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TRADITIONAL CIRCULAR PLAN HOUSING FOR RAPIDLY URBANIZING RWANDA

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Abstract. *Rwanda's plots and housing plans featured a circular shape until the time of colonization by Germany and Belgium, when—beginning with the house of Dr Richard Kandth in 1909—a new configuration of buildings and plots having a square or rectangular base was introduced. Today, some of Rwanda's contemporary public buildings seem to recall traditional circular forms, merging local building tradition with the aesthetics of global architecture. With a population of more than 12 million and an annual growth rate of 2.8%, Rwanda aims to accelerate the pace of urbanization by making significant investments in urban infrastructure and the construction sectors of the capital city Kigali and secondary cities. This includes the recent revisiting and development of Rwanda's master plans and the creation of strict guidelines for plots sizes dedicated to individual housing. This paper reconsiders the shapes that may emerge from these frameworks and raise the possibility of a re-emergence of traditional configurations that would reinforce Rwandan identity and transform rapid urbanization into a mechanism of cultural significance. This paper provides an overview of the historical, technical, cultural, and aesthetic values of pre-colonial architectural circular shapes, while also tracing those influences on twenty-first-century public buildings in Kigali and other cities of Rwanda. Authors consider as well how these traditional shapes may potentially be used in housing solutions given the current master plan requirements. Although the circle is not commonly used at present as a plan for single-family housing due to the technical challenges and higher construction costs involved, it nevertheless remains a historically and culturally important design having significant potential for future applications.*

Key words: *circular plans, built heritage, contemporary architecture, Rwanda*

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1. INTRODUCTION

Unlike settlements, in which units are usually grouped, Rwanda's family units were traditionally spaced apart, and surrounded by planted fields [1]. Such dwellings were typically situated on the tops of hills in areas with minimal slope and could be extended to serve additional functions associated with cattle keeping and artisan workspaces. The size and quality of the hut's construction varied according to the social level of the owner. While living in circular spaces is foreign to most contemporary dwellers, the central plan has been utilized since the prehistoric times [2], while the arrangement was commonly practiced and well-known in pre-twentieth-century cultures, including Rwanda, which, before its colonization, traditionally used circular plans for housing. This design has been also occasionally utilized in Rwanda's twenty-first-century public building architecture (Figure 1). In this study, authors analyze to what extent circular building forms correspond to a sense of efficiency and assess what contemporary architecture can learn from this design.

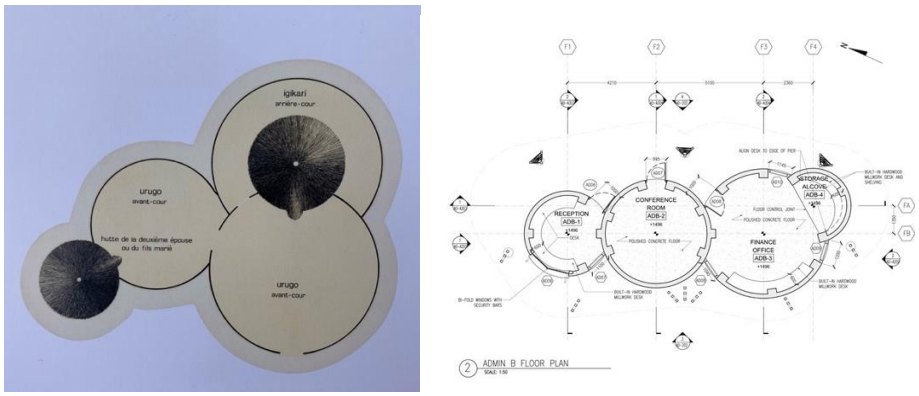

Fig. 1 Traditional habitat of Rwanda with circle plan housing and plots (left) and plan of the Women's Opportunity Center by Sharon Davis Design built in 2013 (right) © Celestin & Van Pee, 2008: 96; Sharon Davis Design

There are no preserved built structures in Rwanda from the period before 1900 that is, before the colonization period, as Rwandans traditionally used perishable construction materials [1]. After being appointed by Germany as a colonial administrator in Rwanda, in 1909 Richard Kandt began building the new capital, including his own house, which is the oldest remaining built structure in Kigali, Rwanda's capital [1, 3, 4, 5]. The colonizing powers, first Germany and then Belgium, introduced housing and public buildings with rectangular or square bases, some of which remain today: Maternity Clinic CHUK, Kigali Central Prison, Cloister of the Bernardine Sisters in Kigali, Group Scolaire, Our Lady of Wisdom Cathedral, and the post office in Huye [5], to name a few. After its independence from Belgium in 1962, Rwanda continued to develop the infrastructure in Kigali and other secondary cities following known, previously introduced models.

