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Comparative Suitability of RISHA's Modular Structure for the Spatial Dimension of Human Activities (Case Study: The Living Bandung Korean Project Building, Indonesia)

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Abstract: *Rumah Instan Sederhana Sehat* (RISHA or the Simple Healthy Instant House) is a prefabricated, modular, and knock-down system for simple housing, developed by the Research Institute for Human Settlements, Ministry of Public Works and Housing in 2004. The current modular grid and its component sizes, which were initially developed based on the type of 36 m^2 simple house, produce a space following the required function. The Living Bandung Korean Project (LBKP) building, selected as the case study of RISHA application on a non-residential building in this research, was programmed with multiple functions on its two stories. The study aims to gauge the suitability of RISHA components against each function in LBKP. Started with a literature study, this research focuses on comparing the referenced standard architectural spatial dimension for human activities and functions to that programmed into the LBKP building. The result shows that of the eight analyzed functions, almost all the spatial dimensions using RISHA components do not meet the standard. The RISHA components are too long for functions requiring smaller spaces, such as pantry and toilet, yet too short for ones requiring larger spaces, e.g., workshops, office, *musala*, minimarket, café, and guest rooms. This result is expected to inform the future development of RISHA's alternative component sizes to fulfill the space functions.

Keywords: RISHA, prefabrication, modular, knock-down, precast concrete, precast design, spatial dimension

1. Introduction

The fact that it serves as an easily shaped, cost-effective, fire-resistant, durable and strong material for nearly all types of infrastructural installations, buildings and houses, has made concrete popular for the last decades [1]. Today, second only to water, concrete is the most consumed material, with three tonnes per year used for every person in the world [2]. The high demand for concrete in the construction industry needs to be balanced with the technology advancement to keep upgrading the advantages, while also reducing the shortcomings. Precast concrete is one of the highlighted technologies to overcome several weaknesses of conventional concrete. The majority of the structural components are standardized and produced in plants in a location away from the construction and then transported to the site for assembly [3]. By pre-casting, the quality and strength of a concrete element can be ascertained. It also offers construction timesaving and a reduction of on-site labor [4-7]. The Indonesian Ministry of Public Works and Housing through its Research Institute for Human Settlements then considered these advantages in developing the *Rumah Instan Sederhana Sehat*, or the Simple Healthy Instant House, later shortened to RISHA.

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RISHA is a prefabricated, modular, knock-down system of structural elements which is then be assembled to form the structural frame construction of a building. It was developed as one alternative to housing provision for low-income communities in Indonesia, other than as the post-disaster quick-response option. RISHA offers three components to form a frame structure. The components are: P1, P2, and P3. Components P1 and P2 can be used as either column or beam, while P3 serves as a knot connector. The bolt and nut fasteners accommodate the joints. Fig. 1 shows those RISHA components.

