measurements carried out of the sampled blends were both in dry and saturated states (after addition of water). Each sample was measured three times from different portions of the larger sample to obtain an average value before recording. Fig. 3 shows the images of the samples prepared for the laboratory and field observation analysis.

Fig. 2. Laboratory measurement apparatus. (Source: Authors' fieldwork, 2023)

Fig. 3. Sampled growth media (L-R) pumice, river stone, laterite, and granite blends. (Source: Authors' fieldwork, 2023)

Sampling; Geometry and green roof models

Typically, green roofs are installed on new projects or remodelled or retrofitted buildings. This study being exploratory in nature was conducted on a proposed project that has the potential of being installed with a green roof system. The geometry selected for this study is a classroom block designed under the MDG (Millennium Development Goals) program for public primary school education in Nigeria. It is a prototypical design to be constructed in many parts of Northern Nigeria. It is therefore a befitting model for testing the efficacy of using the green roof on public buildings in such a hot dry climate. The roof design of the project is a typical reinforced-concrete flat roof; Weiler and Scholz-Barth (2009), opined that reinforced concrete is the most suitable for use in green roof systems due to the large load-bearing capacity it can withstand. Figs. 4, 5 and 6 show the floor plan, section and roof detail of the sampled geometry respectively. The roof has an area of 357 m², it is hypothetically covered with a green roof planted with sedum plants with alternating thicknesses of the growing media of different samples for relevant evaluation.

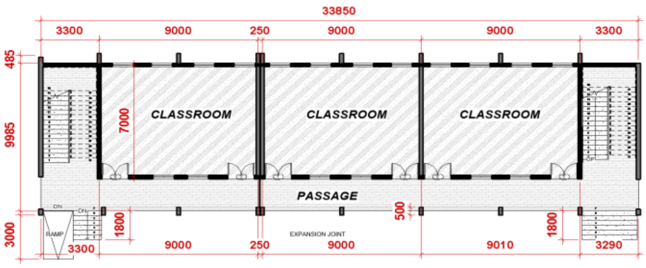

Fig. 4. Floor plan of the sampled building. (Source: MDG Projects, 2023)

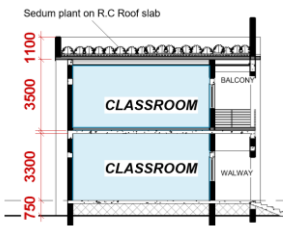

Fig. 5. Section, showing the green roof on the RC Roof. (Source: MDG Projects, 2023)

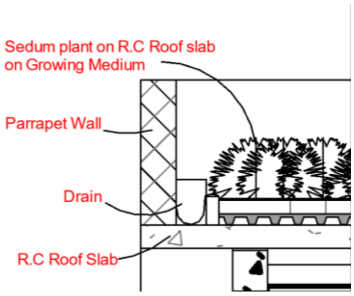

Fig. 6. Detail of the green roof components at the roof drainage. (Source: MDG Projects, 2023)

Loading, structural analysis and compliance

In order to avoid a cumbersome presentation of the load analysis for every extensive green roof model, relevant load calculations were limited to the heaviest and the lightest extensive green roofs. The samples were so selected in order to represent the embodiment of the best- and worst-case scenarios amongst the extensive green roof types. While the best cases present samples with the least problems, Kazman et al. (2002) iterated that the worst case scenarios typically express the most problematic circumstances in carrying out assessments and guarantees adequate and efficient sampling steps required to reach any theoretical saturation.

The study employed a simple structural analysis which involved using basic conservative methods to calculate load effects through simple structural models (Rücker, 2006). From this point of view, wind loading is typically considered to be negligible when acting on grass or low-lying plant life (Weiler, Scholz-Barth, 2009). Also, being an inaccessible green roof, live loads were not considered in the calculations. In contrast, transient loads which are the weight of transient water contained in the geo-composite layers is covered as part of the saturated weight of the samples as stipulated in the IBC load combinations (Gartner, 2008). Using BS8110, the study was focused on determining the compressive strength (fcu), minimum yield strength (fy), depth (d) and the resultant design load of the primary roof structure against the density of the composite nature of the green roof materials. In conclusion, the general green roof design was tested for compliance with the IBC (ICC, 2018).

RESULTS AND DISCUSSION

Results for measured growth media weight

Tab. 2 shows the measured weight of the six samples. The granite-based blend is the heaviest sample with 1,713.30 kg/m³ in its saturated state. River gravel blend and the laterite stones followed closely with 1,264.50 kg/m³ and 1052.20 kg/m³ respectively in their saturated state. The lightest in weight is the pumice blend with 869.30 kg/m³ which is a difference of 942.90 kg/m³ from the heaviest granite blend, implying that it is 50.7% lighter in weight, followed by the masonry debris blend with 1,115.90 kg/m³. Fig. 7 shows an illustration of the weight difference between sampled growth media.

Tab. 2. Measured weight of sampled growth media (m³). (Source: Authors' fieldwork, 2023)

Blend Base	Dry (kg/m³)	Saturated (kg/m³)
Granite based	1,368.80	1,713.30
River gravel blend	1,264.50	1,603.60
Laterite stones	1052.20	1,404.43
Sandstone based	873.10	1,180.10
Debris	755.70	1,115.90
Pumice based	452.90	869.30

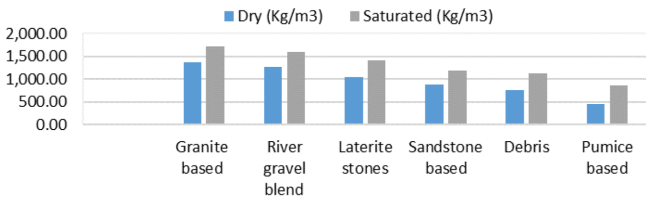

Fig. 7. An illustration of the weight difference between sampled growth media. (Source: Authors' fieldwork, 2023)

Estimated weight for typical growth media blends

Having physically measured the weight of each blend in kg/m³ a successive conversion was conducted to estimate the weight of the commonest extensive types of green roof growth media in kg/m². Tab. 3 shows the estimated weight of the 50 mm, 100 mm, 150 mm, 200 mm, 250 mm, and 300 mm growth media. Results from the conversion showed that in all cases the granite blend medium recorded the heaviest values at 85.65 kg/m² for the 50 mm and 513.90 kg/m² for the 300 mm model, followed by the river stone and laterite blends with slighter respective values. The lightest in weight is the pumice with 43.50 kg/m² for the 50 mm and 261.00 kg/m² for the 300 mm; the debris also recorded an encouraging figure at 55.80 kg/m² for the 50 mm and 334.80 kg/m² for the 300 mm model. Fig. 8 shows an illustrated difference in weight across all the growth media samples.

The results show that most of the substrate blends within the range of 50–100 kg/m² fall within the limit of an appropriate weight for the extensive green roof; which according to Ahmed and Alibaba (2016), and Chenani et al. (2015) should be between 73 kg/m² to 122 kg/m². To a reasonable extent, it also satisfies the stipulations of both the FLL (2008), and the ASTM International (ASTM E2400, 2019).

Tab. 3. Estimated weight of growth media for the green roof models. (Source: Authors' fieldwork, 2023)

	Weight of Saturated Blend (kg/m²)					
Blend (mm)	**50**	**100**	**150**	**200**	**250**	**300**
Granite	85.65	171.30	256.95	342.60	428.25	513.90
River gravel	80.15	160.30	240.45	320.60	400.75	480.90
Laterite	70.23	140.45	210.68	280.90	351.13	421.35
Sand-stone	59.00	118.00	177.02	236.02	295.03	354.03
Debris	55.80	111.60	167.40	223.20	279.00	334.80
Pumice	43.50	87.00	130.50	174.00	217.50	261.00

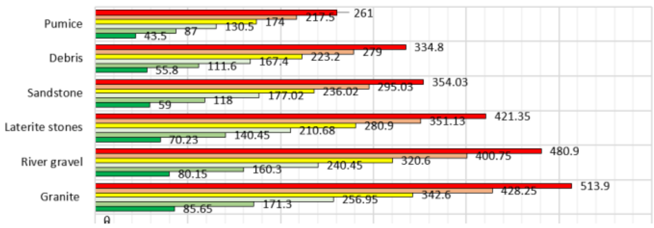

Fig. 8. An illustrated difference in weight across all the growth media samples. (Source: Authors' fieldwork, 2023)

Results from structural analysis of extensive green roof types

A structural analysis was conducted on the sampled building structure covered with a reinforced concrete roof system typical of the study area. Calculations were thus carried out on the heaviest sample from the heaviest category which is the granite blend with a saturated weight of 1,713.30 kg/m³, and the lightest sample from the lightest category which is the pumice substrate with 869.30 kg/m³. The results are shown in Tab. 4.

Tab. 4. Design parameters for a Green roof using composite materials. (Source: Authors' fieldwork, 2023)

Specimens	**f_{cu}**	**f_y**	**Density**	**Depth (d)**	**Design Load**
Pumice substrate	30 N/mm^2	460 N/mm^2	869.30 kg/m^3	130mm	57.65 kN/m
Granite substrate	30 N/mm^2	460 N/mm^2	1713.30 kg/m^3	130mm	95.10 kN/m

According to IBC, (2018); under landscaped roofs (1607.11.2.3) stipulated that where roofs are to be landscaped, the uniform design load in the landscaped area shall be 0.958 kN/m². The weight of the landscaping materials shall be considered as dead load and shall be computed on the basis of the degree of soil saturation. This implies that the saturated granite substrate having a 0.951 kN/m² design load falls within the stipulated range of the IBC, and can therefore be used in any extensive green roof project. On the other hand, the pumice blend, being the lightest substrate examined also satisfies the IBC stipulations. With a design load of 0.576 kN/m² the pumice blend will stand to offer an optimum alternative in green roof retrofitting projects for existing flat-roofed buildings.

CONCLUSION AND RECOMMENDATION

In summary, the study was able to systematically select and evaluate the physical properties of potential green roof growth media compositions that offer the positive potential to be used in the Nigerian built environment. The study was also able to assess the loading implication of all the outlined potential green roof models hypothetically tested on a reinforced concrete flat roof that happens to be one of the predominant forms of roof systems in the study area. Six substrate blends based on laterite stones, sandstone, granite, river gravel, pumice and recycled masonry debris were studied using relevant laboratory and empirical field evaluation methods. The blends were mixed in a 3:1:1 ratio of natural stone-based gravels, soil and compost.

Results revealed that the granite-based blend is the heaviest sample with 1,713.30 kg/m³ in its saturated state, it was followed by the river-gravel blend and the laterite-stones substrate respectively. The lightest in weight is the pumice blend with 869.30 kg/m³ which is 50.7% less than the granite blend. Next in lightweight are the sandstone and the masonry debris blends, which can be used as more favoured choices in green roof design over their heavier counterparts. The heaviest and the lightest outlined models were subsequently subjected to a weight analysis on the proposed reinforced concrete flat-roofed structure. The results showed that all the extensive green roof samples fall within the IBC stipulated range. The heaviest granite substrate obtained a design load of 0.951 kN/m², while the lightest pumice blend recorded a design load of 0.576 kN/m². This implies that the pumice blend could be used as a potential lightweight substrate for green roof retrofitting projects for existing buildings in the Nigerian building industry.

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Enhancing visual comfort in staircases: A comprehensive analysis and design recommendations

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Abstract: People should be walking towards the inside of the dwelling through an appropriate visual environment in transitional space; this environment is the staircase in the collective housing. The proper understanding of visual adaptation parameters in the staircase helps architects provide a suitable environment for inhabitants. This paper aims to specify design elements of the staircase in collective housing, to achieve a visual comfort in this transitional space. The work involved two approaches: field measurements and a visual comfort survey using a questionnaire; 144 questionnaires are collected, in four residential buildings with different staircases treatment in the city of Arris, Algeria, to examine the illuminance levels in different staircase positions along the path from outside the building to inside, in summer and winter where illuminance ratios were calculated and compared with CIBSE Code. The discomfort sensations ranged from "subtle" to "dramatic". The results show that a staircase with the percentage of opening of 88% indicated "strong" and "dramatic" visual shock in many points and as this staircase is open, it is exposed to light conditions and so it does not ensure the necessary transition. This leads to advising against the open staircase. In the case of a staircase treated with transoms of clear glass with the percentage of opening of 11%, these transoms direct the light to specific areas creating "strong" visual shock in many points of the stair landings and hence it leads to advise against that. The staircases treated with vertical bays throughout the façade presenting a percentage of opening between 19% and 22%, these treatments allow the penetration of daylight in a diffused way which ensures a balanced distribution of daylight inside the staircases. The existence of a solid overhang at the entrance; the façade treated with vertical bays, where the percentage of opening of the façade is about 19% and 22%, provided adequate transition leading to reasonable visual comfort.

Keywords: visual comfort, transitional space, adaptation, staircase, design, illuminance, changes, occupants, performance

INTRODUCTION

Sustainable building design is a dynamic field that continuously evolves to incorporate new approaches that minimize a building's environmental impact. A crucial aspect of this approach is creating a healthy and comfortable indoor environment. This, in turn, significantly influences the well-being, comfort, and productivity of the building's occupants. Sustainable structures make the most of natural light and use the right ventilation and moisture control techniques. Additionally, it is crucial to maximize the building's acoustic performance and provide residents control over the lighting and climate systems. Natural light affects not only our biological mechanisms but also our ability to see (Gronfier et al., 2004). It has practical, aesthetic, and emotional effects on the design of the built environment (Belakehal, et al. 2009). It is crucial to consider how the user will feel in the light conditions. By including issues for aesthetics, amenity, comfort, energy efficiency, and cost efficiency, a more suitable approach must balance the needs of owners, tenants, and society (Gregg, Saddler, 1995). Transitional spaces are defined as spaces located in-between outdoor and indoor environments (Pitts, Bin Saleh, 2007), so they are neither interior nor exterior spaces. People should approach the interior of a house through a suitable visual environment in a transitional space; in a collective housing, this last visual environment is the staircase.

When designing a building's interior or transitional space, light is a crucial component. Designing well-lit spaces with daylight presents complexities in achieving optimal lighting conditions. It is not a new concept to use natural light to illuminate indoor spaces. In the 1990s, the well-being of building residents received increasing attention. This interest is driven in part by long-term and broader issues covered by the "green buildings and sustainable design movements" (Gregg, Saddler, 1995). In these spaces, the occupants are able to experience the dynamic effects of the external climatic changes (Taleghani, et al., 2014). The ability of users to adapt to changing dynamic conditions of the environment around them is very important. Luminous conditions can change drastically as users transit from indoor to outdoor spaces or vice versa. The human eye has physical, neural and photochemical mechanisms for adapting to changing light conditions (Rea, 2000). While the human eye can adjust to a wide range of light levels (luminance), rapid changes in brightness, luminance, and contrast can cause temporary discomfort for many; especially for the elderly, for whom such visual shock may be detrimental, painful (Steffy, 2002). Bright light changes cause vision problems. Glare, from excessive or uneven light, disrupts how we see. Scotomatic, a type of glare, reduces our ability to see briefly after bright light exposure. This happens because light receptors in our eyes take time to recover after being overwhelmed. (Wooten, Hammond, 2002)

A study by Araji et al. (2007) identified changes in lighting conditions in architectural transition spaces as one of the main factors in altering human eye adaptation and identified this problem as a possible cause of "visual shock" (Araji et al., 2007). Therefore, in these transitional spaces, subjects might not have enough time to reach a stable state of visual adaptation to ensure the best response needed to perform a task. At the same time, the subjects could suffer some kind of visual discomfort (Owsley, et al., 1983). Most studies were related to thermal comfort in transitional spaces (Li, et al., 2018; Tse, Jones, 2019; Du, et al., 2020; Lu, Li, 2020). A few discussed the problem of visual comfort in transitional spaces, and examined eye adaptation and how users perform in these spaces.

The study effected by Araji et al. (2007), explores the issue of light adaptation and visual discomfort due to drastic variations in light intensity near building entryways. Also López et al. (2012) deals with features of light closer to user perception. To evaluate the visual reaction in a transitional space, four parameters were used. Lasagno et al. (2014) aim to perform a field experiment to quantify the effect of an abrupt change of the illuminance at a transitional space on the task performance under transient adaptation. The limited availability of recent research on the transitional space stems from two factors: a scarcity of studies conducted in this environment and the inadequacy of existing standards for such spaces. This lack of prior research, however, fuelled our interest in investigating the visual conditions within the transitional space, and highlights this neglected space.

Transitional spaces can provide different functions, including seating areas, circulation passage as staircase, entrance lobby, cafeteria, and meeting places (Ilham, 2016). Lighting is an important aspect regarding stair safety design (Van de Perre, et al., 2019). Poor lighting has been associated with an increased risk of falls on stairs (Jacobs, 2016). Staircases shall be provided with adequate natural lighting. Many elements, such as the kind of glass used, the quantity, size and placement of windows, and the layout of the staircase, affect how well natural lighting illuminates staircases (Marco, 2003). This paper studies the effect of staircase design on the visual comfort of users and how they perform and adapt in this transitional space.