During the genocide against the Tutsi in 1994, many of the heritage buildings were places in which crimes took place, and many of the buildings were destroyed either during or after the events of the genocide. Following the beginning of the reconciliation process

with the new government, a period of urbanization began [6]. Kigali is a rapidly growing city, as exemplified by the dramatic increase in its population from 358,200 in 1996 to 1,630,657 in 2017 [6]. Outside Kigali, there are other rapidly growing towns as well, known as secondary cities, which were established to increase the urbanization rate of Rwanda [7, 8]. The growth of these towns led to a rapid population increase in these areas as more economic opportunities emerged, thus influencing the rural-urban migration.

This urban rebirth process was followed by Vision 2020, Vision 2050, the Economic Development and Poverty Reduction Strategy (I & II), the National Strategy for Transformation (I), master plans, and various other new plans and policies related to green cities and green buildings [5, 7, 8]. As Rwanda was economically progressing, the nation also delved into its traditions and culture to find model buildings appropriate for its future development.

Achieving this goal implies an approach that considers how circular plans may be executable through modern housing architectural techniques. Various factors must be taken into account, including current economic opportunities, local (available) materials, construction technology, energy sustainability, climate factors, exposure to sunshine and protection from rain, sloping terrain, and the unique conditions on the particular plot.

2. METHODOLOGY

In researching for this paper, a combination of materials and methods was utilized. As there are no buildings with a circular plan from the pre-colonial period remaining in Rwanda, the authors visited built heritage sites and pre-colonization period housing replicas at the Ethnographic Museum in Huye to better understand the traditional construction materials, construction elements, the size, and the organization of the inner space of circular building plans. In the course of the research, all of the constructed projects of the XXI century in Rwanda discussed in this paper were visited to make comparisons to globally constructed public buildings with circular plans as well. A document review was also carried out to understand both historical and recent developments in the use of circular plans in Rwandan architecture as well as around the globe. The publications consulted are about the culture of Rwanda and were mainly prepared by the Government of Rwanda and published by its Ethnographic Museum, whereas for the global overview, the authors reviewed relevant academic articles published to date. The focus was on examining circular plans in Rwanda's built heritage and tracking emerging patterns within contemporary architecture in Rwanda, as well as understanding how these patterns follow Rwandan traditions and/or global trends concerning the functions and aesthetics of circular shapes. Additionally, this paper includes the data from two school years of a semester-long course "Architectural Theory" at the University of Rwanda, School of Architecture and Built Environment, in which contemporary architecture in Rwanda was discussed and documented throughout 2018–2020, analyzing global examples (as presented in subchapters 3.1 and 3.3.). Within the course "Architectural Theory", architects working for the Mass Design Group were invited as guest lecturers to better understand their construction practices and the reasoning behind their use of circular forms for public buildings – this information further becomes qualitative data that feeds on the present research. The data collected for this research also includes photographs of buildings in Kigali and other cities taken between 2018–2020.

In this paper, only regular and half circles were analyzed, and one example of an ellipse. For further research, the subject of analysis may include a deformed circle or a combination of a circular base with orthogonal shapes: a circle with a cut-out and/or an add-on circle, an orthogonal base with a truncated circular atrium, and so forth.

3. THEORY: CIRCULAR FORMS THROUGHOUT HISTORY AND IN ARCHITECTURAL THEORY

Traditionally, a circle represents unity, the absolute, and the ideal order, yet, not all circular cities and buildings are cosmograms associated with magic, power and religion [9]. In architecture, forms derived from circular geometry are often thought of as a gesture of "divining the constructed world" [10]. Associated with the divine and the notion of 'perfection', it is no surprise that the circle has also come to symbolize power through a variety of approaches, such as "having the idea of physically arising, constituting centrality, creating a powerful look in the cityscape – nearly all examples are landmarks, gathering and uniting people" [11]. The power of this shape is manifested further when related to magic or religion, guided by mathematical perfection, therefore, acquiring symbolic and sacred purposes in architecture and urban design [12]. Distinctive and well-known examples of integrating the circle into architectural and city design are found as early as in the Greek cities, with the statue of Athena Promachos "asserted the circle of presence of the goddess over the ancient city of Athens" [13], while other examples of cities integrate their planning organization through the shape of a perfect circle, as found in The Round City of Baghdad and the Old City of Shanghai.