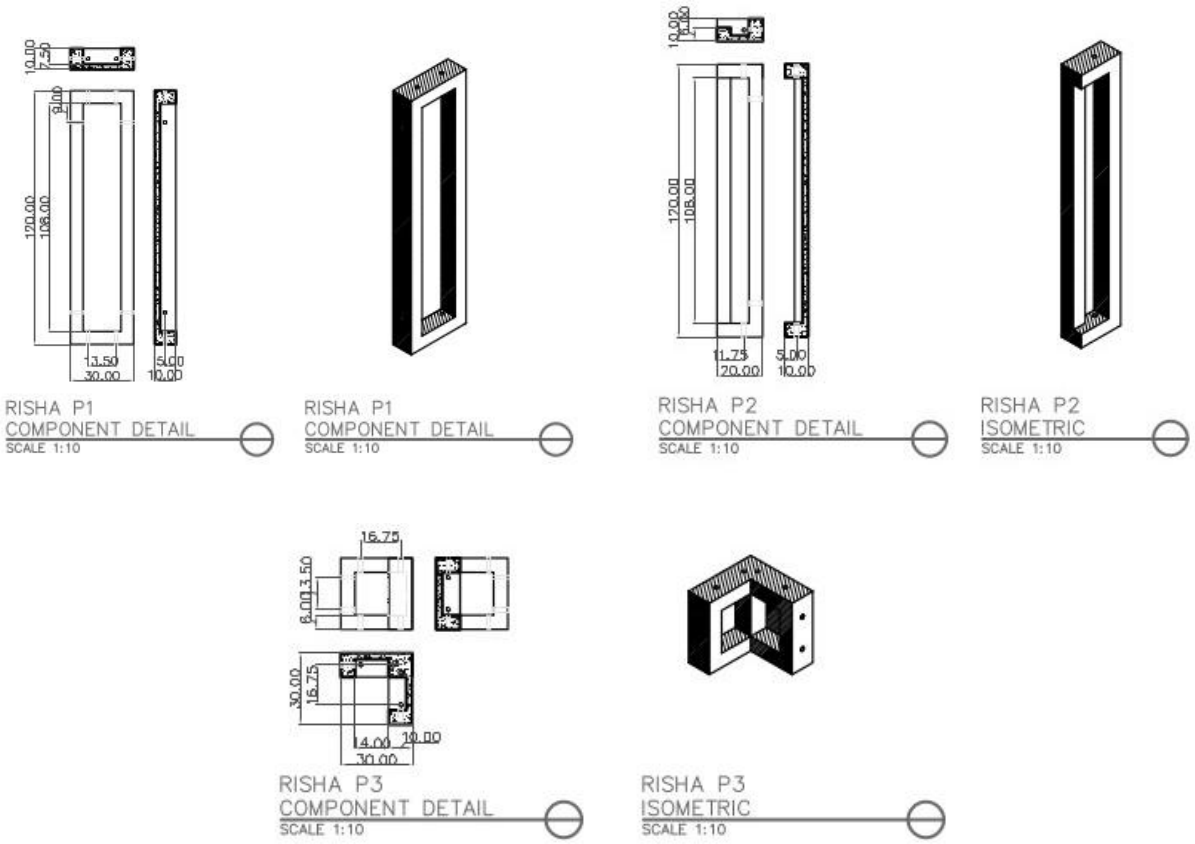

Fig. 1 - Components of RISHA (P1, P2, and P3)

RISHA is assembled in five stages: attachment of the connector plates to the foundation, installation of the first-floor beams (P1), the columns (P1 and P2), connector (P3), and upper-floor beams (P1). Fig. 2 displays the schematic assembly of the RISHA components. They can be assembled to form modular floor areas of 1.8 m x 1.8 m, 1.8 m x 3 m, 3 m x 3 m, as well as the repetition of 9 m^2 area. Additional advantages of RISHA include the capability for modular spatial extension horizontally and vertically (with a maximum height of the two-story building), lightweight components for one-person carry, environmentally friendly, and resistance to seismic forces. RISHA also has the potential to be produced at the home-industry scale for small-medium enterprises. Initially, the size of RISHA components was developed based on type 36 m^2 simple house in Indonesia, as stated under the Ministry of Public Housing Regulation No. 25 the Year 2011 on the Guidelines for The Administration of Low-Cost Housing at that time. Nevertheless, RISHA technology is also applicable to other functions ranging from basic houses, modern residences, schools, religious buildings, clinics, offices, to row-houses to date. Living Bandung Korean Project (LBKP) in Bandung City, West Java, Indonesia, is one of the non-residential buildings that applied the RISHA technology. Each spatial dimension in this building was planned according to the function and programmed activities by taking into account the anthropometric factors.

RISHA technology, which has only been developed and implemented for about a decade, needs to be assessed for its performance so that it can be used more thoroughly for all types of buildings in Indonesia. The performance of RISHA for spatial requirements can be measured based on the need to modify and add preferences on the size, material, and structure of the RISHA technology, as well as its suitability to the local context [8]. A good spatial design needs to meet the requirements for a minimum movement area per person, and accommodate the space where activities take place, as well as the furniture [9].