MATERIALS AND METHODS

This research employs a two-pronged approach: field measurements and a visual comfort survey conducted using a questionnaire. A questionnaire was employed to assess participant responses to luminous environment within staircases in four buildings in Arris, Batna city, Algeria. The survey investigates the subjective appreciation of daylight conditions in typical staircases with varying design and different percentage area of windows opening. The research design is represented in Fig. 1.

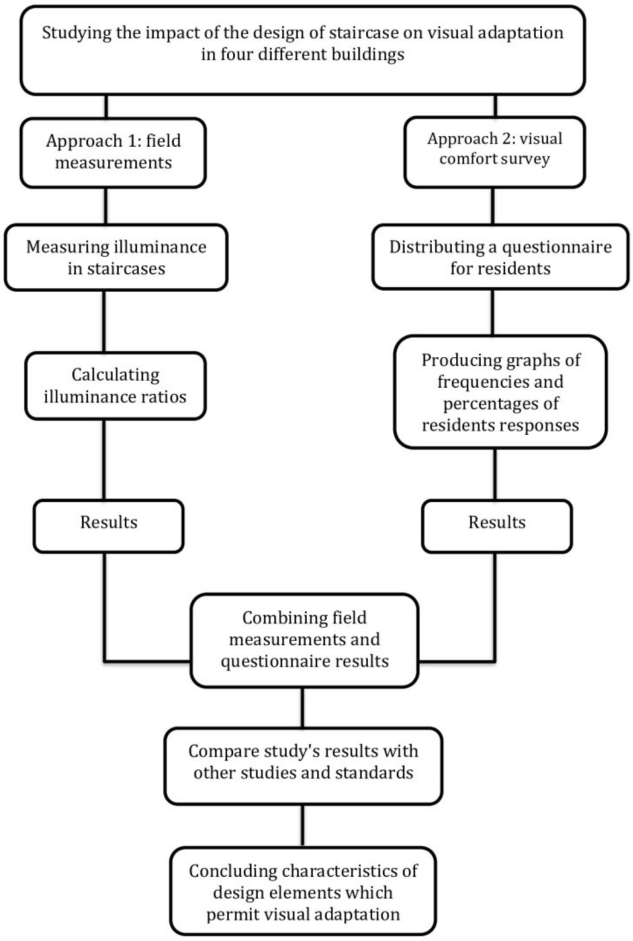


Fig. 1. Research design. (Source: Authors, 2024)

Case study description

Arris is a Daira in the Wilaya of Batna in eastern Algeria. It is located in the South East of the Wilaya, about sixty km (Fig. 2). The coordinates of the city are: 35° 15′ 30″ north, 6° 20′ 40″ east. The region is generally presented as a region of moderate relief and slopes steep. This mountainous region has altitudes between 1100 and 2000 m. The summers are mostly clear; winters are partly cloudy. The climate of Arris is a semi-arid.

The study focuses on four buildings located in three districts: Building 1 in the district of 32 housing units, Building 2 in the district of Zarouali Ahmed Belahcen, Buildings 3 and 4 in the district of 1st November. The details of the selected buildings are listed in Tab. 1. To ensure a controlled investigation of the effect of the transitional space design and daylighting's influence on visual adaptation in different designs, the study employed similar building characteristics throughout. The four buildings selected for this study have a different staircase design with a different percentage of openness. This selection aligns with the study's objective: to investigate the influence of staircase design on visual adaptation. Additionally, the buildings share similar characteristics such as orientation and colour, minimizing the effects of these variables and allowing for a more focused analysis of design impact.

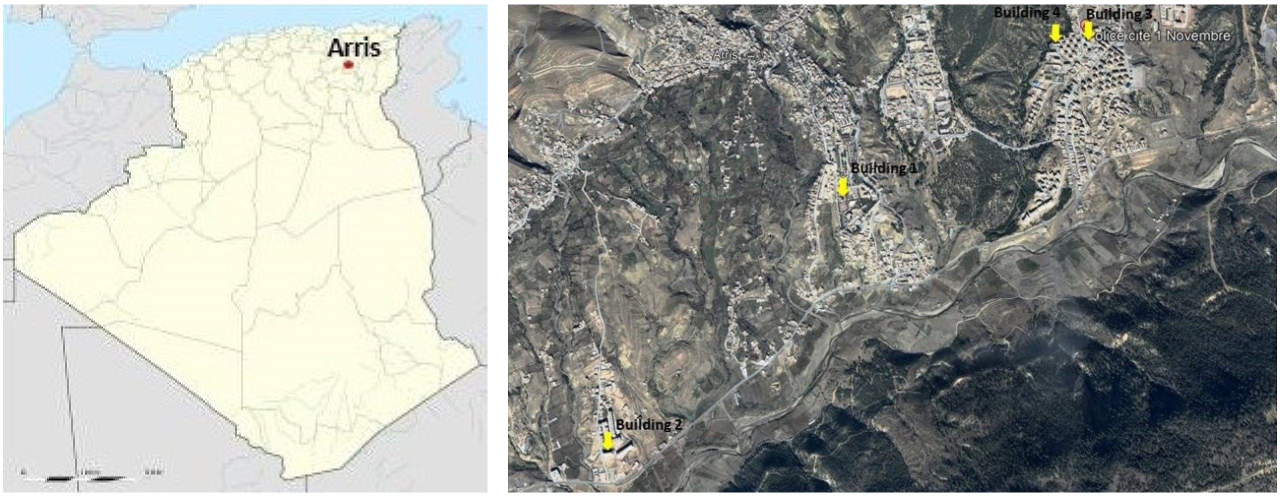
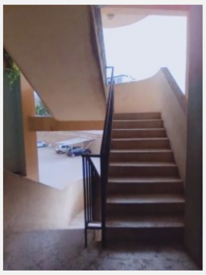
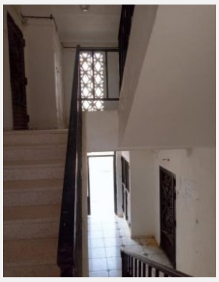
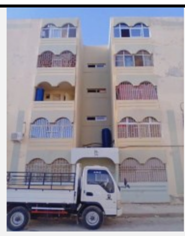
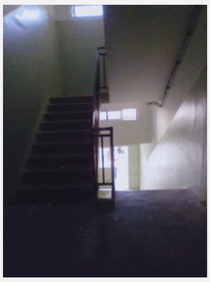
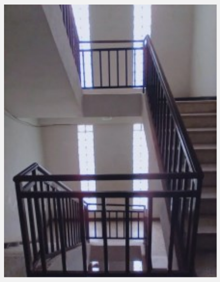
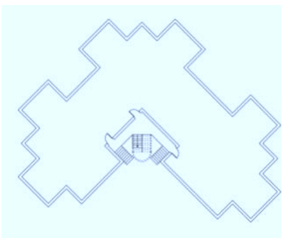
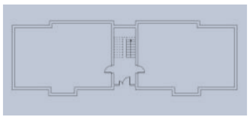
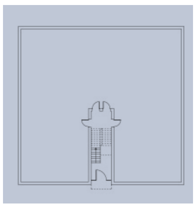
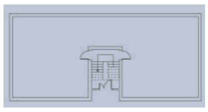


Fig. 2. (a) Geographical location of Arris city (Google), (b) Location of the Buildings in the Arris city. (Source: Google Earth, 2023)

Tab. 1. Case study description. (Source: Authors, 2023)

Information	Building 1	Building 2	Building 3	Building 4
Staircase	 	 	 	 
Plan				
Staircase dimensions	5.60 m * 5.60 m	2.60 m * 6.75 m	2.35 m * 8.0 m	2.70 m * 4.0 m
Percentage of the area which enters the light in the staircase	88%	19%	11%	22%
Staircase treatment	Opened	Vertical bays (10 * 60 cm/120 cm)	Transom of clear glass (4 * 40 cm/140 cm)	Vertical bays (8 * 40 cm/220 cm)
Floors number	4	6	5	5
Orientation	Northeast	North		
Climate	Semi-arid			

Sky conditions	Overcast	
Soil colour	Shades of grey	
Façade colour	Between light brown and off-white	
Colour inside staircase	Between light brown and off-white	
Entrance door dimensions	300 * 250 cm	90 * 210 cm
Distance between each two points of measurements	250 cm	
Measurements day	20, 21, 22 January	
Measurements time	8 a.m., 12 a.m., 2 p.m., 4 p.m.	

Field measurement

Field measurements were conducted in winter 2021 (20th, 21st and 22nd January) and in summer 2021 (20th, 21st and 22nd July), in four staircases of collective housing buildings in the Arris city. Measurements were taken during daytime hours at 8 a.m., 12 a.m., 2 p.m., 4 p.m. as these are the hours when residents go and return from school and work. The quality of day lighting was evaluated by measuring horizontal illuminance levels at the height of 1.5 m from the ground. The measurements were taken at that level to simulate the average human height. Horizontal illuminance is a standard metric for assessing daylight quality in buildings, including on horizontal surfaces like stairs, which are crucial for safe navigation. 172 measurements were taken from the exterior of the buildings to the interior of the houses passing through each landing in the staircase (Fig. 3 left). A distance of 2.5 m is maintained between each measuring point. Illuminances were measured by Delta OHM LP 471 PHOTO (Fig. 3 right) (Photometric probe for measuring the illuminance, spectral response according to the photopic curve, class B according to CIE N° 69, cosine correction diffuser. Measuring range: 0.10 lx…200·10^3 lx).

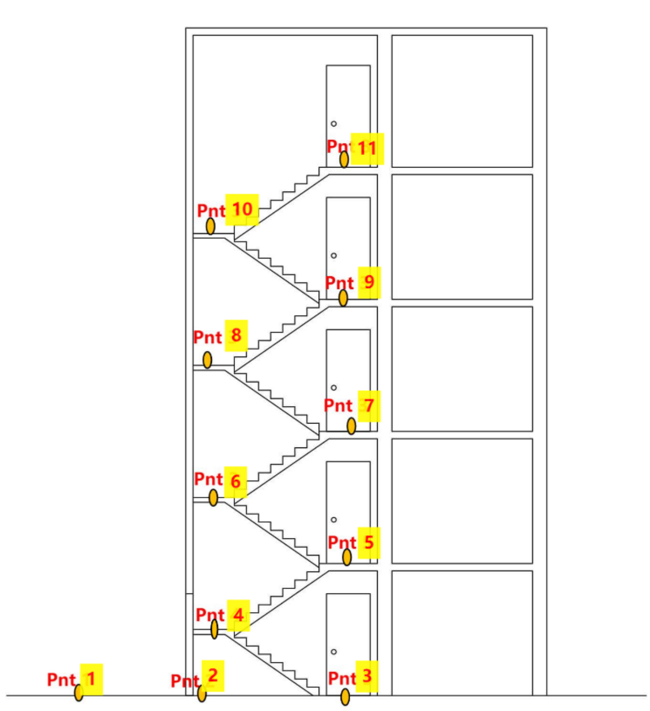


Fig. 3. Top: Measurements points. (Source: Authors, 2023). **Below:** Measurement with Delta OHM LP 471 PHOT. (Source: left – TESTOON, 2022; right – INDOMULTIMETER, 2024)

The illuminance at a point *P* on a particular surface is a physical quantity measured in lx and defined as the ratio of the luminous flux incident on a small surface near *P* to the area of that surface (*Arec*).

$E_p = df / dArec$ (Lx) …………………………… (Eq. 1)

To evaluate the amount of light with a one-sided criterion, illuminance is used to construct a local and short-term metric. Visual comfort is not only related to the amount of light, but also to how it is distributed. The illuminance uniformity (U_0) of a given plane is defined as the ratio, at a given time, between the minimum value of illuminance on the plane (E_{min}) and the average illuminance on that plane ($E_{average}$). It is also possible to use the ratio between the minimum and maximum (E_{max}) values of illuminance on the given plane, but this must be specified (Carlucci, et al. 2015). Illuminance and its distribution across the task area and its surroundings have a major impact on how quickly, safely and comfortably a person perceives and performs a visual task. Excessive variations of horizontal illuminance across an interior must be avoided; the diversity of illuminance expressed as the ratio of the maximum illuminance to the minimum illuminance. In many lighting applications, performing tasks does not require high-precision visual focus. This releases lighting designers from the strict adherence to uniform illuminance levels, allowing them to introduce more variation (CIBSE, 2002).

The established standards, such as Leadership in Energy and Environmental Design (LEED), are primarily focused on optimizing interior spaces. These frameworks may not be directly applicable to transitional spaces, as the activity, behaviour, and needs within these spaces differ significantly from those within traditional interiors; our study highlights a potential discomfort factor due to significant lighting level changes between the house interior and exterior space (as shown in Tabs. 3, 5 and 9 in the result section). Since staircases connect these areas, we examined the visual conditions there. Given the substantial illuminance difference (e.g. 8705 lx and 21.5 lx) and the limited time it takes to traverse a staircase (less than 1 min) compared to human eye adaptation time (up to 30 min in the case of dark adaptation (Rea, 2000)), we are concerned about the ability of occupants to comfortably navigate this transitional space.

Questionnaire survey

To determine how the residents felt and performed inside the staircases, a visual comfort questionnaire was designed. The questionnaire consisted of three sections: physiological symptoms, visual task performance and user preferences. The questionnaire responses were processed using Microsoft Excel, which produced graphs and charts to illustrate the survey results. *Part 1* of the survey asks about the physiological indications that may occur to the residents. The intention for this section was to determine how many people experienced at least one physiological symptom. *Part 2* of the survey asks about how users perform and what kind of disturbances they may feel inside the staircases. *Part 3* of the survey asks about how the user feels about the light in the staircases. The results will show how the users actually perceived the space.

Part 1: Physiological symptoms

Please, choose an answer according to how you feel

When leaving the building:

I feel that it is dark

My vision becomes blurred

Yes / No

When entering the building:

I feel pain in my eyes

My eyes tear up

I have a headache

I blink

My vision becomes blurred

I feel that it is too bright

Yes / No

Part 2: Visual task performance

1. It is difficult to see the first stairs

2. It is difficult to see the handrails

3. It is difficult to find something that I dropped

4. It is difficult to identify people

Very difficult / difficult / neutral / easy / very easy

5. I bump into someone because I did not see them

Yes / no

Part 3: Preferences

1. How do you find the light in the staircase?

Very low / low / neutral / strong / very strong

2. Do you find that the distribution of light is similar along the course of the staircase? Yes / no

3. Which place causes you visual discomfort?

The entrance to the building

The entrance to the house

Moving from one level to another

There is not such a place

RESULTS

Field measurements

According to CIBSE (2002), "Objective Display Illuminance Ratios", can be described on a scale ranging from subtle to dramatic as indicated in Tab. 2.

Tab. 2. Visual comfort sensation according to the CIBSE. (Source: CIBSE, 2002; modified by Authors, 2023)

Display effect	Objective display illuminance ratio	
Subtle	5 : 1	
Moderate	15 : 1	
Strong	30 : 1	
Dramatic	50 : 1	

The current method compares measured data to the CIBSE recommendations. Illuminance ratios were computed and then matched on a four-point scale of "Objective Display Illuminance Ratios" ranging from "subtle" to "dramatic", expressing the variations in illuminance ratios between various points of measurements. It is very important to note that although the CIBSE guidelines were not initially intended to be used for assessing visual comfort in transitional spaces, they measure visual comfort based on objective display illuminance ratios and thus the authors feel that there is no reason not to use them in transitional spaces.

Our field study revealed significant illuminance variations within the staircase. To assess the impact on visual adaptation, we chose the CIBSE Code: Objective Display Illuminance Ratios (2002). CIBSE's illuminance ratio method helps identify zones within the staircase where occupants are more likely to experience discomfort due to significant changes in illuminance levels. It aligns with visual adaptation principles and offers a flexible approach applicable in various contexts, unlike fixed illuminance values in some standards, which can be challenging to maintain with daylight variations in lx.

The sensitivity lag of the cone system adapts in about 5–7 minutes (Miller, Tredici, 1992) or 10–12 minutes (Rea, M.S., 2000) with high levels of luminance. The rod system will take 30–45 minutes or longer to adapt to fully dark situations to attain maximum sensitivity after exposure to bright light (adaptation is about 80% complete within 30 minutes) (Rea, 2000). The equation provides the amount of time (T) required for a walking person to travel within the given transitional space.

$$T = D/V \quad \text{(.Eq2)}$$

Where:

T: is the time (sec)

D: is the distance between two consecutive station points (m),

V: is the average walking speed (m/sec)

On average, a speed of 0.77 m/sec for normal walking speed in stairs for all age groups was used. Therefore, the time required to travel from point to point equals 3.2 sec (3.2 sec = 2.5m / 0.77m/sec).