A defining property of the circle is that every point on the perimeter lies the same distance from the centre. Nothing is in front of or behind anything else; there is no beginning and no end. Structures designed in this architectural tradition are not only societal and cultural manifestations but are also intended to influence the outer and inner lives of anyone who interacts with them, given the perceptual attention that the shape creates. For example, "a standing stone asserts its circle of presence in the landscape and establishes the place of those who put it there" [14]. The circle taken as a basic, universal geometric shape is an intriguing topic for research in contemporary architectural practice. Given the development of new technologies and materials, circular plans and spheres (i.e. circles in bases and sections) are routinely the subjects of research into new aesthetic ideas in architecture, and their various functions (e.g. integration function, centre/core function, space fluidity, democracy and symbol formation) are commonly discussed.

Historically, circular forms at the global level have been employed throughout entire eras, evident as early as in the early Neolithic era in the Near East, "with simple round monocellular structures" [15]. From ancient Roman times, the Vesta temple, as described by Vitruvius, implements a few circular features such as "a round cella, a circle of columns, and the hemispherical dome of the cella" [13, 15]. Bramante added to the integration of the circle as a distinctive architectural shape through "the way in which the drum and dome project beyond the ring of columns", portraying an ascent of the martyr's soul [15]. Convinced by the power and practicality of the circular geometry, it is not only applied to city organization and representational structures of power but also individual houses, from early times, with round houses seeming to "[dominate] the settlement record from at least the beginning of the 2nd millennium BC" [15]. Looking at Chinese culture, for example, it becomes clear that the round form has been in use there for several thousand years. One

example is the tulou ―traditional, circular houses that the Hakka people have been building in Southeast China since the 12th century. These housing complexes, organized around a circular inner courtyard, are built with high clay walls and can accommodate almost 800 people within up to five levels. The circular form endures in many other cultures as well to this day [16, 17]. The nomads of Mongolia, for example, still live in their round yurts.

Circular bases and balls (i.e. circles in bases and sections) are, with the development of new technologies and materials, continuously the subject of research into new aesthetic ideas in architecture that reconsider various program ideas, while they seem to "have a better chance of fitting into the location with low development density or not developed ones […] [with] no clash between the existing orthogonal buildings and a new circle building" [2]. In the following sections, examples of architectural objects of the twenty-first century and several iconic structures from the twentieth century are analyzed in terms of significant aesthetic ideas in which the circle is a key element, where 'aesthetics' go beyond a subjective appreciation of form but are based on parameters that constitute the form as an important perceptual stimulus of i.e. experience, memory, emotion, symbolic function, heritage importance, etc.

Moreover, each aesthetic idea is considered in its entirety, concerning how the space is used, that is, to the program idea, context and materials. Each of the analyzed examples reflects a distinct approach to architectural research and represents a unique spatial-program solution. However, the main goal of this analysis of buildings with circular foundations is to identify topics important for theoretical consideration and which, as such, represent a framework for learning and further application in architecture. Thus, the theoretical potential of aesthetic ideas was the main criterion for selecting the examples included. The following topics have been identified: application of circular foundations to form non-hierarchy architecture; circular bases having the function of emphasizing gathering/integration; circular atriums (circular forms in the negative) to enhance the fluidity of interior space; spiral ramps that enable uninterrupted connection of space vertically to realize various program ideas; spheres and bubbles and the formation of a single inner world; an airy interior "caught" by a ring structure with glass facades, and; irregular circular shapes as part of organic aesthetics. There is no evidence from historical texts or archaeological findings that would elaborate in more detail on the reason why circular shapes were used by the Rwandans to construct their habitat.

3.1. Learning from across the globe: public buildings with circular plan

The 21st Century Museum of Contemporary Art, Kanazawa by SANAA Architects, has a structure of a cylinder with a diameter of 112.5 m and with a glass envelope the height of one floor (ground floor), which is a relatively small height in relation to the diameter [18]. This low cylinder represents a connecting unit in several ways. First of all, the cylinder determines one's first encounter with the museum: While its circular shape clearly defines the boundary of the building, emphasizing the large center dedicated to 21st-century art, its small height and glass envelope make the encounter very welcoming. Secondly, the circle relates equally in all directions to its context, which means that there is no pronounced hierarchy in the classical sense, this being an important theme in SANAA architecture [19]; Thirdly, the cylinder forms the primary medium of communication within the museum, connecting the exterior with the museum's contents, which are located in cubes of higher heights within it. The cylinder offers a view of the context from all sides

equally, which with long, arched benches that follow the diameter makes it an ideally protected resting area. Furthermore, the cylinder's circular shape and glass facade are readily understood by visitors, which contributes to easier navigation within the complex space of the museum. In this building, the circular form highlights the building's main conceptual intention, which is to design a park for people to gather and meet, but at the same time, allow them to have access to multiple spatial directions. Here, the circular form "facilitate[s] easy access and a sense of closeness between the building and the city" [20]. Meanwhile, the glass material takes on the role of a reversible membrane where one person 'senses' the other's presence, simultaneously enhancing "a sense of encounter" [20].