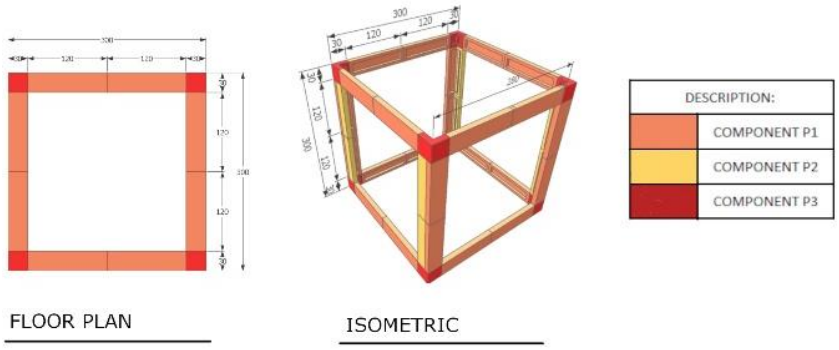

Fig. 2 - Schematic assembly of components

Additional advantages of RISHA include the capability for modular spatial extension horizontally and vertically (with a maximum height of the two-story building), lightweight components for one-person carry, environmentally friendly, and resistance to seismic forces. RISHA also has the potential to be produced at the home-industry scale for small-medium enterprises. Initially, the size of RISHA components was developed based on type 36 m^2 simple house in Indonesia, as stated under the Ministry of Public Housing Regulation No. 25 the Year 2011 on the Guidelines for The Administration of Low-Cost Housing at that time. Nevertheless, RISHA technology is also applicable to other functions ranging from basic houses, modern residences, schools, religious buildings, clinics, offices, to row-houses to date. Living Bandung Korean Project (LBKP) in Bandung City, West Java, Indonesia, is one of the non-residential buildings that applied the RISHA technology. Each spatial dimension in this building was planned according to the function and programmed activities by considering the anthropometric factors.

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To date, there is not much research available out there that discusses the evaluation of RISHA application to spatial synchronicity and function, especially in non-residential buildings. Hence, this study aims to gauge the suitability of the RISHA components to spatial size, oriented towards the activity functions of the LBKP building users. The results are expected to provide a milestone for the further development of alternative sizes for RISHA components to be better used in a variety of functions.

2. Research Methodology

This research combines a mixed approach of quantitative and qualitative techniques to achieve the objectives. It began with a literature study and was followed by the secondary data collection, e.g., architectural drawings of the LBKP building, and existing standards. Along with it, semi-structured interviews with the stakeholders (owner, architects, and RISHA applicators) involved in this project and site observation were also done to probe the opinion regarding the RISHA application in general, as well as to identify multiple considerations behind the design process of the LBKP's rooms. Furthermore, each spatial dimension in the LBKP building was compared to the spatial size standard referring to the Neufert Architect's Data 4th Edition (2012) which is widely referred to by Indonesian architects to date. Based on these comparisons, the suitability of the spatial design at LBKP can be identified. Several recommendations will then be provided as input to RISHA developers for future projects.

3. Case Study: The Living Bandung Korean Project

The LBKP building is a collaborative project between the government of the city of Bandung (Indonesia), The Korean International Cooperation Agency (KOICA), and the Shinhan Bank. Located precisely in Batununggal Residential Complex in Bandung, the 1,000 m^2 building was built in 2016 on land owned by the Social Agency of West Java Province [10]. The building serves as a supporting facility to improve the welfare of the low-income citizens of Bandung and its greater area. Using this building, people having social issues such as street beggars and homeless children, as well as the ones recovering from these social conditions can be assisted and monitored easily. The two-story building was designed to provide facilities such as training rooms, meeting rooms, multi-purpose hall, workshops space, offices, guest rooms, pantries, café, minimarket, prayer rooms, and toilets. Fig. 3 and 4 display the floor plans and the layout of those eight spatial functions. The RISHA technology was applied to form a 3 m x 3 m grid with effective bays of 2.8 m in each direction (Fig. 2).