Building 1:

Tab. 3 indicates big differences in illuminance levels in winter period at 8 a.m. between points three and four (10 lx, 284 lx), five and six (17.2 lx, 420 lx), and between points seven, eight, nine and ten (36.8 lx, 828 lx, 30.7 lx, 1.07 lx), leading to illuminance ratios of 28.4:1, 24.4:1, 22.5:1, 26.9:1, 28.7:1 respectively (Tab. 4). As this staircase is open, it is exposed to light conditions, so it does not ensure the necessary transition. According to the CIBSE, illuminance ratio of more than 15:1 is considered strong and has the potential to provoke a visual shock to residents when they walk through the staircase and when they enter to the house. At the entrance of Building 1, the stair landings protrusion served as an overhang and permitted "subtle" and "moderate" visual shock in summer, providing adequate transition leading to reasonable visual comfort. The staircase presenting the percentage of opening of 88%, indicated "strong" visual shock in most points of the staircase at 8 a.m., and "moderate" visual shock at 12 a.m., 2 p.m. and 4 p.m., while in winter, a strong visual shock was indicated at several points.

Tab. 3. Illuminance value (lx) in Building 1. (Source: Authors, 2023)

Position	Illuminance value (Lux) Building 1							
Time	8 a.m.		12 a.m.		2 p.m.		4 p.m.	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Outdoor (Pnt 1)	291	19720	8947	18940	11037	13340	6368	7440
Door (Pnt 2)	62	4141	2363	4924	1446	1734	1369	1562
Entrance Hall (Pnt 3)	10	763	568	366	411	341	332	303
Stair landing 01 (Pnt 4)	284	13990	6478	5040	5300	4680	2857	4130
Stair landing 02 (Pnt 5)	17.2	677	570	454	396	449	328	345
Stair landing 03 (Pnt 6)	420	10900	8560	5270	6098	4660	2610	3740
Stair landing 04 (Pnt 7)	36.8	960	986	535	552	495	278	433
Stair landing 05 (Pnt 8)	828	18720	11320	6990	7780	6610	4260	6030
Stair landing 06 (Pnt 9)	30.7	904	487	798	450	766	341	719
House (Pnt 10)	1.07	46	15.27	62	17	70	11.3	78

Tab. 4. Illuminance ratio Building 1 (in summer and winter period). (Source: Authors, 2023)

Transition position	Illuminance ratios Building 1								
Winter period	Pnt 1-2	Pnt 2-3	Pnt 3-4	Pnt 4-5	Pnt 5-6	Pnt 6-7	Pnt 7-8	Pnt 8-9	Pnt 9-10
8 a.m.	4.7:1	6.2:1	28.4 :1	10.7:1	24.4 :1	11.4 :1	22.5 :1	26.9 :1	28.7 :1
12 a.m.	3.8 :1	4.2:1	11.4 :1	11.4:1	15 :1	8.7 :1	11.5 :1	23.2 :1	31.9 :1
2 p.m.	7.6 :1	3.5 :1	12.9 :1	13.4 :1	15.4 :1	11 :1	14.1 :1	17.3 :1	26.5 :1
4 p.m.	4.7 :1	4.1 :1	8.6 :1	8.7 :1	7.9 :1	9.4 :1	15.3 :1	12.5 :1	30.1 :1
Summer period									
8 a.m.	4.7 :1	5.4 :1	18.3 :1	20.6 :1	16.1 :1	11.3 :1	19.5 :1	20.7 :1	19.6 :1

12 a.m.	3.8 :1	13.4 :1	13.7 :1	11.1 :1	11.6 :1	9.8 :1	13:1	8.7 :1	12.8 :1
2 p.m.	7.6 :1	5:1	13.7 :1	10.4 :1	10.3 :1	9.4 :1	13.3 :1	8.6 :1	10.9 :1
4 p.m.	4.7 :1	5.1 :1	13.6 :1	11.9 :1	10.8 :1	8.6 :1	13.9 :1	8.3 :1	9.2 :1

Building 2 and 4:

Tab. 4 and 5 show big differences in illuminance levels between points two and three (at the entrance of the buildings), with value of 990 lx, 57 lx and 380 lx, 21 lx respectively, leading to illuminance ratios of 17.4:1 and 18.1:1 and between points thirteen and fourteen 48.8 lx, 1.2 lx with ratio of 40.3:1. (Tab. 7, 8) which according to the CIBSE code (Tab. 2) are considered strong and dramatic and as such cause a visual shock, at the entrance of these buildings and when entering to the houses. As found in the study of Araji (2007), the absence of transition element in the entrance of the building can cause a visual shock. Tab. 5 between points from three to thirteen and from point three to eleven (in stair landings), show little difference in illuminance levels. The values reach 57 lx, 66 lx, 17.9 lx, 58 lx, 26.6 lx, 76.6 lx, 35 lx, 98.9 lx, 45.7 lx, 190 lx, 48.8 lx and 21.5 lx, 26.8 lx, 108 lx, 33.1 lx, 94.1 lx, 35 lx, 115 lx, 28.9 lx respectively, leading to illuminance ratios of 1.2:1, 3.7:1, 3.2:1, 2.2:1, 2.9:1, 2.2:1, 2.8:1, 2.2:1, 4.2:1, 3.9:1 (Table VI) and 1.02:1, 1.2:1, 4.02:1, 3.3:1, 2.8:1, 2.7:1, 3.3:1, 3.9:1. (Tab. 7), which according to the CIBSE code (Tab. 2) are considered subtle. Clearly, these values indicate a better transition as opposed to the previous results. The treatment of the staircases represented in vertical bays throughout the façade allows the penetration of daylight in a diffused way which ensures a balanced distribution of daylight inside the staircases. This design leads to better visual comfort transition between indoors and outdoors. However, there is a rating of "moderate" discomfort as the user transits between point three and point four. The overall results are acceptable and encounter no strong or dramatic visual shock in the transitional space.

Tab. 5. Illuminance value (lx) in Building 2 and Building 4. (Source: Authors, 2023)

Position	Illuminance value (Lux) Building 2							
Time	8 a.m.		12 a.m.		2 p.m.		4 p.m.	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Outdoor (Pnt 1)	1900	7970	13905	12150	11907	13080	5108	14490
Door (Pnt 2)	990	4144	6608	5710	4850	5232	2378	6665
Entrance Hall (Pnt 3)	57	170	291	833	333	704	210	510
Stair landing 01 (Pnt 4)	66	343	274	1001	565	733	292	332
Stair landing 02 (Pnt 5)	17,9	133	115	303	272	399	86	392
Stair landing 03 (Pnt 6)	58	344	583	966	714	774	325	486
Stair landing 04 (Pnt 7)	26,6	163	301,5	354	306	466	103	634
Stair landing 05 (Pnt 8)	76,7	368	1052	849	752	706	233	592
Stair landing 06 (Pnt 9)	35	153	481	354	300	466	109	633
Stair landing 07 (Pnt 10)	98,9	350	1738	871	746	755	261	580
Stair landing 08 (Pnt 11)	45,7	88	587	225	284	223	81	230
Stair landing 09 (Pnt 12)	190	340	1722	1112	1178	841	304	463
Stair landing 10 (Pnt 13)	48.4	134	1527	326	901	444	321	620
House (Pnt 14)	1.2	46	13.2	62	11	69	9.4	73

Position	Illuminance value (Lux) Building 4							
Time	8 a.m.		12 a.m.		2 p.m.		4 p.m.	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Outdoor (Pnt 1)	3300	5580	8705	10220	7362	8680	8169	6360
Door (Pnt 2)	380	613	3240	3781	1928	2256	1777	1335
Entrance Hall (Pnt 3)	21	23	698	211	207	142	57	38
Stair landing 01 (Pnt 4)	21.5	20	470	249	224	198	68	122
Stair landing 02 (Pnt 5)	26.8	22	808	149	191	103	58	35
Stair landing 03 (Pnt 6)	108	96	1592	1057	1178	746	251	279
Stair landing 04 (Pnt 7)	33.1	26	842	134	182	96	62	40

Stair landing 05 (Pnt 8)	94.1	88	1552	1057	832	685	206	128
Stair landing 06 (Pnt 9)	35	27	715	139	148	98	24.3	37
Stair landing 07 (Pnt 10)	115	144	1590	1202	760	796	75	168
Stair landing 08 (Pnt 11)	28.9	390	282	1404	176	1076	20.2	585
House (Pnt 12)	2.19	11	21.5	15	5.9	12	1.4	7

Tab. 6. Illuminance ratio Building 2 (in summer and winter period). (Source: Authors, 2023)

Transition position	Illuminance ratios Building 2												
Winter period	Pnt 1-2	Pnt 2-3	Pnt 3-4	Pnt 4-5	Pnt 5-6	Pnt 6-7	Pnt 7-8	Pnt 8-9	Pnt 9-10	Pnt 10-11	Pnt 11-12	Pnt 12-13	Pnt 13-14
8 a.m.	1.9:1	17.4:1	1.2:1	3.7:1	3.2:1	2.2:1	2.9:1	2.2:1	2.8:1	2.2:1	4.2:1	3.9:1	40.3:1
12 a.m.	2.1:1	22.7:1	1.1:1	2.4:1	5.1:1	1.9:1	3.5:1	2.2:1	3.6:1	2.9:1	2.9:1	1.1:1	115.7:1
2 p.m.	2.5:1	14.6:1	1.7:1	2.1:1	2.6:1	2.3:1	2.5:1	2.5:1	2.5:1	2.6:1	4.1:1	1.3:1	81.9:1
4 p.m.	2.1:1	11.3:1	1.4:1	3.4:1	3.8:1	3.2:1	2.3:1	2.1:1	2.4:1	3.2:1	3.7:1	1.1:1	34.1:1
Summer period													
8 a.m.	1.9:1	24.3:1	2:1	2.5:1	2.5:1	2.1:1	2.2:1	2.4:1	2.2:1	3.9:1	3.8:1	2.5:1	2.9:1
12 a.m.	2.1:1	6.8:1	1.2:1	3.3:1	3.1:1	2.7:1	2.3:1	2.3:1	2.4:1	3.8:1	4.9:1	3.4:1	5.2:1
2 p.m.	2.5:1	7.4:1	1:1	1.8:1	1.9:1	1.6:1	1.5:1	1.5:1	1.6:1	3.3:1	3.7:1	1.8:1	6.4:1
4 p.m.	2.1:1	13.0:1	1.5:1	1.1:1	1.2:1	1.3:1	1.0:1	1.0:1	1.0:1	2.5:1	2.0:1	1.3:1	8.4:1

Tab. 7. Illuminance ratio Building 4 (in summer and winter period). (Source: Authors, 2023)

Transition position	Illuminance ratios Building 4										
Winter period	Pnt 1-2	Pnt 2-3	Pnt 3-4	Pnt 4-5	Pnt 5-6	Pnt 6-7	Pnt 7-8	Pnt 8-9	Pnt 9-10	Pnt 10-11	Pnt 11-12
8 a.m.	8.7:1	18.1:1	1.02:1	1.2:1	4.02:1	3.3:1	2.8:1	2.7:1	3.3:1	3.9:1	13.2:1
12 a.m.	2.7:1	4.6:1	1.5:1	1.7:1	1.9:1	1.9:1	1.8:1	2.2:1	2.2:1	5.6 :1	13.1:1
2 p.m.	3.8:1	9.3:1	1.1:1	1.2:1	6.2:1	6.5:1	4.6:1	5.6:1	5.1:1	4.3:1	29.8:1
4 p.m.	4.5:1	31.2:1	1.2:1	1.2:1	4.3:1	4:1	3.3:1	8.5:1	3.1:1	3.7:1	14.1:1
Summer period											
8 a.m.	9.1:1	26.6:1	1.1:1	1.1:1	4.3:1	3.6:1	3.3:1	3.2:1	5.3:1	2.7:1	35.4:1
12 a.m.	2.7:1	17.9:1	1.1:1	1.6:1	7.0:1	7.8:1	7.8:1	7.6:1	8.6:1	1.1:1	93.6:1
2 p.m.	3.8:1	15.8:1	1.3:1	1.9:1	7.2:1	7.7:1	7.1:1	6.9:1	8.1:1	1.3:1	89.6:1
4 p.m.	4.7:1	35.1:1	3.2:1	3.4:1	7.9:1	6.9:1	3.2:1	3.4:1	4.5:1	3.4:1	83.5:1

Building 3:

Tab. 7 indicates little difference in illuminance levels between points one, two and three: 1115 lx, 186 lx, 42 lx and 4680 lx, 1440 lx, 313 lx and 4519 lx, 860 lx, 276 lx and 5004 lx, 1115 lx, 186 lx, respectively, leading to illuminance ratios of 5.9:1, 4.4:1 and 3.3:1, 4.6:1 and 5.3:1, 3.1:1 and 4.5:1, 5.9:1. However, there is a rating of "moderate" discomfort, when the overall results are acceptable and encounter no strong or dramatic visual shock in the transitional space. As mentioned in the study of Araji (2007), the presence of solid overhang at the entrance of the building leads to smaller or moderate visual shock in the transitional space. Illuminance ratios between points four, five, six, seven, eight, nine and ten change from subtle to dramatic discomfort (Tab. 8). The transoms pierced along the façade allow the penetration of daylight in a directional way which creates areas less illuminated and then some big differences in illuminance levels between stair landings which cause visual discomfort inside the staircase. The little difference in illuminance levels between points ten and eleven (Tab. 9) leads to illuminance ratios of 10.7:1, 1.8:1, 5.7:1, 4.9:1 (Tab. 10) indicating subtle and moderate discomfort. Reducing the illuminance levels near the doors of houses can guarantee entering the house without suffering from visual discomfort.

Tab. 8. Illuminance value (lx) in Building 3. (Source: Authors, 2023)

Position	Illuminance value (Lux) **Building 3**							
Time	8 a.m.		12 a.m.		2 p.m.		4 p.m.	
	Winter	Summer	Winter	Summer	Winter	Summer	Winter	Summer
Outdoor (Pnt 1)	1115	4370	4680	8990	4519	10730	5004	13360
Door (Pnt 2)	186	699	1440	2697	860	2038	1115	2939
Entrance Hall (Pnt 3)	42	65	313	588	276	526	186	432
Stair landing 01 (Pnt 4)	3.6	8	12.53	21	13.5	19	13.7	17
Stair landing 02 (Pnt 5)	33.4	65	104	134	112	117	129	92
Stair landing 03 (Pnt 6)	1.55	7	8.8	18	8.8	16	9	14
Stair landing 04 (Pnt 7)	67	65	97	106	125	109	142	113
Stair landing 05 (Pnt 8)	3.8	8	14.6	19	13.1	17	10	14
Stair landing 06 (Pnt 9)	74	89	103	145	165	144	215	143
Stair landing 07 (Pnt 10)	4.9	13	24.9	45	23.1	35	18.9	20
House (Pnt 11)	0.46	6	13.55	7	4	4	3.8	7

Tab. 9. Illuminance ratio Building 3 (in summer and winter period). (Source: Authors, 2023)

Transition position	Illuminance ratios Building 3									
Winter period	Pnt 1-2	Pnt 2-3	Pnt 3-4	Pnt 4-5	Pnt 5-6	Pnt 6-7	Pnt 7-8	Pnt 8-9	Pnt 9-10	Pnt 10-11
8 a.m.	5.9:1	4.4:1	11.6:1	9.3:1	21.5:1	43.2:1	17.6:1	19.5:1	15.1:1	10.7:1
12 a.m.	3.3:1	4.6:1	24.9:1	8.3 :1	11.8:1	11:1	6.6:1	7.1:1	4.1:1	1.8:1
2 p.m.	5.3:1	3.1:1	20.4:1	8.3:1	12.7:1	14.2:1	9.5:1	12.6:1	7.1:1	5.7:1
4 p.m.	4.5:1	5.9:1	13.6:1	9.4:1	14.3:1	15.7:1	14.2:1	21.5:1	11.4:1	4.9:1
Summer period										
8 a.m.	6.2:1	10.7:1	8.1:1	8.1:1	9.2:1	9.2:1	8.1:1	11.1:1	6.8:1	2.1:1
12 a.m.	3.3:1	4.5:1	28:1	6.3:1	7.4 :1	5.8:1	5.5:1	7.6:1	3.2:1	6.4:1
2 p.m.	5.2:1	3.8:1	27.6:1	6.1:1	7.3:1	6.8:1	6.4:1	8.4:1	4.1:1	8.7:1
4 p.m.	4.5:1	6.8:1	25.4:1	5.4:1	6.5:1	8.0:1	8.0:1	10.2:1	7.1:1	2.8:1

Tab. 10. Comparison of Illuminance ratios in different building. (Source: Authors, 2023)

	Illuminance ratios (Summer period)			
Transition position Pnt 1-3	Building 1	Building 2	Building 3	Building 4
8 a.m.	25.8	46.8	67.2	242.6
12 a.m.	51.7	14.5	15.2	48.4

2 p.m.	39.1	18.5	20.3	61.1
4 p.m.	24.5	28.4	30.9	167.3
Illuminance ratios (Winter period)				
8 a.m.	29.1	33.3	26.5	157.1
12 a.m.	15.7	47.7	14.9	12.4
2 p.m.	26.8	35.7	16.3	35.5
4 p.m.	19.1	24.3	26.9	143.3

QUESTIONNAIRE RESULTS

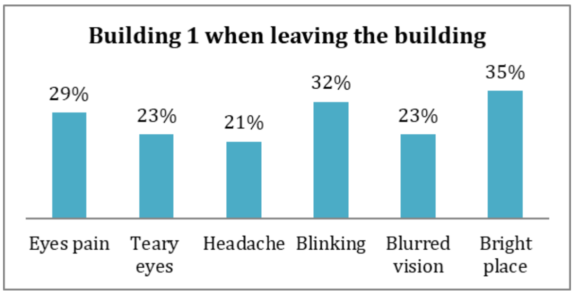
In the four buildings, 144 questionnaires were collected. The number of male respondents is 46%, and the number of female respondents is 54%. In order to produce graphs and charts for further comparisons, the data from each section of the questionnaire was processed in Microsoft Excel. This study employs a self-administered questionnaire for data collection. Questionnaires were distributed in paper format to residents of the four surveyed buildings. A brief explanation of the study's purpose accompanied the questionnaires. Residents completed the questionnaires at their convenience within their homes. Following completion, the questionnaires were retrieved. We conducted a pilot test with 14 participants from our target population (residents of the four surveyed buildings) of the visual comfort questionnaire to assess its clarity and effectiveness. The pilot test results were positive, and the questionnaire did not require any significant changes.