The Rolex Learning Center (SANAA) building can be described in terms of a shape having two parallel horizontally-oriented surfaces that are wavy in certain places and contain irregular circular atriums (cylindrical shapes in the negative; i.e. "cut-out"). These atriums, in addition to providing natural lighting and enhanced ventilation, provide through their organic aesthetics the undisturbed fluidity of the interior space. This experience of fluidity and interconnectedness of space is especially important considering the main purpose of the facility: to function as a learning laboratory - an international cultural hub for EPFL that is open to both students and the public. Thus, the aesthetic idea of circular forms is present in the function of the fluidity of space, that is, the program. The circular form here is used to experiment with new and radical ways of interaction, taking advantage of the form to experience views from a variety of levels. On the larger scale and concerning the landscape, the circular shape can minimize the sense of physical boundaries and create a type of artificial geography – "an interior landscape" [21], while on the architectural scale, it reinforces social interaction and learning through the circle's introvert properties.

The first thing one notices in the iconic Solomon R. Guggenheim Museum by Frank Lloyd Wright is the conical structure (inverted truncated cup) that dominates the museum's architectural composition. Although the first impression is of the sculptural quality of this form, Hal Foster emphasizes its essential, integral nature as "formal logic, whitish spiral, as well as program idea, [a] museum as an uninterrupted ramp" [21], which makes this circular interior iconic. Here, the circular form emerges from the continuous logic of the spiral, where the moving force is towards the center, however, objects are placed on the structure's perimetric boundaries, not allowing people to experience the surrounding urban landscape. This building, therefore, highlights the circular form's introvert properties, and its possibilities for an endless type of circulation deriving from the properties of the spiral (Figure 2).

Fig. 2 and 3 Solomon R. Guggenheim Museum by Frank Lloyd Wright in New York City, USA (left) and Reichstag by Foster and Partners in Berlin, Germany (right) © Ilija Gubić, 2010

In contrast, the uninterrupted circular ramp in the glass dome of the Reichstag (New German Parliament) by Foster and Partners, which is also a public space, has a different function: It allows an uninterrupted view of the surrounding space, the city of Berlin. From this vantage, a visual connection with the space occupied by the Assembly Council, located below, is established and "the Bundestag's significance as a democratic forum, an understanding of history, [and] a commitment to public accessibility" [22] is emphasized (Figure 3).

Similarly using the circular shape as an extrovert opportunity for surrounding viewing, Your Rainbow Panorama, artwork by Olafur Eliasson, is a ring structure that was placed on the roof of the ARoS Aarhus Kunstmuseum in Denmark from 2006 to 2011. The small thickness of the ring (approximately 3m) and its rainbow-colored glass façade allowed a view through the walls of the ring (to the visitors moving inside it) from either side of it. This also meant that visitors could view the surrounding city through color filters, allowing for a dynamic view of the very structure of the ring and the colors that overlap. Adding on to this concept, the designers took advantage of the endless properties of the shape, its creation of continuous and uninterrupted movement, and its always changing orientation, creating spaces where one only sees things when moving, and experiencing a variety of different light intensities and spectrums, creating experiential conditions of shifting appearances and constantly renewing relationships between the museum and city.

Exploring the spheres (biosphere) and forming the idea of a specific inner world is a popular topic in architecture in the twenty-first century, often found in coexistence with the concept of ‘Anthropocene’, implying the message that “human activity is having a dominating presence on multiple aspects of the natural world and the functioning of the Earth system, and that this has consequences for how we view and interact with the natural world” [23]. While the emphasis on the shape was first highlighted in architectural design through Buckminster’s Geodesic Dome for the 1967 Montreal exhibition, materializing the aspiration to “make shelter more comfortable and efficient” [24], drawing our attention to the needs of the people, the present-day sphere reference also targets a contemporary triggering issue of climate change and the energy crisis, seeking to allegorically represent the dynamics between human and nature. Consequently, the biosphere calls people to examine their surroundings closely, as that is where living organisms exist, while “no entry of life into the biosphere from cosmic space has ever been observed” [25]. The Amazon Headquarters building in Seattle, designed by American architecture firm NBBJ, for example, is a structure made up of three connected spheres within which the workspace is intertwined with “more than 40,000 plants” [26]. The project is the product of research into the connection between interior space and nature, with the aim of a new, more pleasant work environment.