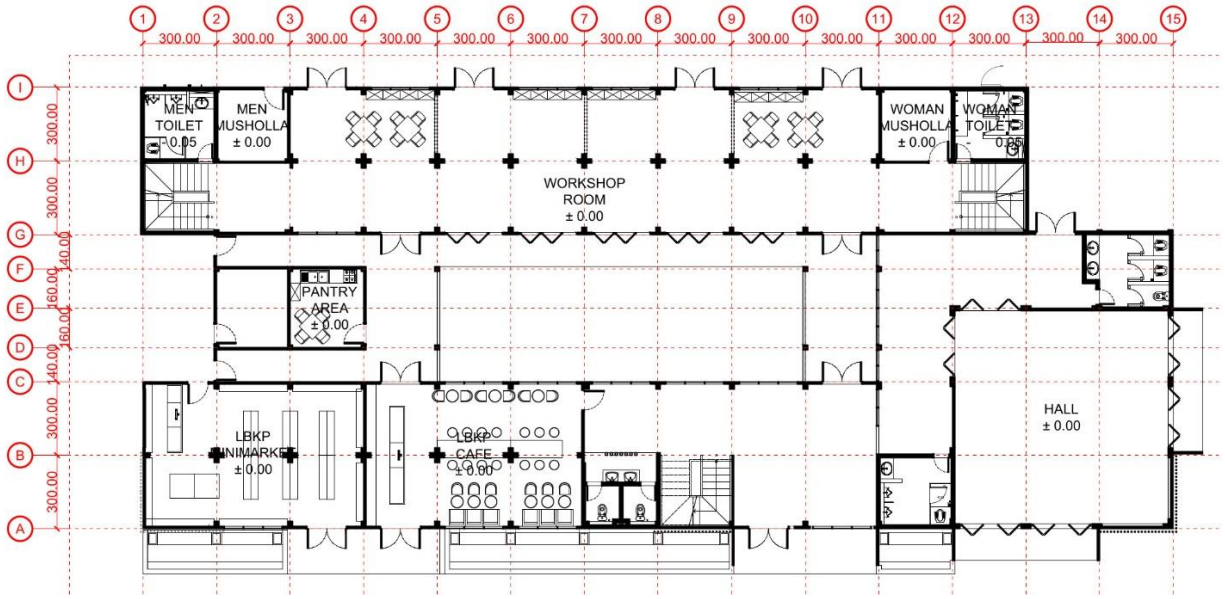

Fig. 3 - Ground floor (GF) plan in centimeters

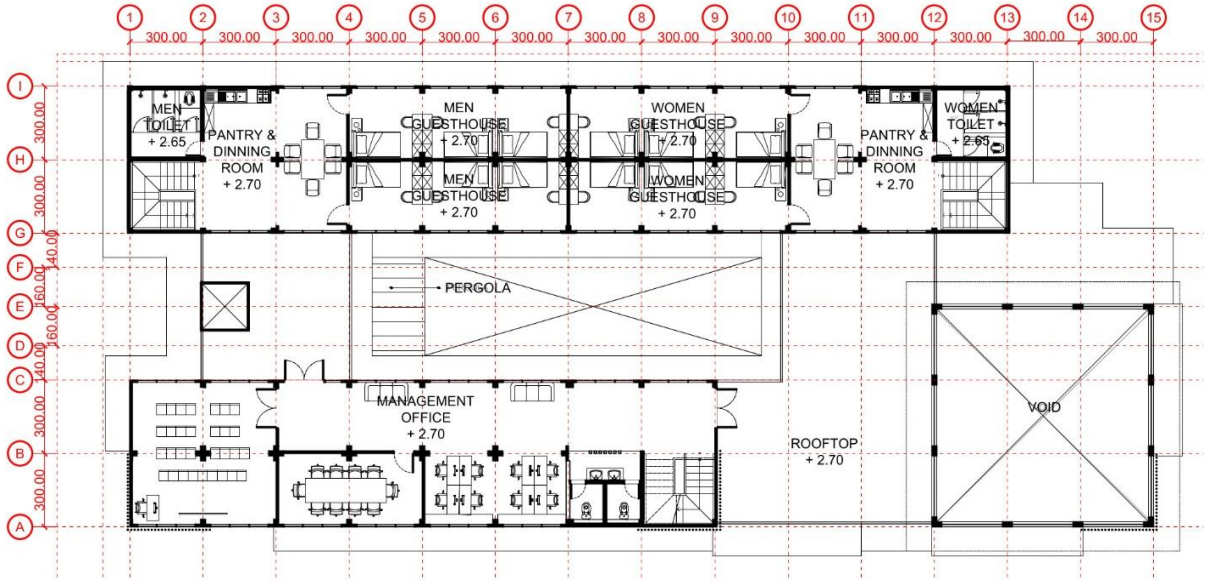

Fig. 4 - First-floor plan in centimeters

3.1 Workshop

The 162 m^2 workshop was designed to provide spaces for artistic practices such as dance, music, and handcraft (Fig. 5). Area for one table set of 4 to 6 people capacity (1.5 m x 1.5 m) is assigned on the left and the right sides of a 24 m x 6 m workshop space. Meanwhile, an area for four cabinets with a dimension of 2.8 m x 0.4 m each was placed on the outer side of the space. It leaves with 0.45 m of circulation path on both sides of the tables. Based on Neufert [11], the optimum width for the circulation path is 0.6 m. The acquired data shows that the LBKP's workshop space does not meet the minimum spatial standard to be comfortably functional. The 3 m module mandates the existence of mid-space columns (Fig. 5) that are considered restrictive to the activities and reduce the usable spatial dimension.