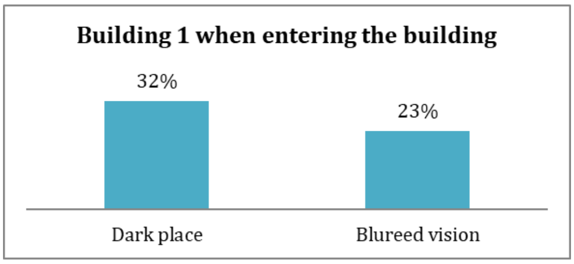
The statistical analysis of the visual comfort questionnaire data will help us understand how residents perceive the transitional space, represented by staircases, and their experiences within them. Since the questionnaire uses a combination of yes/no and Likert scale questions, we will employ appropriate statistical methods for each type of data. For yes/no questions, we calculate frequencies and percentages of 'yes' and 'no' responses. This will help us understand the prevalence of specific visual discomfort issues. For Likert scale questions, we calculate descriptive statistics like means and medians to identify the most common visual discomfort factors. This will provide a more nuanced understanding of how residents perceive different aspects of visual comfort within the staircases. To ensure validity, we conducted a pilot test with a small group of participants. The pilot test helped us assess whether the questions accurately captured residents' experiences and identify any areas for improvement in the questionnaire's clarity or comprehensiveness. The pilot test we conducted played a valuable role in assessing the questionnaire's potential reliability. By administering the questionnaire to the same participants twice, their responses remained consistent, which would be an indicator of reliability.

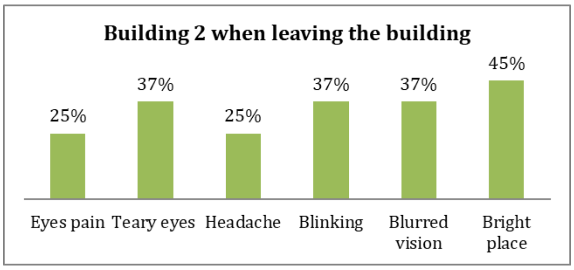
Participants were provided with a form that clearly explained the purpose of the study, the type of questions involved, and how their data would be used. They were assured of their anonymity and right to withdraw from the study at any point. All data will be anonymized and stored securely. Only authorized researchers will have access to the data. We are committed to conducting research ethically and respectfully of all participants.

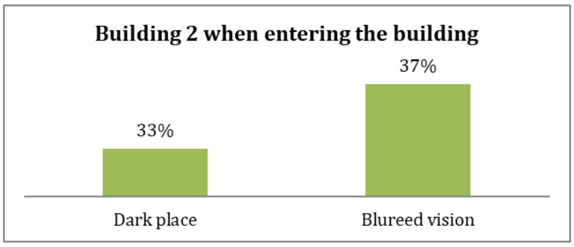
Part 1: Physiological symptoms

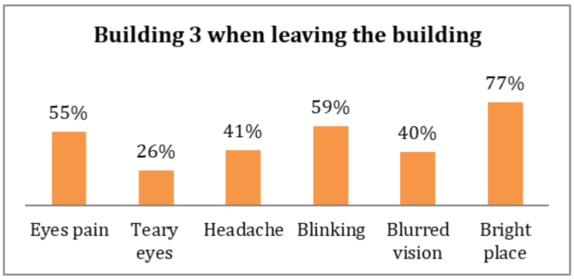
The results show that residents from the four buildings experience physiological symptoms of visual discomfort when leaving and entering the building, which signifies that the staircases do not represent the transitional space which offers the necessary conditions of adaptation. The highest percentages (Fig. 4) were found when residents were asked if they found the place too bright when they leave the building 35%, 45%, 77%, 83% respectively, which means that the illuminance is not gradual as needed in the path from the house to the outside of the building to make the necessary adaptation and to avoid visual shock.











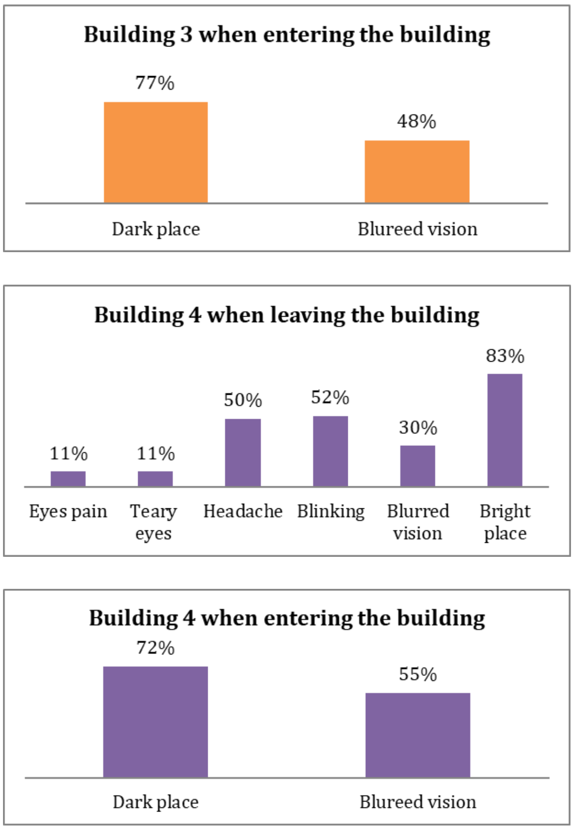
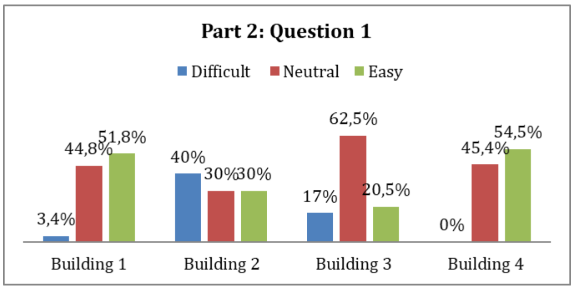


Fig. 4. Answers to Part 1 of the questionnaire. (Source: Authors, 2023)

Part 2: Visual task performance

Part 2 of the questionnaire will be assessed in the next discussion. Values range from -2 to 2, where -2 represents the most negative result (very difficult), while 2 represents the most positive result (very easy). In the four buildings, there are residents who have difficulties in performing visual tasks like difficulties to see the first stair, see the handrail, to find something that they dropped or identify people, which indicates problems in light distribution. In Building 2 negative values were more frequent than positive values, in buildings 1, 3 and 4 there were more positive values than negative ones, indicating that some residents adapt to the conditions in the staircases and used to them and perform normally (Fig. 5). For question 5 the highest percentage was in Building 3 because of the poor light in the staircase (Fig. 6).



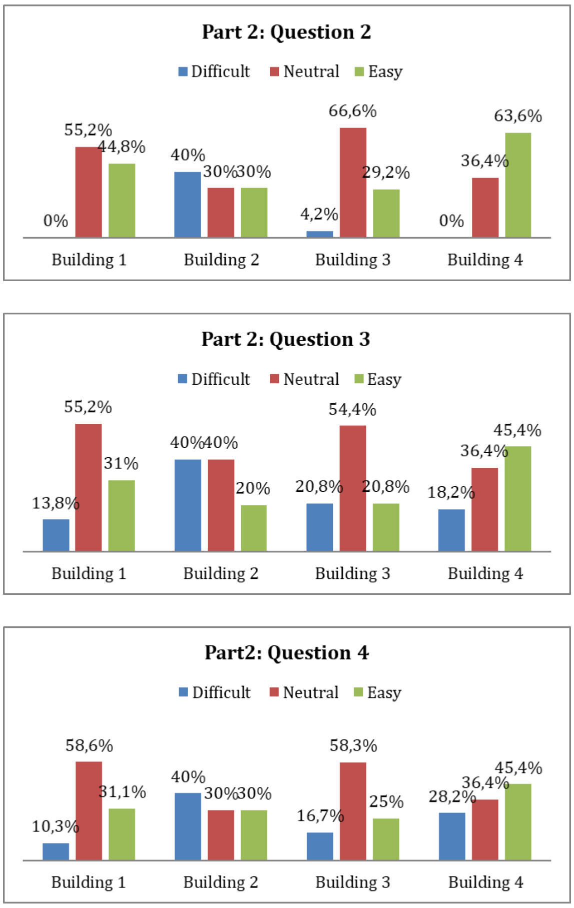


Fig. 5. Answers to Part 2 of the questionnaire. (Source: Authors, 2023)

Question 5: I bump into someone because I didn't see them

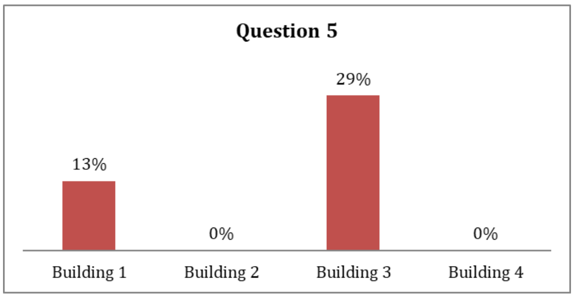


Fig. 6. Answers to Part 2, question 5 of the questionnaire. (Source: Authors, 2023)

Part 3: Preferences

In the four buildings, most respondents were neutral (Fig. 7). In Building 1, the second highest percentage of answers stated that the lighting is strong or very strong, and this is confirmed by the measurements, which is due to the fact that the staircase is open and exposed to direct lighting conditions. In Building 2, the second highest percentage of answers stated that the lighting is strong. In Building 3, the second highest percentage of responses stated that the lighting is weak and very weak, and this is confirmed by the measurements, which is due to the fact that the staircase openings are small and direct the lighting to specific areas. In Building 4, the second highest percentage of responses stated that the lighting is weak because there is no element at the entrance of the building ensuring the diminution of light with a comfortable gradation. In all buildings, there were residents who saw that the distribution of light is unbalanced while passing the staircases; the high percentage was in Building 3 confirming that treating the staircase with transoms introduce bad light distribution (Fig. 8).

Question 1: How do you find the light in the staircase?

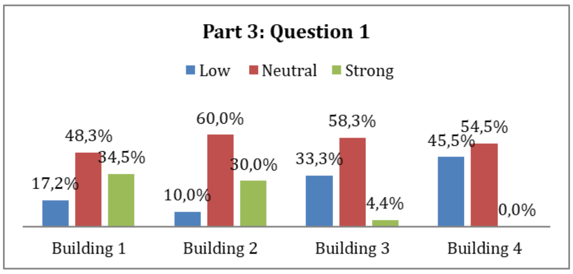


Fig. 7. Answers to Part 3, question 1 of the questionnaire. (Source: Authors, 2023)

Question 2: Do you find that the distribution of light is similar along the course of the staircase?

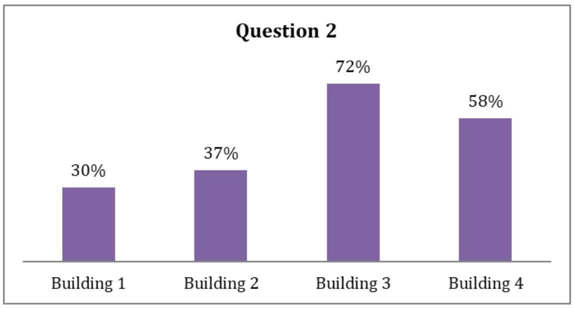
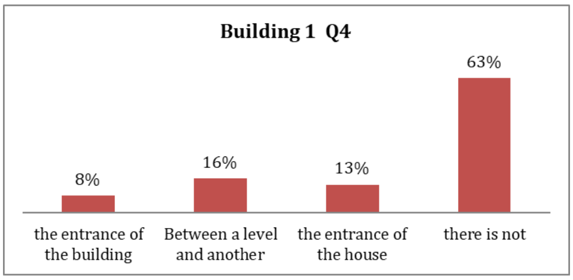
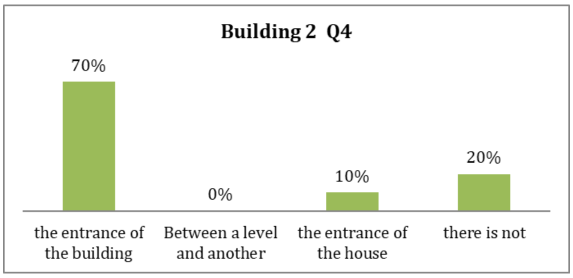


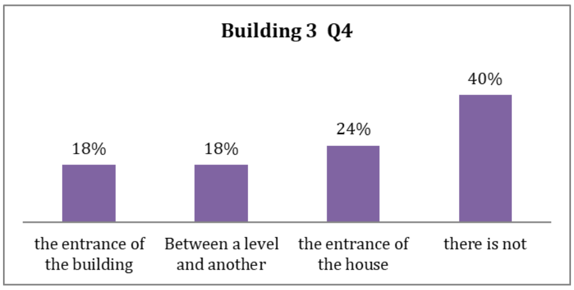
Fig. 8. Answers to Part 3, question 2 of the questionnaire. (Source: Authors, 2023)

Question 3: Which place causes you visual discomfort?

In this question, for buildings 1, 3 and 4, the highest percentages were for the inexistence of a place causing visual discomfort, showing that residents are used to the light conditions in staircases so they do not feel discomfort (Fig. 9). In Building 1, for the residents who expressed the presence of a place that causes them visual discomfort, the percentages were close, and the highest percentage was between one level and another, which confirms the results reached in the field measurements.







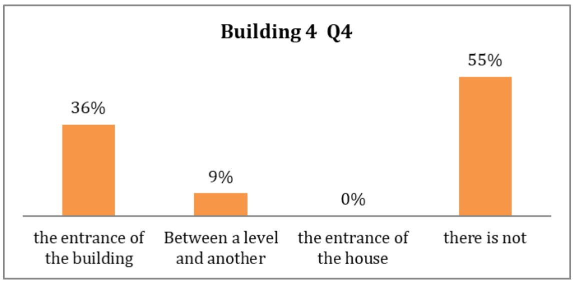


Fig. 9. Answers to Part 3, question 3 of the questionnaire. (Source: Authors, 2023)

DISCUSSION

Winter season

For the entrances:

At the entrance of Building 3, the solid overhang (with a depth of 2 m) permit "subtle" and "moderate" visual shock providing adequate transition leading to reasonable visual comfort and prepare the eye for the changes in illuminance (Fig. 10). As mentioned in the study of Araji (2007), the presence of solid overhead element at the entrance of the building leads to smaller or moderate visual shock in the transitional space. The absence of solid overhang at the entrances to Buildings 2 and 4 means that there is no area that allows for the gradation of illuminance values, making the eye experience a sudden change between the outside and inside of the building, which makes entering and exiting the building visually uncomfortable. In addition to that, in part 3, question 4 of the questionnaire, when residents were asked what place caused them visual discomfort, most of those who answered: the entrance to the building, were from Buildings 2 and 4.

Inside the staircases:

In Building 1 with percentage of the area entered by light of 88% indicated "strong" and "dramatic" visual shock in many points and as this staircase is open, it is exposed to light conditions so it does not ensure the necessary transition, which leads to advising against the open staircase. In Building 3 the staircase treated with transoms of clear glass with percentage of the area entered by light of 11%, these transoms direct the light to specific areas creating "strong" visual shock in many points of the stair landings which leads to advising against that. Buildings 2 and 4: the staircases treated with vertical bays throughout the façade presenting a percentage of opening of 19% and 22%, these treatments allow the penetration of daylight in a diffused way which ensures a balanced distribution of daylight inside the staircases, indicating "subtle" in most points and "moderate" in some points provides adequate transition leading to reasonable visual comfort in the stair landings, according to CIBSE (2002). In part 3, question 4 of the questionnaire, when residents were asked what place caused them visual discomfort, for who answered: between level and another, low percentages (0%, 9%) were from buildings 2 and 4.