A unique example of the use of an ellipse in a multi-family residential building is the Zug Schleife by Valerio Olgiati. Its longitudinal façade, which features consoles with ellipses in the negative (cut-out), can be understood once these elliptical forms in the negative are viewed from the interior. That is, behind each ellipse there is a living room. Looking out from the interior of the cube-shaped living room towards the ellipse, the impression is created that the room is in the center. Therefore, the program idea involves experiencing the space from the interior of the apartment such that residents have the impression of being in the small center of each apartment, while the elliptical openings also “generate a sense of distance” [27].

Finally, the base of the Chapel of Reconciliation in Berlin by local architects Rudolf Reitermann and Peter Sassenroth consists of two irregular circular shapes, one inside the other. A space of deceptive width has been created between two shells, of which the outer one is semi-permeable (composed of elegant vertical wooden elements) and serves as a filter. In this way, this interspace together with its envelopes is a connection between the outer world (context) and the inner world of the chapel: a preparation for movement from one world to another. The irregularity of the circular bases makes this transition more spontaneous and organic.

3.2. Examples from Rwanda: public buildings with circular plan

A modern example of the use of circles and circular structures in Rwanda is the Ellen DeGeneres Campus of the Dian Fossey Gorilla Fund, which opened in 2022 (Figure 4), designed by Mass Design Group (MASS). The flat green roofs of the complex are intersected by low circular structures, that is, shallow cylinders with glass cladding that slightly overhang the roof and provide natural lighting to the interior space. Also, these circular structures affect the internal organization of space by forming a center in the open, circular interiors below. Immediately noticeable is that the spatial program solution formed in this way provides natural lighting to the space in the middle. The interior space here is more used compared to classic atriums, and the use of glass is minimal, which is important for Rwanda (given the limited availability of glass).

Fig. 4 Ellen DeGeneres Campus of the Dian Fossey Gorilla Fund by MASS Design in Musanze, Rwanda © Iwan Baan, 2021

The Rwanda Institute for Conservation is a new campus designed by Mass Design Group (MASS) in Bugesera, Rwanda. The primary guiding concept for the RICA campus was the creation of a so-called “one health" space, which refers to the integration of humans, animals and plants in one space as a single element. Through this approach, MASS transformed the previously existing conditions of degraded soil, food insecurity

and deforestation into a "one health" design promoting environmental, human and animal wellness. Through a climate-smart design, MASS is using locally available materials and incorporating passive design systems. Circulation throughout the spaces has been created to promote different flexibility. In addition, the design approach aims to reduce the embodied energy of the building through better integration of space and through the building materials used, namely, wood, rammed earth and reinforced concrete. Passive lighting and ventilation systems have also been incorporated as an example of sustainable architecture. Perforations along the north-south side are meant to improve the ventilation of the building. In addition, the use of large windows and clear glass optimizes daylight. Cross ventilation and stack ventilation through the dining and sleeping rooms were also integrated into the design, and long, vertical wooden slats are integrated into the space to ventilate the corridors and bathrooms. In addition, clerestory windows have been used to create more lighting in the building and ventilate the space even further.

Kigali Convention Complex comprises Kigali Convention Centre and Radisson Blu Hotel, designed by German architect Roland Dieterle. The complex spans over 13 hectares on 80,000 m^2. The landmark Kigali Convention Centre (KCC) is shaped like a dome, which has special significance in traditional Rwandan architecture: By use of the dome, the architect refers to the King's palace in Nyanza (which is also dome-shaped) and has adopted traditional construction technologies but with modern materials, resulting in a steel structured dome (Figure 5). The KCC has 17 function rooms and an auditorium, with its unique design integrating the culture and traditions of Africa into the facilities and their functional technology. The first and largest convention centre in the region, with a capacity of 2600 guests, the KCC is the leading destination for large events in Rwanda.

Fig. 5 Kigali Convention Centre and Radisson Blu Hotel by Roland Dieterle in Kigali, Rwanda © Emmanuel Kanmugire, 2016

Designed by Sharon Davis, the Women's Opportunity Centre (Figure 6) is a village-like series of low-rise pavilions serving as classrooms and arranged in a circular pattern at the heart of the Kayonza site in the eastern region of Rwanda. The project aims to design a safe public space for over 3000 women and girls so as to promote their social and economic development within the context of the local Rwandan culture using available natural materials [5]. A farmers' market, a community space, gardens, and guest lodgings are all arranged along the outer edges of the circle. The design revives a lost Rwandan design tradition, as its main idea is derived from vernacular Rwandan villages. The buildings have round shapes, perforated brick walls, and hanging roofs, thus allowing passive cooling and natural ventilation.