3.2 Minimarket

The minimarket space is on the ground floor (GF) with a 54 m^2 area. Fig. 6 and 7 display the minimarket floor plan and the shelves layout. Each shelf has a dimension of 0.60 m x 1.80 m with a 0.9 m distance in between. Meanwhile, according to Neufert (2012), the minimum required distance between two facing shelves to accommodate 2 people circulation aisle is 1.8 m (Fig. 7). Thus, the 2.8 m bay of the minimarket is ineffective due to its smaller size than the

required standard, i.e., 4.9 m. On the other hand, utilizing two RISHA components of 2.8 m effective bays for the aisle arrangement will be spatially inefficient.

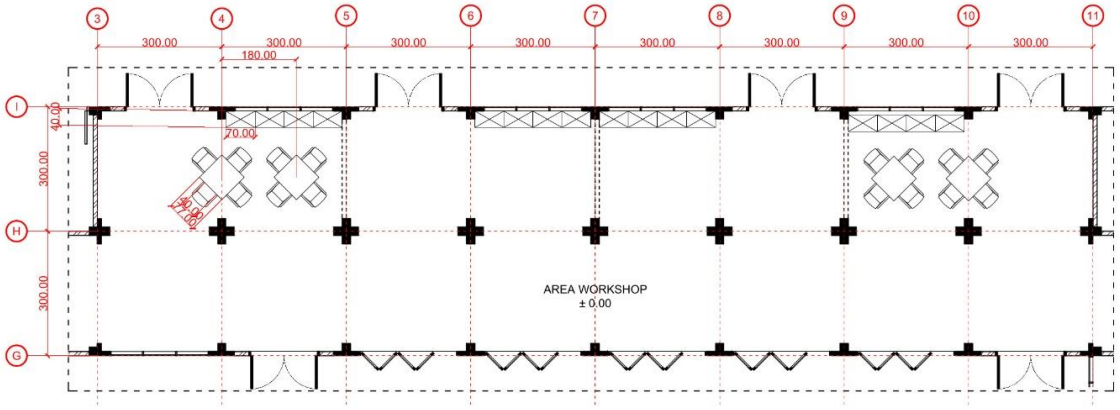

Fig. 5 - Workshop room layout on the GF in centimeters

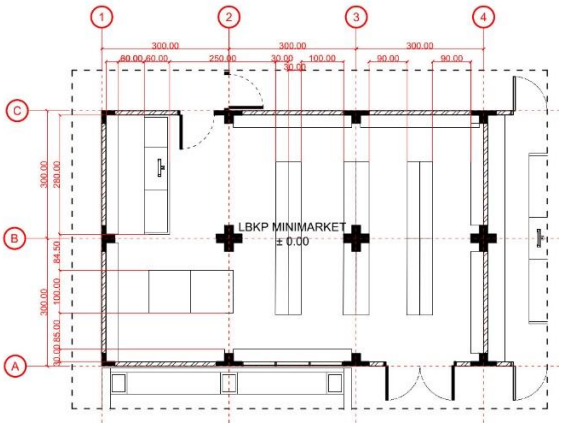

Fig. 6 - Minimarket layout in centimeters

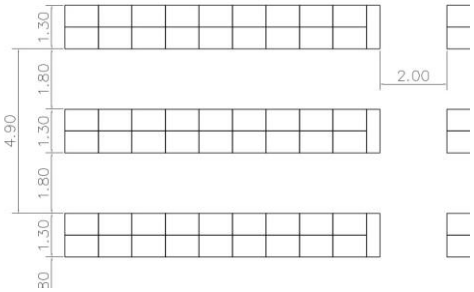

Fig. 7 - Furniture layout inside the minimarket in centimeters [11]

3.1. Café

A 6 m x 9 m x 3 m café on the ground floor filled with several types of furniture such as tables of 2–person and 6-person capacity. Generally, the first type of table requires an area of 0.5 m x 1.6 m while the latter one needs an area of 2.1 m x 1.6 m each. Fig. 8 shows the café's layout. According to Neufert (2012), the minimum length between the end of one chair to the other on the opposite side is 1.6 m (Fig. 9). Thus, only one set of table and chairs for 2 to 4 people can fit into available space in the LBKP building. Having more than one set of table and chairs will result in an ineffective functional space.