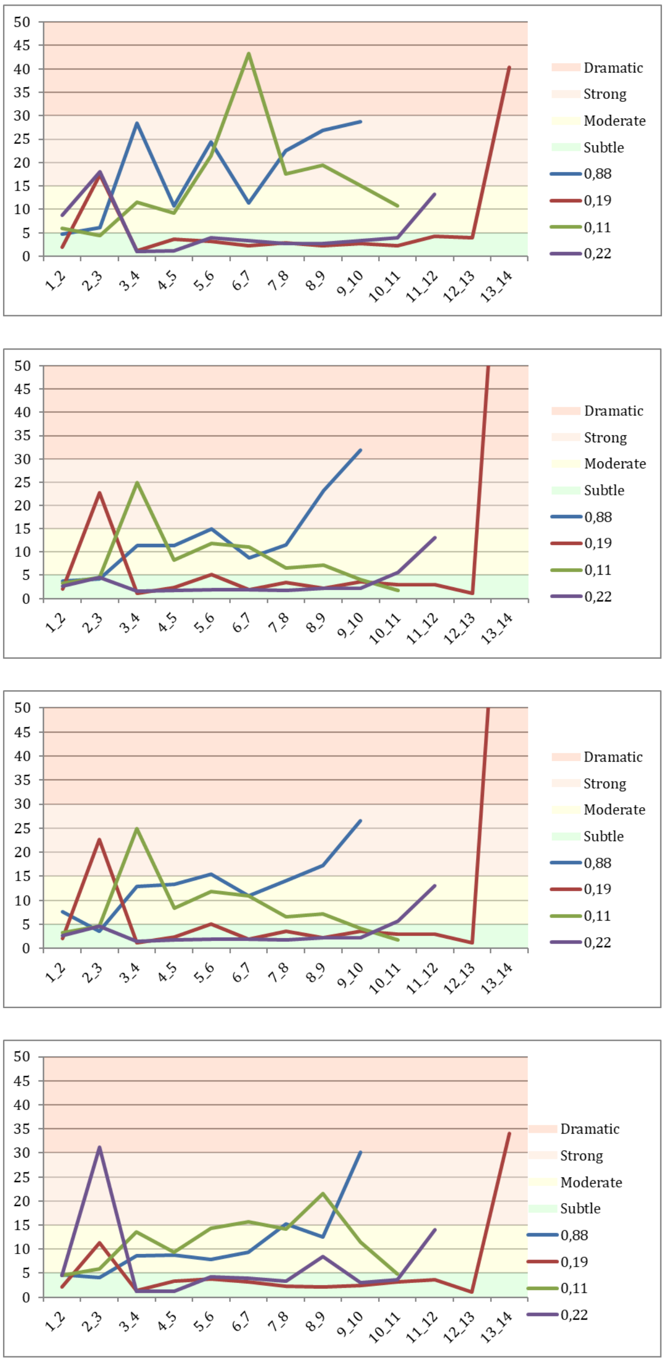


Fig. 10. Relation between percentage of opening of the staircase and visual shock in winter at 8 a.m., 12 a.m., 2 p.m. and 4 p.m. (Source: Authors, 2023)

Summer season

At the entrance of Building 1, the stair landings protrusion served as an overhang and permitted "subtle" and "moderate" visual shock providing adequate transition leading to reasonable visual comfort. At the entrance of Building 2, "strong" and "moderate" visual shock (Fig. 11) was indicated. As mentioned in the study of Araji (2007). At the entrance of Building 3, the solid overhang (with a depth of 2 m) permits "subtle" and "moderate" visual shock providing adequate transition. At the entrance of Building 4, "strong" and "dramatic" visual shock was indicated. The strong visual shock in summer was higher than in winter. The staircase presenting percentage of opening of 88%, indicated "strong" visual shock in most points of the staircase at 8 a.m., and "moderate" visual shock at 12 a.m., 2 p.m. and 4 p.m., while in winter, a strong visual shock was indicated at several points.

The staircase treated with vertical bays throughout the façade presenting a percentage of opening of 19% indicated "subtle" visual shock in all points of the staircase. "Subtle" and "moderate" visual shock was indicated at the entrance of houses, while in winter, it was strong. The staircase treated with transoms of clear glass presenting a percentage of opening of 11% indicated "moderate" visual shock in most points of the staircase and "strong" and "subtle" visual shock in some points; the "strong" visual shock in summer is less strong than in winter. The staircase treated with vertical bays throughout the façade presenting a percentage of opening of 22% indicated "subtle" and "moderate" visual shock. "Dramatic" visual shock was indicated at the entrance of houses, while in winter, it was mostly "moderate", according to CIBSE (2002).

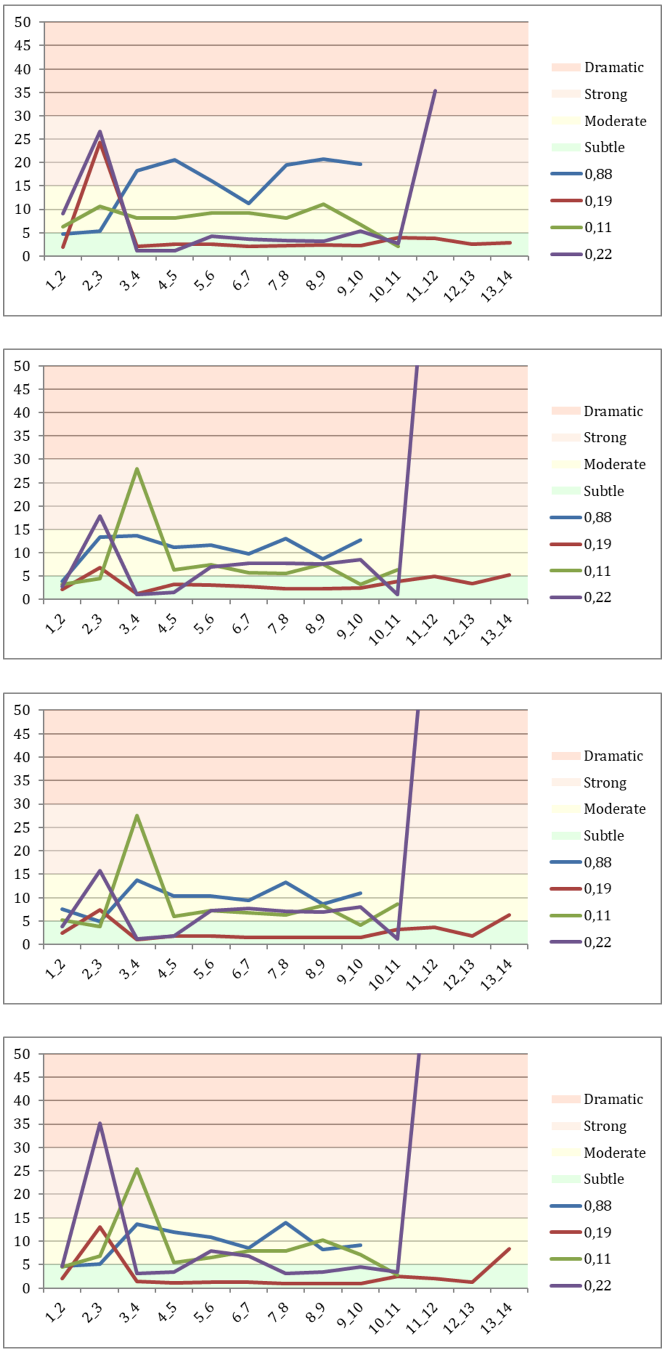


Fig. 11. Relation between percentage of opening of the staircase and visual shock in summer, at 8 a.m., 12 a.m., 2 p.m. and 4 p.m. (Source: Authors, 2023)

CONCLUSION

Accessing and walking in a building through comfortable transitional spaces is a necessity. These spaces ought to permit the user's visual system more time to make the necessary changes in adaptation. While relating physical measurements and questionnaire results with perceptions of visual comfort, this study indicated that: An open staircase, with the percentage of opening of 88%, exposed to light conditions, indicated "strong" and "dramatic" visual shock at many points in the staircase, which leads to advice against the open staircase. This was the staircase where the highest percentage of residents expressed that the light in the staircase is strong. Staircases treated with vertical bays throughout the façade, with percentages of opening ranging between 19% and 22%, allow the penetration of daylight in a diffused way which ensures a balanced distribution of light inside the staircases, indicating "subtle" in most points and "moderate" in some points providing adequate transition leading to reasonable visual comfort in the stair landings. These vertical bays reduced the percentage of residents expressing visual discomfort inside the staircase to 0%, while it was 18% inside the staircase with transoms, and 16% inside the open staircase.

The staircase treated with transoms of clear glass, with percentage of opening of 11%, directed the light to specific areas creating a "strong" visual shock in many points of the stair landings, hence it leads to advice against that. The highest percentage of residents (72%) expressed that the light distribution in the staircase is imbalanced. The existence of a solid overhang (2 m deep) above the entrance of a building, permits "subtle" and "moderate" visual shock providing adequate transition leading to reasonable visual comfort in the entrance of the building. Moreover, its inexistence caused visual discomfort, where the percentage of residents who expressed their visual discomfort at the entrance of a building without an overhang, reached 70%.

Residents from the different buildings experience physiological symptoms of visual discomfort when leaving and entering the building through the staircases, and there are residents who have difficulties in some visual tasks like difficulties to see the first stair, to see the handrail, finding something that they dropped or identifying people. However, significant percentages of them (55%, 63%) expressed that there was no place in the staircase causing them visual discomfort, even if they experienced it, showing that they are used to the light conditions in staircases that they do not feel disturbed or upset. Hence living in the same conditions for a long time makes them adapted to these conditions which makes it unnecessary to set very precise visual environment and allows wider visual comfort ranges in this transitional space.

Limitations and future studies

The study has limitations. Including a larger and more diverse sample of buildings with varying staircase designs and openness percentage would strengthen the findings and provide valuable insights to inform future building design. Future studies can build upon this research by expanding the diversity of staircases studied. This could involve including a wider range of architectural styles and locations.

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Social housing - between design and social practices: The case of the 670 social housing units in Oran

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Abstract: Housing represents the initial place where each individual has the opportunity to reconnect with their identity. It should offer every family the opportunity to live according to their lifestyle. Most people aspire to a living space that reflects both their aspirations and their way of life, while also taking into account the demands of everyday life. Since independence, Algeria has shown a remarkable commitment to promoting social housing, mobilising significant efforts in this area. However, what has been observed is that professionals design housing that occupants adapt to their daily needs. Despite the in-depth analyses by numerous researchers revealing the significance of these transformations, professionals persist in reproducing the same spatial patterns, thus demonstrating a certain indifference towards the work of academic research. Residents have tried to adapt to these housing units by making modifications to gain more space both inside and out. Inside, these transformations were appreciated by the occupants. From the outside, these remodellings have had a negative impact on the overall image of the city. The balance between quantity and quality was not taken into account, even though the aim of rapid construction was to alleviate pressure on the housing market. This article aims to question occupants' practices to establish a link between the housing designed and built, and occupants' expectations. The analytical approach used is post occupancy evaluation (POE) - a multi-method approach to data collection that includes direct observation, plan analysis and questionnaire. The housing units studied were not selected according to any particular method but rather chosen on the basis of the residents who agreed to answer the questions and share their lifestyle and expectations regarding their housing. Data processing, through a comparison between the initial plan drawn up by the designer and the current plan modified by the inhabitant, enabled us to deduce the discrepancies that exist between the two plans and to understand the modes of appropriation of the housing's interior space.

Keywords: social housing, occupants, needs, housing designed, occupant expectations

INTRODUCTION

In developing countries and in times of crisis, social housing has become a vital necessity for the most disadvantaged individuals and families. However, despite the targets set by the public authorities, the allocation of social housing has not always been sufficient to meet the urgent demand of those most in need; social housing has become an important issue, as it is seen as the only way for these populations to integrate into society. For the homeless, it offers a means of avoiding social exclusion. The link between supply and demand is a decisive criterion for measuring the severity of the crisis, given that demand often exceeds available supply (Kara, 2019). Faced with a pressing demand for housing in Algeria, the government created a new built environment from the 1970s onwards, by Ordinance 74/26 of 20 February 1974. This type of housing, known as ZHUN (zone d'habitat urbain nouvelle—new urban housing zone in Algeria, designed to create new residential areas to meet the urgent housing crisis and offer modern infrastructure), was built on the outskirts of cities. By analogy, it is reminiscent of the ZUP (zone à urbaniser par priorité). European housing production in the 1950s influenced how housing was built in Algeria. In the latter's case, foreign design offices reproduced a similar model without considering the Algerian family's characteristics. However, the dominant model of urbanisation in Algerian cities is based on the standardisation of repeated parallelepiped-shaped constructions according to a programmatic approach, known as collective social housing (ZHUN), and has evolved to include financing formulas such as evolving social housing, participative and public rental housing (Adimi, Bellal, 2012).

The aim of this article is to explore residents' practices in order to establish a connection between the housing designed and built on the one hand, and residents' expectations on the other. Indeed, the question that concerns us is this: how do Algerian households approach redeveloping housing that was initially designed without taking their needs and preferences into account? According to the common assumption in Algeria, the differences between the space conceived and the space realised result from the variety of procedures, skills, and public and private partners involved: *"It's impossible to refute the passionate and sometimes impassioned nature of debates on questions of appropriation and use of space. Through the appropriation and use of space, man exists, expresses himself, imposes himself, distinguishes himself, builds and reproduces"* (Mebirouk et al., 2005). This means that the appropriation and use of space are important concerns for practitioners, decision-makers, and researchers. But above all, they remain topical. Finally, this article presents preliminary results from a study of social rental housing (LPL—Logement Public Locatif: a program established by the government in Algeria to provide housing for low- and moderate-income households on a long-term rental basis) in Oran, which has benefited from extensive social housing programs since the 1970s. In 1980, *"it was definitively recognized that resources had to be reallocated to provide housing for low-income groups. At the meeting of the Central Committee of the Front de Libération Nationale (December 1979), obvious resolutions were taken on housing, in preparation for the new national development plan"* (Benmatti, 1982, p. 195).

Data is collected on the housing, and interviews are conducted with residents to compare the housing in its delivered state with its future state. The aim is to evaluate users' ability to redesign their housing to suit their lifestyles and personalise it to improve their quality of life. The object of study is the 670 housing estate (LPL) at Hai El Sabah. The methods used in this research were direct observation, analysis of plans, and a questionnaire sent to residents. The housing units studied were not selected according to any particular method, but rather based on the residents' willingness to answer questions and share their lifestyles and expectations regarding their housing.

STANDARDISATION OF COLLECTIVE HOUSING

During the modern movement, the integration of standardisation into the collective housing design process became increasingly common. Several German architects developed standardised methods in this context to facilitate the mass production of buildings. According to Le Corbusier, standardisation (normalisation) is indispensable for the human habitat, given that human beings have comparable organisms with identical functions and vital needs. Consequently, a streamlined approach is required to produce standardised housing (Adimi, Bellal, 2012). In their study, Foufou (2013) examines another key element of standardisation in the design of minimal housing, namely the "Modulor". This measure, invented by Le Corbusier, enables harmonious proportions between the various constituent elements of a construction. There are two aspects to consider: the first concerns the notion of universal standardisation in keeping with the architectural environment, while the second emphasises the preponderant use of square geometry in the design of housing plans.

Similarly, Le Corbusier attempted to create a link between the human body and space using his idea of the Modulor. He argued that the layout of architectural space should be based on the measurement of a human being's raised arm. Le Corbusier set out his vision of the functional city at the Fourth International Conference of Modern Architecture (CIAM—Congrès International d'Architecture Moderne; international organisation founded in 1928 that brought together architects and planners of the modern movement, it aimed to consolidate the doctrines of modern architecture through international collaboration), held in Athens in 1933. Each space is specifically intended for a precise function such as living, moving, working, and leisure, with the main aim of encouraging the circulation of air, light, sun, and greenery throughout the urban space (Foufou, 2013). This means *"orienting buildings so that they can benefit as much as possible from sunlight, spacing the built environment to let in air, light, and vegetation"* (Le Gall, 2013, p. 24).

During the industrialisation era, the modern movement built many social collective housing units, using modern construction techniques such as post-and-beam structures and innovative materials like concrete (Foura, 2007). Standardisation focuses on the production and use requirements of social collective housing. It considers that the dwelling must be functional for its occupants, and the designer must therefore be able to determine the space required for furniture in domestic spaces through efficient distribution that avoids wasting space. The minimum and maximum dimensions of the parts have been determined by the standards that govern them. Coordination and dimensional modulation are based on two sets of dimensions. The first set is based on the standard measurements of human beings, derived from their everyday movements at a person's height of 1.75 metres. The second set is based on furniture dimensions, which are determined according to their utility and mode of operation. The geometry of the rooms is regulated by the layout of the proposed theoretical furnishings, which serve as a reference for judging the habitability of a cell. Take the kitchen, for example, where size is influenced by the number of objects to be integrated, including the sink, stove, food preparation area, refrigerator, and similar equipment. Similarly, bathrooms and toilets are also subject to the same principles. Regulatory standards have been established to facilitate the circulation of people and allow for optimal furniture layout. By way of example, passageways must be 0.74 m wide for wet spaces such as bathrooms and toilets, 0.84 m for bedrooms and kitchens, and 0.94 m for the housing entrance door (Hendel, 2016).