Fig. 6 Women's Opportunity Center © Elizabeth Felicella

The Gahanga Cricket Stadium designed by Light Earth Designs is the home of Rwandan cricket. It was constructed to promote reconciliation through sports after the 1994 genocide against Tutsis. The stadium is a sustainable project which used local materials to promote carbon savings. The roofs of the primary stadium enclosure utilize the tile-vaulting technique of compressed soil-cement tiles. In appearance, these vaulted roofs imitate both the Rwandan hilly landscape and a bouncing ball's trajectory. The vaults are made with a thin shell layer of tiles laid on a temporary timber skeleton that spans up to 16m. A waterproof layer is then added, followed by small chunks of local granite, which increase the stability of the structure by adding weight. Perforated brick walls were used to mark the spaces and allow lighting and ventilation. The banking creates a wonderful natural amphitheater with great views of the pitch and wetland valley beyond.

Bisate Lodge is one of the eco-retreat lodges located in the northern region of Rwanda. The site is characterized as a "natural amphitheater of an eroded volcanic cone". The lodge itself is a contemporary architectural response in the form of an alternative stimulus of a primordial volcanic landscape, as explained by Nicholas Plewman, architect of the project. The project features six villa units with spherical, thatched structures that imitate the topography of Rwanda. The villa is warmed by a central fireplace with a private viewing deck overlooking Mount Bisoke. The architectural inspiration for the lodge came from the layout of a traditional royal palace, and the interiors are decorated with Rwandan arts and cultural items. The project used local materials such as colorful textiles and other artefacts to decorate the spaces, with construction materials consisting of concrete, steel, timber, synthetic thatch, lava stones, natural granite, bamboo, reed and papyrus.

As indicated by the above descriptions, public buildings with circle forms in Rwanda are generally inspired by the Rwandan traditional building layout and mountainous topography. This can be explained as creating a "syntax of perceptual security" in the contemporary space of the people, inspired by the surrounding landscape, and expressed through people's reliance "towards pure compositions and […] faithfulness towards 'schemata' (pure forms)" [28]. Consequently, the inspiration for shape formation is not only a matter of traditional arrangement based on the continuation of habit, but seems to have deeper justifications on perhaps on-situ arrangements that consider a "wider urban

landscape configuration" and a sensitivity towards "green objects" that play a role in compositional gestures [29].

3.3. Learning from across the globe: Single family housing with circular plan

A well-known and documented example of a single-family house with a circular base is the iconic Melnikov House by Konstantin Melnikov, located in Moscow, Russia. This is a classic residence with an aesthetic different from other traditional Soviet residential architecture. The concept of the house evolves from two interlocking cylindrical volumes that stand at a height of three stories, with the capacity to accommodate all the spaces needed for family and work [2, 30, 31]. The architect's reasoning differs for the two cylinders. The first cylinder was put at a lower height than the second one, which faces the street with a glazed curtain wall that includes the entry of the house. In the rear, the façade is constructed in a honeycomb latticework using local bricks, resulting in a rigid structure with numerous hexagonal windows to light the interior part of the house and resulting in a unique aesthetic for the rear cylinder. The walls of the cylinders are the sole load bearers, leaving the interior spaces free. The kitchen and bathroom are located on the main floor, with a winding staircase going to the first floor, which contains the bedrooms and living rooms. Another unique aspect of this building is the use of staircases, with a spiral one rising from the family spaces on the first floor to reach a double-height studio and roof terrace. The whole house is designed with a quasi-open plan (with partial walls separating the bedrooms) to allow sunlight to soak the interior through the continuous glazed walls of the cylinder.

The Casa Rotonda by Mario Botta is another example of a single-family house with a circular plan. Located in Ticino, Switzerland, this cylindrical house was developed on four levels to avoid any comparison to neighboring buildings, while connecting with the distant landscape and the horizon. South of the house, the skylight is linked to two large side openings that serve to connect its interior and exterior. On the other side, to the north, a set of staircases rise like a column interrupting the continuous wall of the cylinder. The four floors of the house have mostly open plans with few separation walls, emphasizing the continuity of the space and at the same time allowing the natural light to amply flow over the interior spaces. The house is subdivided to handle the different functions of life: The basement is reserved for technical and service use, the ground floor acts as a transition between inside and outside and contains the entrance and the portico, the first-floor functions as the day area and contains the living areas arranged in an open and continuous space, while the second floor contains the sleeping areas with some separation walls.