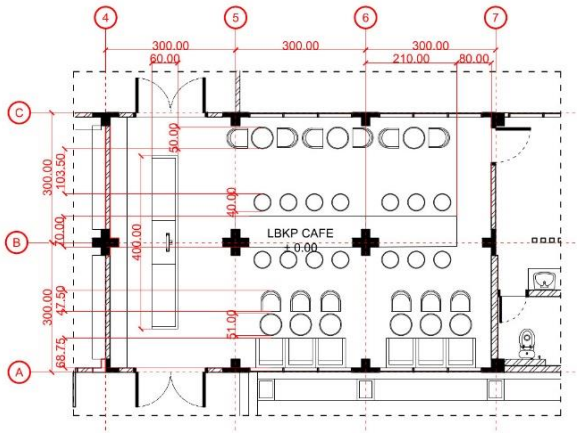

Fig. 8 - Café layout in centimeters

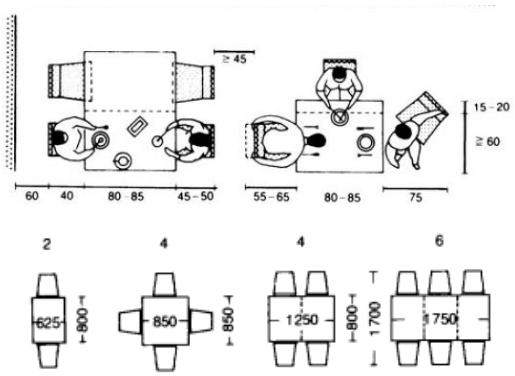

Fig. 9 - Minimal space requirement for a café table in centimeters and different sets of tables and chairs in millimeters [11]

3.3 Office

The office space with a 6 m x 18 m floor area is placed on the upper floor. It contains a presentation room, workspace, and meeting room (see Fig. 10). Several pieces of furniture in various sizes are provided in each room. Based on Neufert (2012), the required effective space for an office desk and chair is 3.1 m. The desk and chair placement can be arranged either facing each other side by side with an additional drawer console of 1.875 m x 0.3 m (Fig. 11). The RISHA structural grid inadequately accommodates the standard workspace. Again, its structural grid forced inefficient and inflexible desk placement.

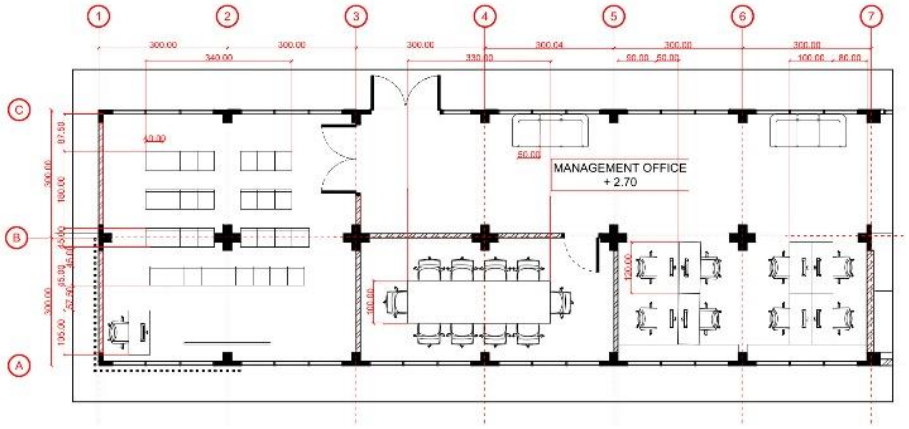

Fig. 10 - Office layout in centimeters

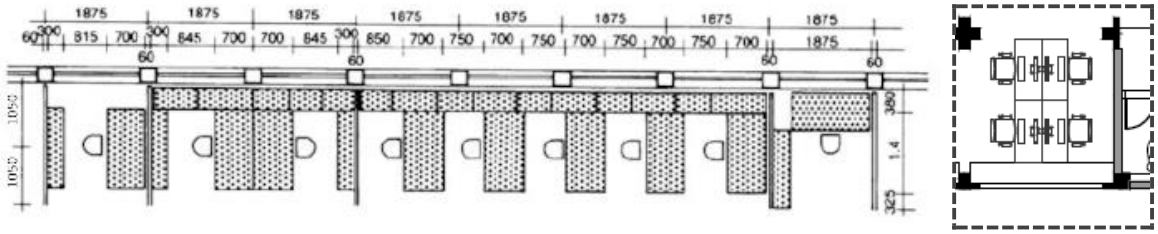

Fig. 11 - Minimum space requirement for a workstation in millimeters [11]