RESIDENTS' ACTIONS ON BUILDINGS

In the 1970s, ZHUNs played a key role in stimulating large-scale collective housing construction in post-independence Algeria. Initially, a sufficient number of vacant dwellings in 1962 led to a relaxation of attention to the housing issue. However, by the end of the 1960s, the problems associated with housing shortages began to be felt in earnest, although their impact varied from city to city (Boutabba et al., 2019). The buildings erected during the Constantine Plan were chosen as the model for housing construction in independent Algeria, favouring the use of "matchbox" shaped buildings and squared-off structures, neglecting local architectural references. Emphasis was placed primarily on site organisational technique and speed of completion, to the detriment of architectural and constructive quality (Mouaziz-Bouchentouf, 2014).

The mass adoption of the apartment block was not just a technical solution but revealed the character and principles underpinning the newly independent state (Filali et al., 2023). Moreover, this approach allowed the authorities to consolidate its image as a benefactor. The move away from the traditional house can be seen as a move by the powers that be to promote an image of modernity and development. The authorities took an approach similar to that of the technocrats of the Constantine plan, invoking urgency and economy to justify the imposition of their ZHUN model, whereas *"Housing construction is one of the most important factors in the composition of the human environment, and especially the urban environment"* (Moley, 1979, p. 41).

From the 1970s onwards, collective housing in Algeria did not meet the demands and daily living habits of the Algerian domestic group. The narrowness of the cells and the large number of occupants were the main reasons behind this problem. Up to the present day, the European plan type has become a model for application in the field, without any real change (Lakjaa, 1998). With all the modifications made by users, domestic distribution has always remained unchanged. Although the economic situation in Algeria has undergone major changes, such as the various major transformations in the housing and construction sector, the imported housing model has remained inadequate. Those responsible for the production of social housing refer mainly to the knowledge acquired during the construction of the large-scale housing estates of the Constantine Plan, which were discussed in depth by researchers, practitioners, and civil society. To meet the evolving aspirations of each individual in the family, improve their appropriation of the cell's interior space, and guarantee a certain degree of privacy, users were forced to implement transformations both inside and outside their housing (Goubaa, 2018).

The unsuitability of the designed space for the different social-spatial practices of the inhabitants is justified by their instantaneous actions on public space (creation of a delineated space on the ground floor that serves as a courtyard or parking space for a car, creation of areas specifically dedicated to playing, etc.) and on private interior space (inclusion of balconies in living areas and bedrooms to enlarge the living space and have more square metres inside, a transformation of loggias into a kitchen or even a bathroom if the original kitchen is converted into a bedroom or dining area, installation of a metal grille for safety reasons on windows overlooking the outside, etc.). There is no denying that the façade undergoes a series of transformations, from obstruction to perforation. In most cases, this space is integrated into the interior to serve as an extension of the private part of the housing. The obstruction of this space can take different forms: in some cases, lightweight materials such as smoked glass are used, ensuring a certain degree of transparency while preserving interior privacy. In other situations, partitions are installed using heavier materials, with an opening to allow air and light to circulate. In this particular context, Bernard (2010) argues that inhabited space can only be truly appropriate if the people who live there can reshape it according to their needs and preferences.

METHODOLOGY

The Post occupancy evaluation (POE) - analytical tool to decipher the relationship between the individuals and their housing has been employed. As early as the 1960s–1970s, countries such as the United States, Great Britain, Canada, and France began to collect information on POE through questionnaires, interviews, analyses and in-depth observations, which they made available to researchers to study users' impressions of their homes (Federal Facilities Council, 2002). However, Post Occupancy Evaluation was not considered a discipline in its own right until the 1980s. Since then, theory in this field has undergone a remarkable evolution in analytic procedures, and techniques, including in terms of applications (Mazouz, Mezrag, 2014). While architectural criticism is generally concerned with aesthetics and construction evaluation, POE aims to integrate the design process of the built environment into the scientific research cycle. Occupants replace any architectural aspects of the building that do not correspond to their needs. This feedback is taken into account by specialists when making improvements or designing future architectural projects (Zimmerman, Martin, 2001).

This being said, in our case study, the POE approach is carefully adopted in a social housing context; to evaluate the ability of users to completely rethink the layout of their homes, adapting them to their individual needs and personalising them to create an environment that fosters a better quality of life. The study was carried out in January 2023 in a social rental housing estate in Oran, Algeria. The target population was the residents of the 670-unit collective housing estate in Oran. The techniques used in this study were direct observation, analysis of plans and a questionnaire sent to residents. The housing units visited were not selected according to any particular method, but rather chosen on the basis of the residents' willingness to answer questions and share their lifestyles and expectations regarding their housing. Data processing involved a comparison between the initial plan drawn up by the designer and the current plan modified by the resident, taking into account the residents' responses.

CASE STUDY: 670 SOCIAL HOUSING ESTATE

The 670 housing estate is located in the commune of Hai El Sabah, in the eastern part of the city of Oran, Algeria (Fig. 1). Initially designed to provide social rental housing, it is part of a project that was to build 1,000 housing units of this type. The project's design was done by the ICAR engineering firm. The housing estate comprises 19 collective housing blocks, including 4 angular blocks and 15 linear blocks, each with a differently designed main and rear façades (Fig. 2, 3). The blocks were designed to provide four housing units per level, with living areas ranging from 45.25 m² to 72.4 m² (Tab. 1). Construction work began in 2003 and was supervised by the project owner OPGI (Office de Promotion et de Gestion Immobilière), a public body responsible for promoting and managing real estate projects, particularly public housing. The first housing units were completed in 2009 and have since been occupied by tenants. The buildings of the 670 housing estate were constructed using a self-stabilising reinforced concrete structural system, based on post-and-beam and sail-wall construction. This construction technique ensures maximum strength and stability for all the blocks.

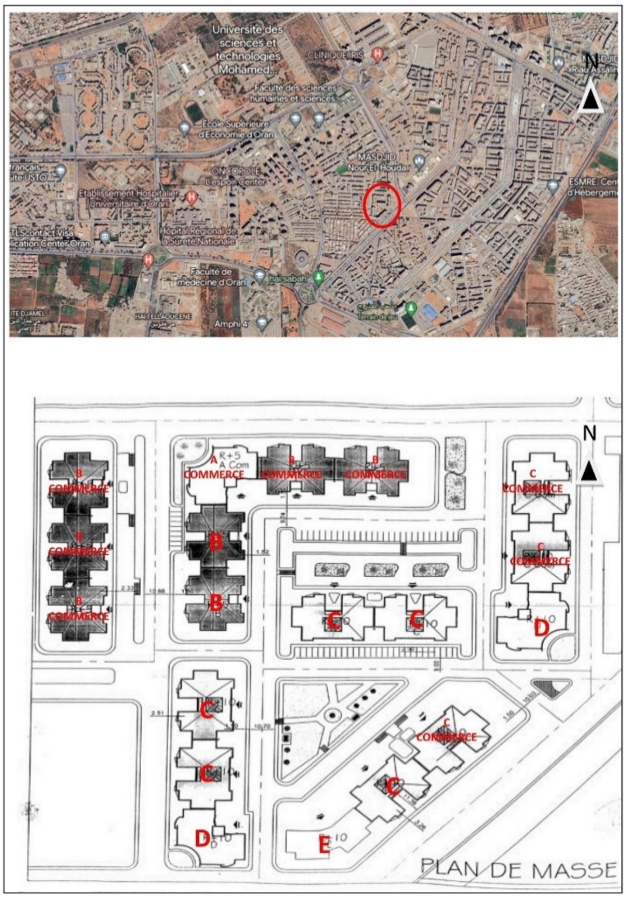

Fig. 1. Site plan and mass plan, 670 LPL housing estate, Oran. (Source: OPGI, 2022)

Fig. 2. View of the main façade. (Source: Authors, 2023)

Fig. 3. View of the rear façade. (Source: Authors, 2023)

Tab.1. Type of buildings. (Source: Authors, 2023)

No.	Categories	Building type							
01	Type	B	B trade	C	C trade	D	E	A trade	Total
02	Number of blocks	2	5	5	3	2	1	1	19
03	Number of levels	Six-storey building, with ground floor	Six-storey building, with ground floor	Eleven-storey building, with ground floor	Eleven-storey building, with ground floor	Eleven-storey building, with ground floor	Eleven-storey building, with ground floor	Six-storey building, with ground floor	
04	Form of blocks	Bar	Bar	Bar	Bar	Angular	Angular	Angular	
04	Number of housing units per level	4	4	4	4	4	4	4	28
05	Number of housing units per ground floor	4	4	4	2	4	4	4	26
06	Number of housing units per block	24	24	44	42	44	44	24	246
07	Total number of housing units	48	120	220	126	88	44	24	670
08	Average living area F2	45.25	45.25	45.25	45.25	55.04	49.85	55.04	
09	Average living area F3	60.05	60.05	60.05	60.05	70.91	72.40	70.91	
10	Number of commercial premises per block	0	5	0	5 6 7	0	0	4	27
11	Number of commercial premises	0	25	0	18	0	0	4	47

In our case study, F2 and F3 housing includes a horizontal circulation space (such as a corridor or hallway), a living room, one or two bedrooms, a kitchen, a bathroom, a toilet and intermediate spaces such as a loggia or balcony (Fig. 4, 5). Initially, plans are designed to place the living area near the entrance, while the sleeping area is located at the back of the housing. Most kitchens are judiciously positioned on the day side, often opposite the living room, but in the F2s of the linear blocks, the kitchen is positioned at the back. Bedrooms in F3 housing are side-by-side and vary in surface area from 10 m² to 12 m². Bathrooms and toilets are well positioned and separated in the linear blocks, but in the angular blocks, their proximity to the front door and lack of separation pose a problem for residents (Fig. 6, 7). The façades of the 670-unit housing estate, built in a post-and-beam system, are rather ordinary in style, characterised by pure, regular openings, balconies and loggias (Fig. 8).

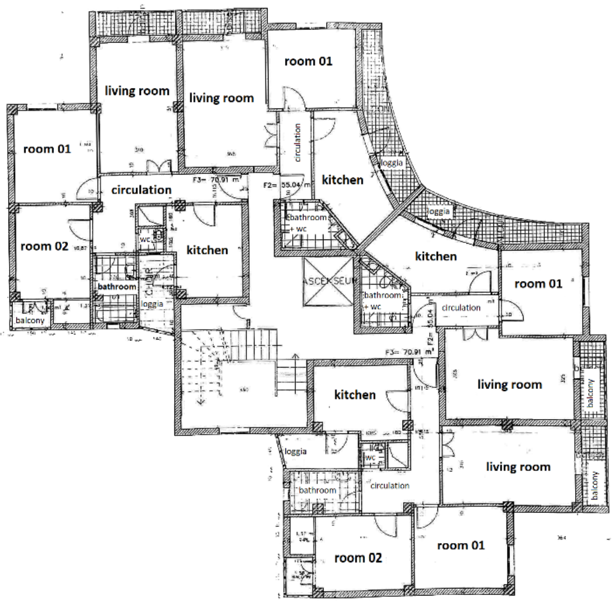

Fig. 4. Floor plan F3 and F2—angular block. (Source: OPGI, 2023)

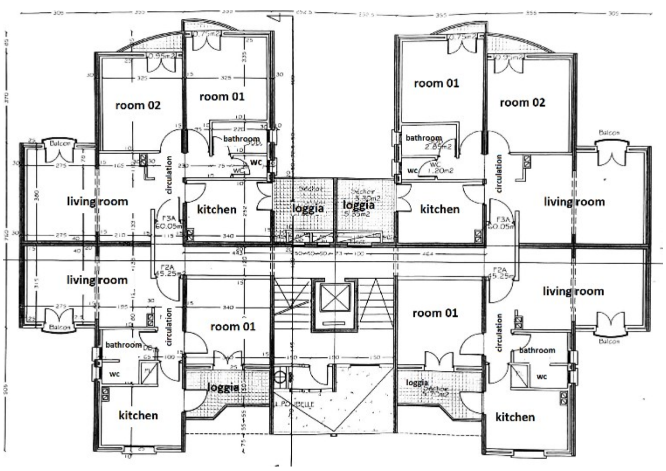

Fig. 5. Floor plan F3 and F2—linear block (Source: OPGI, 2023)

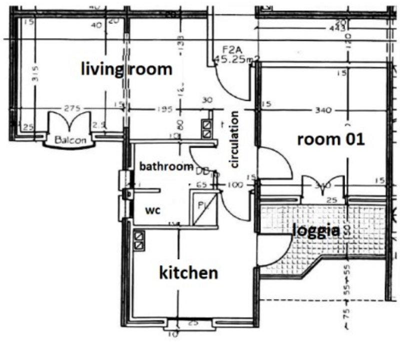

Fig. 6. F2 housing in a linear block. (Source: OPGI, 2023)

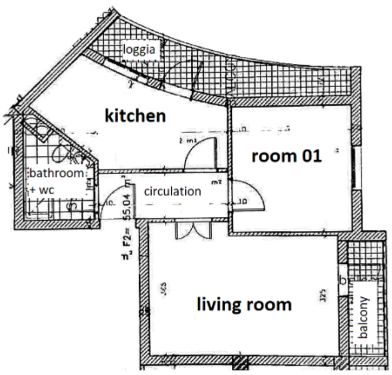

Fig. 7. F2 housing in an angular block. (Source: OPGI, 2023)

Fig. 8. View of the façade. (Source: Authors, 2023)

Social housing is facing a new reality that requires it to adapt to the lives of its occupants. Tight spaces have created major constraints within housing, leading residents to seek multi-functionality in a single space. This approach has led to a certain versatility in the various components of the housing. However, these modifications are different for each housing, as there is often a contradiction between the design made by the professionals and the real needs of the occupants, which is reflected in a comparison between the initial plan and the lived plan. In our case study, many families opted for living room conversions, of which two configurations are particularly common. The first configuration (Fig. 9, 10) removes the balcony and replaces it with a bay window, giving the living room a larger surface area and freeing up space for some much-needed furniture. In the second configuration (Fig. 11, 12), a dining room and a cupboard have been added to the living room, transforming it into a multi-purpose space much appreciated by residents, as it allows them to enjoy this spacious area while freeing up some space in the kitchen.

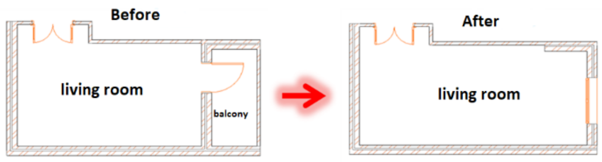

Fig. 9. First configuration: removing the balcony and installing a bay window. (Source: Authors, 2023)

Fig. 10. Views of the living room (Source: Authors, 2023)

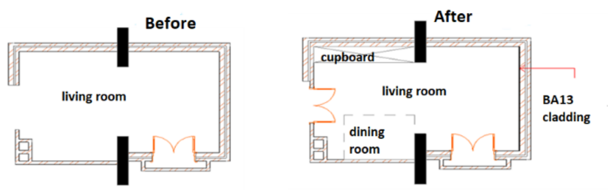

Fig. 11. Second configuration: cupboard and dining room layout. (Source: Authors, 2023)

The F2 housing units were cleverly redesigned, transforming the loggia into a modern, practical kitchen (Fig. 13). By removing the space reserved for the kitchen counter and rearranging it in the loggia, an additional room has been created. This multi-purpose room metamorphoses into a welcoming dining room during the day, then transforms into a comfortable bedroom for the night. This reconfiguration has enabled households to benefit from more generous living space, with some even using the room for professional purposes. However, for the F3 housing, residents were creative in raising the loggia wall (Fig. 14), expressing their preference for elegant bay windows rather than traditional lattice panels, to avoid dust infiltration. Unfortunately, this modification led to a reduction in the level of ventilation inside the kitchen, which elicited mixed reactions from users, particularly women who spend a large part of their day in this room.