Lastly, the Round Beach House in St Andrews, Australia, designed by Austin Maynard Architects, is another family house that was developed on a circular base. This unique beach house was conceived to eliminate any dominant orientation: having no front, back or sides, it instead features a continuous façade where all sides are equally important. In the interior, the round floor plan reflects a desire to remove the corridor, a banal link between rooms that seems to be an underused space. In this beach house, all the rooms are open to each other with no fixed separation walls and with a central staircase that provides a vertical link but occupies minimum space. This central stairwell is well-lit to openly amplify the depth of the small rooms while at the same time providing a visual link between them. The ground floor plan is divided into sections from the perimeter to the center, allocating various functions such living room, dining room,

kitchen, bathroom, and laundry room, all taking up minimal yet sufficient space. The first floor, with the free arrangement of sleeping spaces, is entirely open except for the bathrooms. Another interesting aspect of this house is its entrance, which is formed by a covered double-high open space extended from the living room inside the cylindrical volume, which acts as a boundary between the inside and the outside.

4. DISCUSSION & CONCLUSION

The use of the circle in the foundations of single-family housing is uncommon due to "design difficulties, technological difficulties as well as construction costs" [2], but it is important nonetheless. Since the traditional residential architecture of Rwanda is based on a circular foundation and this tradition has not been interrupted so far in the past, the authors wanted to explore to what extent the use of traditional circular bases is optimal at the present moment. As noted earlier, this required an approach that examines how circular plans may be executable through modern housing architectural techniques in a way that fits with the life habits of contemporary Rwandans and that is at the same time aesthetically pleasing. Among the factors that must be taken into account are current economic opportunities, local (available) materials, the use of sometimes low-tech construction technology, energy sustainability, climate factors, exposure to sunshine and protection from rain, the prevalence of sloping terrain, and the unique conditions on the particular plot.

Concerning aesthetics, the "gathering" effect of a circular foundation, namely, that the building is provided with a common core or center, with equal treatment of the periphery on all sides, can in principle be applied in contemporary Rwandan single-family residential architecture. In context, however, it should be taken into account that large glass facades increase the price of construction, and in Rwanda, where glass is not easily accessible, alternative means of allowing light to permeate the interiors of circular houses may need to be explored.

Regarding the utilization of space in a house with a circular base, especially when the size of the plot is limited, the concept of "cheese" architecture or multiple circular atriums (such as used at the Rolex Learning Center) for single-family homes is not directly applicable unless they are relatively large. The aesthetic idea of fluidity is more strongly experienced when the space is larger, according to an analysis conducted in the research of 24 objects, with "circle in [a] circle" being the least represented [2]. According to the case study in question, a circular base with an orthogonal division was the most common, followed by the radial division [2].

Based on these considerations, we analyzed the following shapes: circle with orthogonal division, radial organization with center function, radial organization circle with atrium, several circles in the given parameters of plots having 300 m^2 and the possibility to construct 50% of the plot. In addition, important to consider is the slope of the terrain of 30%.

Housing culture, that is, life habits and how these affect the internal organization of a building, must feature in the conclusions one reaches about what is feasible. For example, orthogonal furniture is harder to place in a circular room [31]. The authors pose a series of questions to better understand Rwandan culture and habits, for example: Do they need a covered space to be shielded from the effects of rain and sun? (Although the latter question is not among the traditional practices, it might yet be the case because Rwanda

has extended rainy periods). Concerns of such nature further illustrate how climatic conditions can shape the way space is used.

The issue of energy use and local materials is also relevant. On the one hand, the circle reduces the relevance of the construction material because the coverage volume is smaller, and this is emphasized as a positive [31]. Stone coverings on the circular facade are expensive, or formwork is more expensive if concrete is used. There is also the question of the price of a roof over a circular foundation: Does the circular shape increase the price, and is the roof made of tile or metal?

Another issue is upgrading. In case new circular structures are added to the existing ones, this requires more materials and more facades that are not energy efficient [29]. On the other hand, adding a circle has the advantage of allowing for phased construction, so not everything has to be built at once.

Also, there is the question of the originality of the author's concrete solution of applying the circle in a more abstract creative way: This is an important issue that depends on the design preferences of clients (e.g. Oligiati Atelier Bardill introduced a circular geometry that was not intended to be adapted to the plot, i.e. the context, but opens inward so that the circle provides centricity).

The question of optimality, then, hinges on the ratio of price, spatial quality, and materials. Is luxury required, or can we achieve the same effect with modest construction technologies?

Given the master plan that was adopted in 2020, according to which the challenge of urbanization is seen as being solved by limiting single-family housing construction, we investigated whether circular forms would be suitable for the housing given the new master plan requirements. The new zoning regulations for single-family houses allow for a maximum plot of 500 m^2 with 40% of maximum building coverage and 0.5 maximum floor area ratio. The regulations also allow for G + 1 + P, where the roof pitch shell is less than 30%. This research might guide researchers and practitioners to further explore possibility to build housing with circle base, optimizing scarce resources.