3.4 Guest Room

The LBKP building also provides two guest rooms on the first floor. Each area has a 3-person capacity space on a 3 m x 9 m floor area. Fig. 12 displays the guest room layout. The furniture dimension and the circulation in that area are noted to be smaller than the recommended standard [11] as shown in Fig. 13. For this reason, custom-made furniture must be used to accommodate the smaller space (1.04 m x 2 m). Nevertheless, the guest room can still function effectively. The additional cost due to the custom-made furniture is a drawback to the RISHA's resulting space.

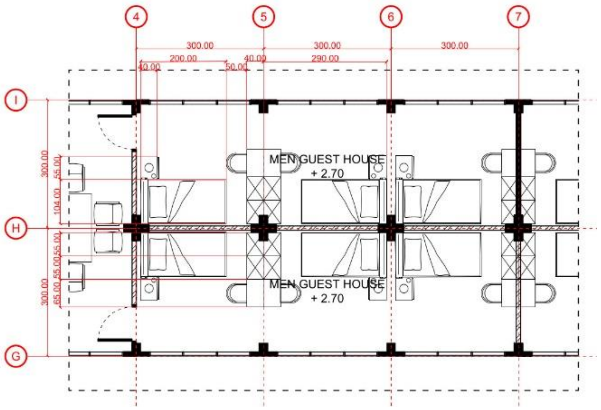

Fig. 12 - Guest room layout in centimeters

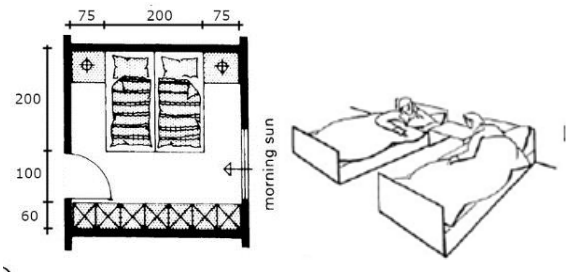

Fig. 13 - Minimal dimension for furniture in a guest room in centimeters [11]

3.5 Pantry

The LBKP has two pantries, one on each floor. The 36 m^2 upper floor pantry has four times the floor area of the pantry on the GF. This is due to the upper ones being dedicated for public use. Fig. 14 and 15 show the layout of both pantries. GF pantry has a one-sided layout equipped with one sink and one stove. The effective spatial width is 20 cm short to meet the minimum standard for this type of layout, which is 3 m effective [11]. Fig. 16 shows the minimum furniture dimension for such a pantry. In the case of an upper floor pantry, it has a larger floor area due to the addition of a dining area. Once again, the RISHA structural grid causes the existence of mid-space columns that reduce the effectiveness of the furniture layout.

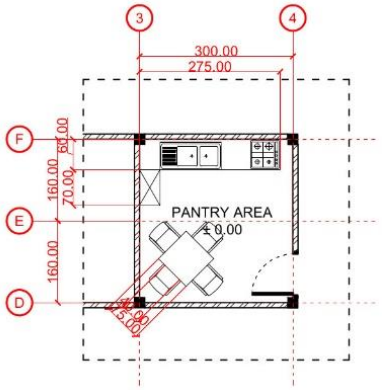

Fig. 14 - Pantry layout in GF in centimeters

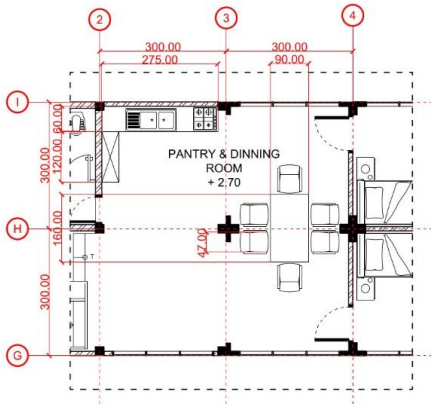

Fig. 15 - Pantry layout on 1st floor in centimeters

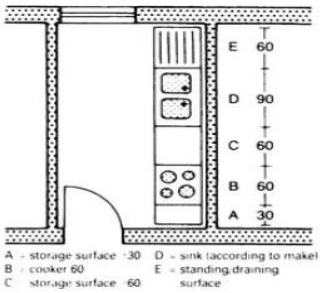

Fig. 16 - Minimum dimension for one-sided pantry in centimeters [11]