Fig. 12. Views of the living room (Source: Authors, 2023)

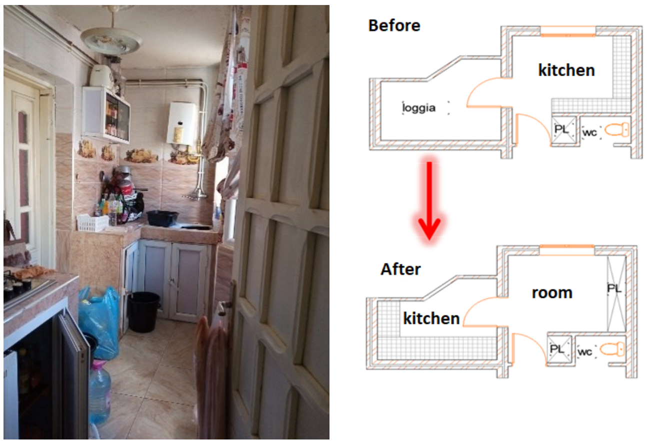

Fig. 13. Transforming the loggia into a kitchen. (Source: Authors, 2023)

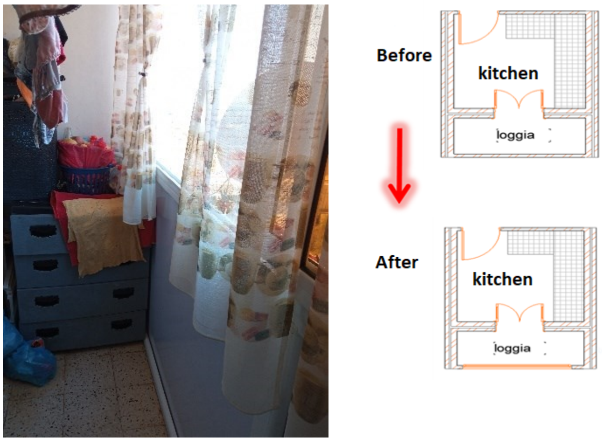

Fig. 14. Replacement of the loggia lattice panels with a bay window. (Source: Authors, 2023)

Fig. 15. Installing a cupboard. (Source: Authors, 2023)

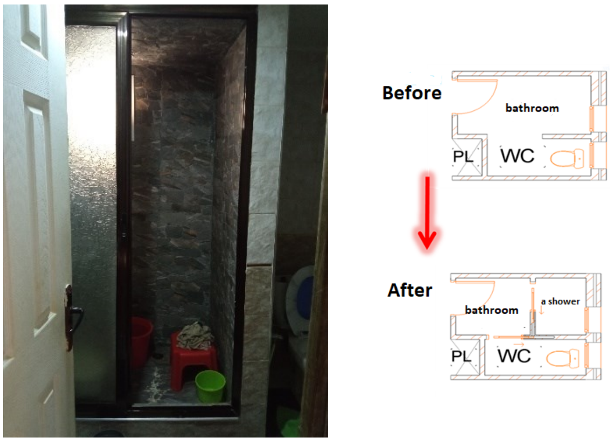

Fig. 16. Separating the toilet (WC) by a door. (Source: Authors, 2023)

Bedrooms have undergone only a few transformations, with the exception of the installation of a cupboard to provide storage space in some housing (Fig. 15). As far as the bathroom and toilet are concerned, the separation by a door between the two has become commonplace among users. This proved to be very practical, particularly in terms of hygiene during the health crisis (Fig. 16). A second transformation took place due to the unfavourable location of the toilets, prompting households to move the door to gain privacy and reduce unpleasant odours. At the entrance, a door was added to the vestibule. Previously, this space was used as a storeroom for unnecessary items, but during confinement, this change provided an additional space used as a sterilisation area before entering the housing. A small washbasin was even installed, along with a wall-mounted box containing disinfectant. In this way, residents wash and disinfect their hands before touching the front door handle (Fig. 17).

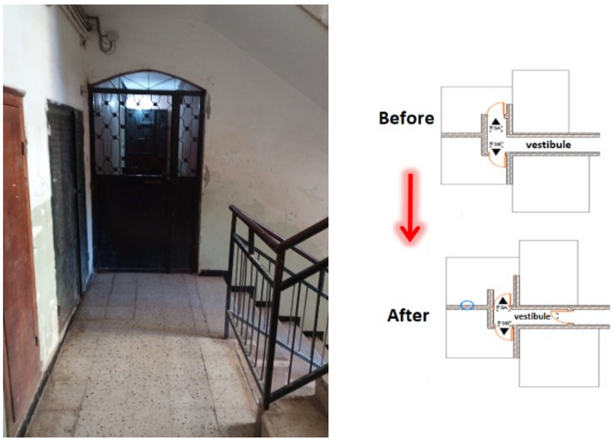

Fig. 17. Door layout in the entrance vestibule. (Source: Authors, 2023)

ANALYSIS OF SPECIFICATION

In an interview with a liberal Algerian architect, head of the ACAD design firm, who has designed several collective housing projects in Algeria, with the OPGI as the project owner, it was pointed out that state contractors are the main designers of housing, while architects focus mainly on adapting spaces to a given site. The specifications for collective housing, drawn up by Oran's OPGI (Office Public de Gestion Immobilière), describe the evaluation stages for collective housing, based on five key criteria: architectural appearance, functionality, urban planning, construction system, and compliance with the program. Each criterion must meet the following requirements and conditions: from an architectural point of view, it is essential to take into account harmony with the environment and the spatial distribution of the housing plans. Regarding functionality and compliance with the program, the layout of the various rooms must be studied in the light of the available surface areas, while taking into account the economic aspect of the project. The construction system must be adapted to the project and be in line with the estimated budget. As for the urban planning aspect, the evaluation is based on elements such as compliance with urban planning instruments (limits and dimensions of the plot, harmonious integration into the site, spatial composition, and easements).

The average living area of an F3 housing unit is 67 m^2 (Fig. 18). When designing the rooms, certain requirements need to be taken into account. The living room, for example, needs to be positioned close to the entrance, so that visitors can access it directly without crossing the other spaces while maintaining a certain degree of privacy from the other rooms. A rectangular shape is preferred, with an average surface area of between 18 and 21 m^2. As for the kitchen, it should include a space dedicated to meals, with an average surface area of around 10 m^2. Bedrooms should be rectangular, with a surface area of around 12 m^2. The bathroom should be approximately 3.5 m^2 and equipped with a bathtub. The toilet should be separate from the bathroom and occupy a surface area of around 1 m^2. Shower rooms should have good natural light and adequate ventilation. Circulation space should not exceed 12% of the cell's living area. This space should be laid out as a hallway, serving as a central point to link the various rooms. The loggia, which is an extension of the kitchen, should be around 1.40 m wide for optimum layout (Tab. 2).

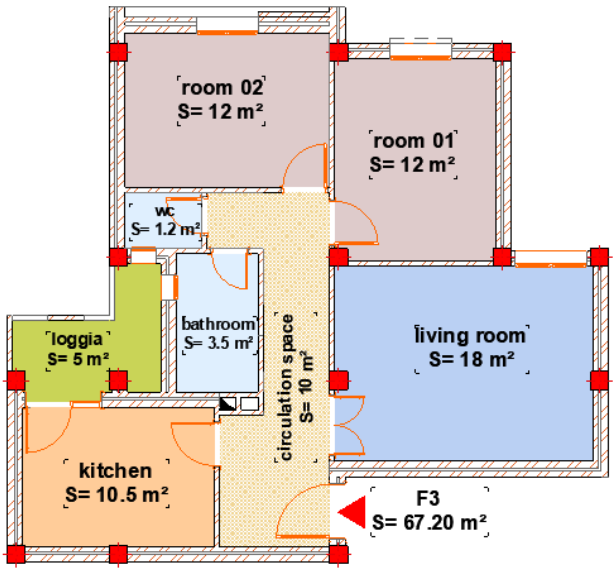

Fig. 18. Typical floor plan of a collective social housing project (LPL). (Source: ACAD design firm, 2023)

Tab. 2. The living area of an F3 housing, as adopted in the specification. (Source: OPGI, 2023)

Spaces	F3 housing (m²)
living room	20
Kitchen	11
Room 01	12
Room 02	12
Bathroom	3.5
Toilets	1.5
Storage	1
Circulation space	6
Total	67
Balcony	4
Loggia	4

As far as the construction system is concerned, the designer is free to choose the structure best suited to the project, the site and its location. The structure must harmonise with the local architecture, while the materials used should guarantee safety, stability, acoustic and thermal comfort. The ground plan must provide a clear understanding of the overall organisation of the project, and the building must be consistent with the external spaces, while creating an appropriate hierarchy between public, semi-public, and private spaces. After comparing the requirements in specifications with what was designed and built, we found numerous contradictions:

The rooms are too small, creating a feeling of confined space in which the inhabitants feel constrained to live without being able to personalise it. The initial design limits their freedom, leaving no room for the concepts of flexibility and "open design" of housing (Boudon, 1977), which are completely neglected. If, on the other hand, the design incorporates volumetry and compositional principles that offer the possibility of modification, then users can intervene and remodel their space according to their desires, without altering the architectural appearance of the building. Thus, it is through a well-established design model that occupants can truly make their housing their own. A large number of builders see the housing space solely as a shelter, a solution to the housing crisis. They give too much importance to this issue, whereas a minority of developers recognise that housing represents the culture of its occupants through its spatial composition and can make a real difference in people's lives.

DISCUSSION

Modifications to the built space generally precede the action of adaptation, so it is through the use of space that users become aware of the unsuitability of their cells for their lifestyles, and processes of appropriation or re-appropriation have been carried out to adjust the living environment to their ways of life (Mezrag et al., 2018). The appropriation of interior spaces has a strong relationship with the different ways in which inhabitants appropriate these spaces, and this becomes apparent through their socio-cultural behaviours, practices and activities, which sometimes leave physical traces; traces that contribute to changing the morphology of the space either totally or partially, or conversely, that leave no physical marks at all, implying the possibility of several modes of appropriation (Mezrag, 2015). In our case study, the appropriation of space shows us the reaction of residents to the housing imposed on them, and reveals the mechanisms used by users to create a certain adaptability between their housing and their daily practices.

The living room, the main reception area for guests, is often transformed into a bedroom at night, and can also be used as a workspace, dining room and TV entertainment area, depending on the number of people in the household. The kitchen, generally managed by women in Algerian society (Mili et al., 2015), has undergone appropriations due to its small size. It is designed for meal preparation, while the adjacent loggia offers continuity with the kitchen area and can be used for baking bread using a gas stove. *"I spend more time in the kitchen and living room because these are the two spaces where I carry out the majority of my activities. For me, these two rooms are of considerable importance for our socio-spatial practices"* (a resident of the 670 housing estate).

In families with children, mothers often take their meals with their little ones in the kitchen. In some cases of cramped housing for large families, non-habitable spaces are transformed into habitable ones, such as loggias that become kitchens. The parental bedroom, an intimate space in the housing, is analysed from the point of view of its appropriation. Not only is it seen as a place to sleep, but residents also want it to be a well-organised living space. According to the survey, this room is used during the day as a living space for young children, and sometimes as a place for infants to sleep. Modifications to this room often focus on creating storage space for children's belongings, such as installing a cupboard. As for the children's bedroom, in the 670 housing estate, it is intended for children's sleep at night, but during the day it can accommodate a variety of domestic activities thanks to its flexible layout including sofas, offering greater freedom to practice other activities apart from the children's sleep.

CONCLUSION

This study highlights a crucial new line of thinking: exploring effective mechanisms for encouraging resident participation. To implement this approach, it is imperative to integrate a new dimension i.e. that of the user, into decision making and housing management processes, to ensure optimal housing performance. The analysis carried out in this article enabled us to understand how the users integrate their daily and personal habits into the context established by the designer. The aim was to highlight any differences between the functional system of the housing designed by the designer and the actual use by the occupant. The results revealed an urgent need on the part of occupants in terms of surface area and spatial layout inside and outside the housing, to be able to carry out their socio-spatial activities adequately and under standardised conditions. The availability of space dictates its layout. When space is limited, daytime and night-time activities are "separated" only by the time of the day. On the other hand, when space is generous, the two activity categories separate and each develops in a suitable area. It is clear, then, that availability reduces the risk of polyvalence of space. Analysis of the organisation of living space reveals an inconsistency between the layout planned by designers and the practices of users. It should be emphasised that the layout of space is a significant indicator of household lifestyles. Residents aspire to make their housing their own, which reflects their habits, culture and practices. The changes they make reflect their dissatisfaction with the spatial distribution of certain rooms. Restricted spaces limit the freedom to arrange furniture, forcing users to make modifications to make their lifestyle more suited to the space available.

The uncontrolled alterations performed by residents have resulted in several disadvantages for the building façades. A noticeable lack of finish quality is observed in the majority of interventions made by residents. This situation stems from a lack of consideration for the exterior appearance. In addition, the multi-functional use of loggias and balconies has led to uncontrolled drainage of wastewater along the façade. In addition, the drying of laundry at the windows accentuated the deterioration of the walls and the colour of the façade. In this case, the designers could have initially provided suitable spaces for users. This underlines the crucial importance of an in-depth analysis of the relationship between the inhabitants and their housing before any design approach. Researcher Belbacha-Merouche (2009) stresses the need to improve the quality of social housing to prevent constant modifications that hurt buildings and the urban environment. To ensure a better match between layout and needs, it is essential to carry out an analysis of users' desires and expectations. These surveys provide designers with the tools they need to identify gaps in existing layouts, opportunities for improvement and use, as well as fundamental principles that can guide the design of future housing. Involving users in the planning of housing projects facilitates the effective management of project complexity and the implementation of appropriate solutions. Communication is the minimum threshold for any participatory process. Fostering dialogue between project owners on the one hand, and residents on the other, is key to addressing the housing issue in line with current policy. Designers must then put this vision into practice in spatial layout.

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Summaries

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SOCIALIST IN CONTENT, NATIONAL IN FORM: SMALL-SCALE HOUSING ESTATES IN BUDAPEST BETWEEN 1945 AND 1960

Bence Bene

Keywords: post-war, socialist realism, socialist modern, Budapest, housing estate

In the second half of the 20th century, solving the housing crisis became a significant social issue and political task throughout Europe, particularly in the countries of the Eastern Bloc. Although due to its quantity, prefabricated large mass housing estates became overrepresented, dozens of smaller, experimental, and diverse mass housing forms also emerged. It is hypothesized, that due to their scale and quality, these small housing estates are urban planning projects that were realized across political, economic, and architectural changes. To demonstrate their adaptability, this paper presents the small housing estates (HEs) built in one of the capitals of the Eastern Bloc countries— Budapest—during the most turbulent one-and-a-half decades of the socialist era (1945–1960).

The period between 1945 and 1960 is unique because Hungary's housing policy was characterized by immaturity, rough ideas, a lack of resources, and frequent political directive changes (Kocsis, 2009). In this dysfunctional system, alongside reconstructions, new socialist cities, and private family house constructions, only the construction of small HEs can be considered a relevant urban planning project. 60% of the 37 HEs built in Budapest between 1945 and 1960 were small-scale. These smaller interventions were scattered across a wide area of the city, while medium and large HEs served sort of a model, clustered in a few focus areas. This dispersion further emphasizes the uniqueness and independence of small HEs. My hypothesis is that the small housing estate is a persistent urban form that withstands political and architectural changes, adapting to and continuing to meet their requirements.

The research consists of three main parts: (1) Hungarian politics and housing policy, (2) Budapest's urban policy, and (3) a brief presentation of the urban planning and architectural aspects of Budapest's small housing estates. The result of the research is the creation of a complete small housing estates portfolio, illustrated archive articles, archival plans, and photographs. It becomes evident that although the times from World War II to the consolidation of power saw vastly different political eras, directives, and ideals, along with various architectural styles and housing policies, the small housing estate as an urban planning product was able to adapt and survive. Moreover, it is a valuable architectural, housing, and urban planning imprint of the era, the only mass housing form realized in numerous examples in Budapest.

After outlining the housing policy in Hungary and Budapest between 1950 and 1960, the research presents small HEs built in Budapest during this period based on urban planning and architectural considerations. The small-scale housing estates can be divided into three groups, corresponding to political—(1) transition period, (2) Rákosi

dictatorship, (3) consolidation; and architectural—(1) post-war, (2) socialist realism, (3) socialist modern—changes.

During the establishment of state socialism, the post-war small HEs were mostly implemented in the centres of working-class neighbourhoods. The buildings adhered to modern architectural and urban planning principles, but the quality of their construction was poor. During the harshest years of state socialism, the style terror of socialist realism prevailed. The target audience of the small HEs built during this period was, more diverse: along-side elite HEs hiding behind decorative façades with statues and fountains on private plots, there were also barracks-like estates consisting of one-room apartments with reduced comfort. During the years of consolidation, socialist modern small HEs represented consistently high quality, perhaps due to their placement on private plots. They featured diverse architecture and urban forms.

Overall, it can be stated that these small HEs were built in diverse styles, architectural quality, layout, and budget, catering to both the party elite and the working class. Given this universality, they provide an excellent layer of housing and city policy in Budapest of the 1945–1960 period. Over the years, there has been an improvement in the architectural and construction quality of the buildings, with the emphasis shifting from developments floating in public spaces to private plot constructions. Except for the downtown area, small HEs can be found in all areas of Budapest, which demonstrates their success.

Examining the individual small HEs, we can conclude that the research hypothesis has been confirmed, namely that a small housing estate is a persistent urban form that withstands political and architectural changes, adapting to and continuing to meet their requirements. Focusing on the 22 small HEs built in Budapest between 1945 and 1960, the paper highlights the diversity of their inhabitants, the adaptability of their architecture style, and the resilience of their urban form.