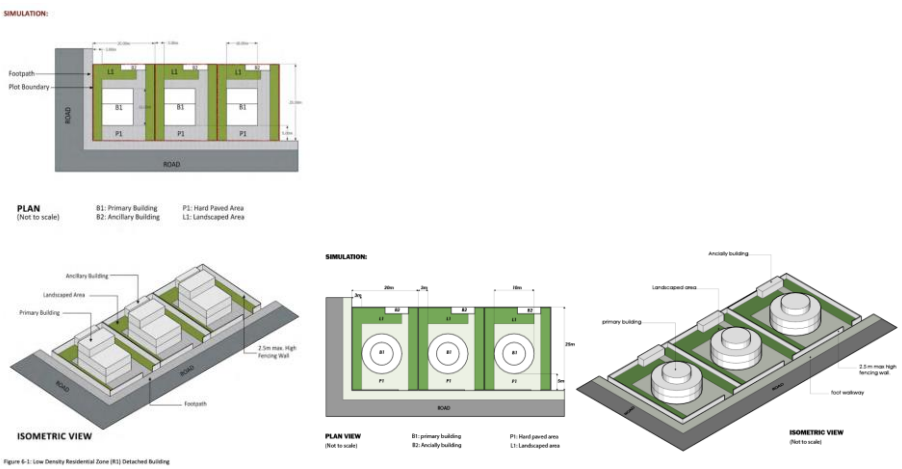

Fig. 7 Simulation prepared by the Government of Rwanda illustrating master plan R1 (left) and the alternative simulation of circle base building, prepared by authors (right).

In designing a circular house, it is incumbent upon the architect to define its spatial organization. The absence of fixed, solid walls, for example, offers more room for flexibility and simplifies subsequent adaptation and reconfiguration of the structure's interior. Indeed, it is not only the interior which opens up new possibilities when conceived of as round—the particular stability of such houses and the enhanced insulation against wind and cold make a circular design especially sensible. The construction of circular houses requires fewer materials than rectangular ones of the same floor area because, mathematically speaking, round figures possess the most favorable ratio of base to the lateral surface area. Yet another advantage of a circular house is the fact that both energy loss and materials input is 13% lower on average than in even the best-built rectangular houses. When temperatures drop, one benefits not only from the superior insulation but also from increased sun exposure: In winter, the sun is lower on the horizon, shines into the building and warms the interior. By contrast, because of the sun's higher angle in the summer sky, it barely shines into the building, thereby heating it less. And in addition, the large, flat roof offers the possibility of installing solar panels to efficiently utilize the sun's energy.

This research contributes to the knowledge fund on buildings with circular plan, with both public and private functions, that would further guide researchers and practitioners interested in the theme. In addition, paper uses Rwanda as a case study, contributing to the very limited academic production on architecture in East Africa.

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TRADICIONALNA JEDNOPORODIČNA STAMBENA ARHITEKTURA KRUŽNOG PLANA ZA SAVREMENO STANOVANJE URBANIZUJUĆE RUANDE?

Dok je tradicionalno oblik parcele i stambenog prostora bio krug u Ruandi, kolonijalne sile su, Nemačka pa Belgija, počevši od kuće dr Ridžarda Kandta iz 1909. godine, počeli da grade zgrade i parcelišu zemlju sa kvadratnom ili pravougaonom osnovom. U nekim slučajevima, savremena arhitektura HHI veka javnih zgrada u Ruandi crpi inspiraciju iz tradicionalnih kružnih formi, i prevodi tradiciju u estetiku od globalnog arhitektonskog značaja. Danas, sa populacijom od više od 12 miliona, sa projekcijama na 24 miliona do 2050. godine, Ruanda ima za cilj da ubrza svoju stopu urbanizacije značajnim ulaganjima u infrastrukturu i građevinski fond glavnog grada Kigalija i manjih pograničnih gradova. Ruanda je nedavno izradila nove urbane planove dajući stroge smernice o veličinama parcela za individualno stanovanje. Ovaj rad pruža pregled istorijskih, tehničkih, kulturnih i estetskih vrednosti oblika prekolonijalne arhitekture i prati te uticaje na javne zgrade danas, i proučava da li se takvi oblici mogu koristiti za jednoporodično stanovanje po zadatim uslovima iz urbanih planova. Upotreba kruga u osnovi jednoporodičnog stanovanja nije uobičajena zbog tehnoloških poteškoća, kao i troškova izgradnje, te je kontinuitet tradicioalne forme teško preporučljiv za savremeno stanovanje u Ruandi, imajući u vidu zavisnost od uvoznih materijala, i pretežno siromašnpo stanovništvo.

Ključne reči: *kružne forme, graditeljsko nasleđe, savremena arhitektura, Ruanda*