FRAMEWORK FOR OPTIMISING DAYLIGHTING AND PASSIVE INDOOR THERMAL COMFORT IN SINGLE-BANKED OFFICE BUILDINGS IN THE TEMPERATE DRY CLIMATE OF NIGERIA

Muhammad Aminu Musa, Abubakar Sadiq Salisu, Murtala Muhammad Salihu

Keywords: daylighting, daylight autonomy, operative temperature, parametric analysis, single-banked office building, thermal comfort, validation

Achieving adequate passive indoor environmental comfort determines whether a sustainable building design succeeds or fails. The relationship between daylighting and passive thermal comfort is crucial in tropical countries like Nigeria in order to prevent environmental disorder. Maximisation of sunshine during periods of strong solar radiation, for instance, would result in an increase in indoor temperature and discomfort from heat. This is an example of a single comfort element taken out of context. As observed, comfort increases performance, which is a function of three factors acting together: ability; motivation; and opportunity. Many researchers have differed on the optimum values of Daylighting and Passive Indoor Thermal Comfort (DPITC) determinants in tropical climates. For example, one researcher recommended the best orientation of office spaces in a temperate dry climate with the windows north- and south-oriented, while another proposed a compromise position of 22.5° (south-south-west) for thermal and visual comfort. However, a different researcher proposed 15° west of south and 15° south of west as the compromised value for DPITC. ASHRAE 90.1 recommends a window-to-wall ratio (WWR) of 20% for mid-rise buildings while the International Energy Conservation Code (ICC) recommends a different value of 30%. Another study carried out in the temperate dry climate of Singapore suggested the use of 24% WWR, whereas one scholar found a range of 20% to 30% as the recommended values of WWR in the temperate dry climate of Lahore Pakistan for PITVC. For R-values, ASHRAE 90.1 recommends a minimum range of 1m2K/W to 2.68m2K/W, while International Energy Conservation Code (ICC) suggests 2.64m2K/W to 3.52 m2K/W, and Energy Conservation Building Code (ECBC) recommends a value of 3.7 m2K/W.

The study is aimed at developing a framework for optimising DPITC in singled-banked mid-rise office buildings, during the activity period (8 a.m. to 5 p.m.), in the temperate dry climate of Nigeria. It was achieved by evaluating the effects of Orientation, WWR, R-values, and shading devices on DPITC. A quantitative research design using an explorative design approach was employed in the study as well as an experimental research strategy using a simulation method to enhance DPITC. The study used the Federal Secretariat building as a prototype of a single-banked office building. The criteria used in the selection of this building were based on the building type, number of storeys, access to buildings, and its passive method of achieving indoor comfort. The Google SketchUp 2022, Radiance, and OpenStudio simulation tools were used to evaluate the prototype building of the Federal Secretariat in the temperate dry climate of Nigeria from January to December 2023. Six (6) sets of offices (48) were selected for the simulation and the data generated was analysed using relevant statistical tools (MANOVA, ANOVA, column charts, graphs, and tables).

The findings revealed that the best orientation for daylighting and thermal comfort was found to be 00 and 11.50 respectively, while the compromise value was found to be 11.50. For WWR, the optimum for daylight and thermal comfort were found to be 20% and 15% respectively while the compromise value was 20%. The result has also revealed that 0.6 was the most appropriate projection factor for better operative temperature as well as relative humidity, and 0.35 for daylighting and the compromised value for DPITC was found to be 0.5. It was also noted that the R-value of the external wall insulation material does not affect the daylighting of the office building but affects operative temperature as well as relative humidity; the optimum value was found to be 3.26 m2·K/W. These were all done using parametric optimisation due to its easy use and vivid logical procedure. A framework was developed and used to obtain four more optimised DPITC values for single-banked buildings. The multiple regression was then carried out to investigate whether the optimised values of WWR, projection factor, and R-value of external wall material could significantly predict different enhanced azimuth angles for DPITC in single-banked office buildings in a temperate dry climate of Nigeria. The results of the regression indicated that the model explained 99.9% of the variance and that the model was a significant predictor of azimuths, F(3,1) = 4700.848, p = .010721.

The WWR, projection factor (PF), and R-value of external wall materials (R) contributed significantly to the model (B = -1254.84, p=0.010872), (B = 102.8743, p=0.017526), and (B = -4.10695, p=0.044915), respectively.

Y=C+M1X1+M2X2+M3X3……..4.1

The 4.1 formula was used to develop the model from regression results as follows:

Azimuth (A)= 224.5802 + (-1254.84 x WWR) + (102.8743 X Projection Factor) + (-4.10695 x R-Value)

A= 224.58 - 1254.84WWR + 102.87PF - 4.11R…….4.2

SI Units: A= (0); R= (m2.K/W); C= (0); M1= (0); M2= (0); and M3=(0 W/m2.K).

The framework was then validated using the examination of framework output for reasonableness under a variety of settings of the input parameters. The values given by the Building Code of Australia (BCA), Australia's guide to environmentally sustainable homes (AGESH), ASHRAE standards as well as International Energy Conservation Code (IECC) were tested, and the results were complied with A= 224.58 - 1254.84WWR + 102.87PF - 4.11R.

WEIGHT AND STRUCTURAL CONSIDERATIONS OF POTENTIAL GREEN ROOF GROWTH: MEDIA COMPOSITIONS FOR THE NIGERIAN BUILDING INDUSTRY

Murtala Muhammad Salihu, Aminu Muhammad Musa, Abdullahi Getso Ibrahim, Jamilu Usman, Abubakar Sadiq Salisu

Keywords: green roof, growth-media composition, substrate weight, lightweight construction

Green roof technology is still in its incipient and exploratory stage in the Nigerian built environment industry. It is a technology that is yet to be locally embraced due to a lack of adequate awareness of its benefits, limited technical knowledge and high initial and/or maintenance costs of the system. Most importantly, the green roof system is technically associated with problems that are centred on the characteristic weight of its growing media (substrate). This is regarded as the most critical and challenging aspect of a green roof project that must be considered to avoid the ultimate failure of the primary roof system. Although the International Building Code (IBC) has stipulated that green roofs are computed as live loads calculated based on saturation of the soil and shall be within the range of 0.958kN/m2, studies have shown that values and attributes of green roofs are location-specific and each scheme must therefore be considered as a distinct case from one setting to another. This study hence becomes a necessary platform for evaluating the weight implication of the outlined potential green roof growth-media compositions in Nigeria for subsequent reference and possible adoption.

The approach adopted for the study involves laboratory procedures and experimental field observation. Guided by pertinent literature review, the most available and appropriate natural stones in the Nigerian building industry were evaluated, the stones outlined for the study include laterite stones, sandstone, granite, river gravel, pumice, and recycled masonry debris. The geometry selected for this study is a classroom block designed under the MDG (Millennium Development Goals) program for public primary school education in Nigeria. The roof design of the project is a typical reinforced-concrete flat roof which is the most suitable for use in green roof systems due to the large load-bearing capacity it can withstand. To avoid a cumbersome presentation of the load analysis for every extensive green roof model, relevant load calculations were limited to the heaviest and the lightest green roof alternatives to represent the embodiment of the best- and worst-case scenarios to guarantee adequate and efficient sampling steps required to reach any theoretical saturation. Using BS8110, the study was focused on determining the compressive strength (fcu), minimum yield strength (fy), depth (d) and the resultant design load of the primary roof structure against the density of the composite nature of the Green roof materials. The general green roof evaluation was finally tested for compliance with the IBC (2018).

The laboratory analysis revealed that the granite-based blend is the heaviest sample with 1,713.30 kg/m3 in its saturated state. River gravel blend and the laterite stones followed closely with 1,264.50 kg/m3 and 1052.20 kg/m3 respectively. The lightest in weight is the pumice blend with 869.30 kg/m3 which is a difference of 942.90 kg/m3 from the heaviest granite blend, implying that it is 50.7% lighter in weight; followed by the masonry debris blend with 1,115.90 kg/m3. A successive conversion was conducted to estimate the weight of the 50 mm, 100 mm, 150 mm, 200 mm, 250 mm and 300 mm-thick models in kg/m2. The granite blend medium recorded the heaviest values at 85.65 kg/m2 for the 50 mm and 513.90 kg/m2 for the 300 mm model, while the lightest in weight is the pumice with 43.50 kg/m2 for the 50 mm and 261.00 kg/m2 for the 300 mm. The masonry debris also recorded an encouraging figure at 55.80 kg/m2 for the 50 mm and 334.80 kg/m2 for the 300 mm model. The results show that most of the substrate blends satisfy the stipulations of both the FLL (2008) and the ASTM International (2014). Results from the structural analysis conducted on the heaviest sample (Granite substrate) and the lightest sample (Pumice substrate) showed that the saturated Granite substrate having a 0.951 kN/m2 design load falls within the stipulated range of the IBC, and can therefore be used in any extensive green roof project. On the other hand, the pumice blend, being the lightest substrate had a design load of 0.576 kN/m2. It therefore stands to offer an optimum alternative in green roof retrofitting projects for existing flat-roofed buildings.

In summary, the study concludes that all of the substrate compositions covered in the study involve materials that are readily available in the studied area and can be used with respect to their characteristic properties as presented in this study. The study therefore serves as a reference point for all stakeholders in the research and building construction industry in Nigeria and places with similar bearing in the need to develop and promote the use of green roofs as a mainstream feature of the built environment.

ENHANCING VISUAL COMFORT IN STAIRCASES: A COMPREHENSIVE ANALYSIS AND DESIGN RECOMMENDATIONS

Hassina Benkouda, Samira Louafi, Ammar Mebarki

Keywords: visual comfort, transitional space, adaptation, staircase, design, illuminance, changes, occupants, performance

People should be walking towards the inside of dwelling through an appropriate visual environment in transitional spaces. In these spaces, the occupants are able to experience the dynamic effects of the external climatic changes. The ability of users to adapt to changing dynamic conditions of the environment around them is very important. It is crucial to consider how the user will feel in the light conditions. Luminous conditions can change drastically as users transit from indoor to outdoor spaces or vice versa. A study by Mohamed et al. (2007) identified changes in lighting conditions in architectural transition spaces as one of the main factors in altering human eye adaptation, and identified this problem as a possible cause of "visual shock". Therefore, in these transitional spaces, people might not have enough time to reach a stable state of visual adaptation to ensure the best response needed to perform a task. At the same time, the people could suffer some kind of visual discomfort. The proper understanding of visual adaptation parameters helps architects provide a suitable environment for inhabitants. Most studies were related to thermal comfort in transitional spaces. A few discussed the problem of visual comfort in transitional spaces, and examined eye adaptation and how users perform in these spaces.

This paper studies the effect of staircase design on the visual comfort of users and how they perform and adapt in this transitional space; it aims to specify design elements of the staircase in collective housing, to achieve a visual comfort in this transitional space. This research employs a two-pronged approach field measurements and a visual comfort survey conducted using a questionnaire; 144 questionnaires were collected, in four buildings with different staircases treatment in the city of Arris. Field measurements were conducted in winter 2021 and in summer 2021. The quality of day lighting was evaluated by measuring horizontal illuminance levels at the height of 1.5 m from the ground. 172 measurements were taken from the exterior of the buildings to the interior of the houses passing through each landing in the staircase. Illuminances were measured by Delta OHM LP 471 PHOTO. Illuminance and its distribution across the task area and its surroundings have a major impact on how quickly, safely and comfortably a person perceives and performs a visual task. Excessive variations of horizontal illuminance must be avoided; the diversity of illuminance expressed as the ratio of the maximum illuminance to the minimum illuminance.

The current method compares measured data to the CIBSE recommendations. Illuminance ratios were computed and then matched on a four-point scale ranging from "subtle" to "dramatic", expressing the variations in illuminance ratios between various points of measurements. To determine how the residents felt and performed inside the staircases, a visual comfort questionnaire was designed. The questionnaire consisted of three sections: physiological symptoms, visual task performance and user preferences. The questionnaire responses were processed using Microsoft Excel, which produced graphs and charts to illustrate the survey results. The results show that at the entrance of Building 3, the solid overhang (with a depth of 2 m) permit "subtle" and "moderate" visual shock providing adequate transition leading to reasonable visual comfort and prepare the eye for the changes in the illuminance. The absence of solid overhang at the entrances to buildings 2 and 4, means that there is no area that allows for the gradation of illuminance values, making the eye experience a sudden change between the outside and inside of the building, which makes entering and exiting the building visually uncomfortable. In addition to that, in part 3, question 4 of the questionnaire, when residents were asked what place caused them visual discomfort, most of those who answered: the entrance to the building, were from buildings 2 and 4.

In a staircase with the percentage of opening of 88% indicated "strong" and "dramatic" visual shock in many points and as this staircase is open, it is exposed to light conditions so it does not ensure the necessary transition which leads to advise against the open staircase. In the staircase treated with transoms of clear glass with the percentage of opening of 11%, these transoms direct the light to specific areas creating "strong" visual shock in many points of the stair landings which leads to advise against that. The staircases treated with vertical bays throughout the facade presenting a percentage of opening between 19% and 22%, these treatments allow the penetration of daylight in a diffused way which ensures a balanced distribution of daylight inside the staircases, indicating "subtle" in most points and "moderate" in some points provides adequate transition leading to reasonable visual comfort in the stair landings. In part 3, question 4 of the questionnaire, when residents were asked what place caused them visual discomfort, for those who answered: between level and another, low percentages (0%, 9%) were from buildings 2 and 4. The study suggests design elements that support the visual adaptation in the staircase: the existence of a solid overhang at the entrance; the façade treated with vertical bays, where the percentage of opening of the façade is between 19% and 22%, provide adequate transition leading to reasonable visual comfort and adaptation.

SOCIAL HOUSING - BETWEEN DESIGN AND SOCIAL PRACTICES: THE CASE OF THE 670 SOCIAL HOUSING UNITS IN ORAN

Bachir Benyamina, Sidi Mohammed el Habib Benkoula

Keywords: social housing, occupants, needs, preferences, housing designed, occupant expectations

Habitable architecture, intrinsically linked to its user, has an essential social dimension that finds its meaning in a specific context. This context defines space as both a physical and a cultural entity, which raises the fundamental question of the spatial organisation of housing, particularly from the modern era to the present day. This spatial organisation is based on the idea of harmony between the designed space and the values of the society that generates it. The dialectical relationship between the intimacy of private space and the collective aspect of housing in relation to its immediate environment is analysed from a social perspective, taking into account family dynamics and everyday practices.

With this in mind, the interior of the housing and its external environment form a spatial whole that responds to the needs and expectations of the occupants, materialised in the plans and façades. Aesthetic and decorative choices, such as the paintings and photographs adorning the walls, bear witness to the culture and lifestyle of the inhabitants, reflecting the objects and values of contemporary civilisation. However, several factors can create a gap between the space designed and the space lived in, including the layout of rooms, their relationship with the outside world, access to the home, proximity to neighbours, and many others.

Collective housing policy varies between socialist and capitalist regimes, with significant differences from one country to another. Its implementation depends largely on government action. In Algeria, the collective housing strategy has been a means by which the relevant institutions have been able to guarantee the right of homeownership for Algerian families, an achievement stemming from the housing policy put in place by the authorities since the 1980s. However, the mass construction of social housing has put considerable financial pressure on state resources, with difficulties in making a profit. From the 1970s onwards, the demand for housing urgently intensified, prompting the state to resort to the industrialisation of the construction sector. This led to the import of various construction technologies and methods to meet the growing demand.

Despite these efforts, the social housing built in Algerian cities does not always correspond to the needs and expectations of local families. Programs such as the ZHUN formula, designed within the framework of urban planning, often without taking into account the socio-cultural realities of the inhabitants, have been criticised from their inception to the present day. The cramped nature of housing and the high number of people per household remain among the main obstacles to their adaptation to the real needs of Algerian families.

Residents tried to adapt to these housing units by making modifications to gain more space, both inside and out. While these adjustments benefited occupants in terms of interior comfort, they also hurt the overall appearance of the city. Indeed, these redesigns have often deteriorated the urban aesthetic. The compromise between quantity and quality was not fully taken into account, despite the initial objective of rapid construction to relieve pressure on the real estate market. The aim of this article is to explore residents' practices in order to establish a connection between the housing designed and built on the one hand, and residents' expectations on the other. Indeed, the question that concerns us is this: how do Algerian households approach redeveloping housing that was initially designed without taking their needs and preferences into account?

This article presents the initial results of a study of social rental housing (LPL) in Oran, Algeria, a city that has benefited from large-scale social housing programs since the 1970s. From 1980 onwards, it was widely recognised that a reallocation of resources was needed to guarantee access to housing for low-income groups. At the December 1979 meeting of the Central Committee of the National Liberation Front, clear resolutions were made concerning housing, as part of the preparation of the new national development plan.

The study involves collecting data on the housing, as well as interviewing residents to compare the initial state of the dwellings with their subsequent evolution. The aim is to evaluate the ability of users to adapt and personalise their housing to improve their quality of life according to their needs and preferences. The study object is the 670 housing estate (LPL) at Hai El Sabah. The analytical method used is the Post Occupancy Evaluation (POE) approach, a multi-method approach to data collection that includes direct observation, plan analysis and questionnaire. The housing units studied were not selected according to any particular method, but rather chosen on the basis of the residents who agreed to answer the questions and share their lifestyle and expectations regarding their housing. By comparing the initial plan drawn up by the designer with the current plan modified by the inhabitant, we were able to deduce the differences between the two plans and understand the ways in which the housing interior is appropriated.

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