3.6 Islamic Prayer Space (*Musalla*)

As with the other public facilities, the LBKP building is equipped with an Islamic prayer space on the GF with a-3 m x 3 m floor area. Based on the standard spatial dimension [11] as seen in Fig. 17, the minimum required space per person for going down into prostration is 1.2 m. With a-3 m x 3 m grid area, the *musalla* can only accommodate two people praying in a column at one time, with 30 to 40 cm circulation between them. The distance is too close compared to the recommended 40 to 60 cm [11]. A larger grid is required to provide an appropriate praying space.

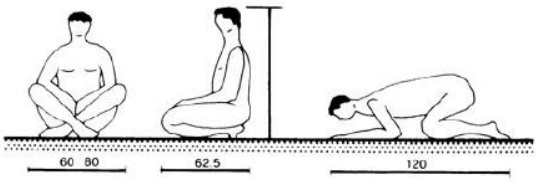

Fig. 17 - Minimum space requirement for prayer in centimeters [11]

3.7 Toilet

The LBKP building has two types of toilets. The first one is the public toilet on the GF, and the second is the toilet serving the staff and visitors on the first floor. The upper one has a shower area as seen in Fig. 18. The circulation width in the GF's toilet is 1 m, while the upper floor has a 1.5 m width. As seen in Fig. 19 describing Neufert's

recommendation, the minimum circulation width for toilets is 1.14 m. Hence, only one toilet space on the upper floor meets the standard. A wider circulation width will add up to the construction cost.

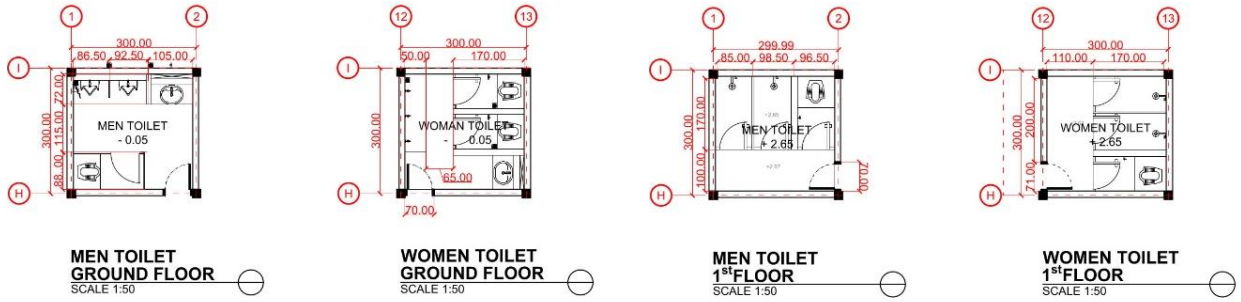

Fig. 18 - Layout of the toilets in GF and 1st floor

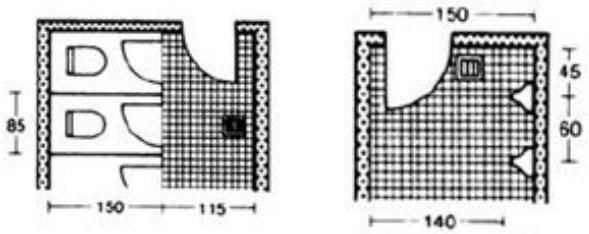

Fig. 19 - Minimum space requirement for toilet in centimeters [11]

Table 1 shows the analysis result examining RISHA's spatial suitability to accommodate the eight spatial functions of the LBKP building. It can be summarized that only two rooms, namely the pantry on the first floor and the toilet on the ground floor that meet the spatial dimension standards based on Neufert.

Table 1 - RISHA's spatial suitability of different space functions

Room Function	Size (m^2)	Volume	Suitability
Workshop	162	1	No
Minimarket	54	1	No
Café	54	1	No
Office	90	1	No
Guest room	54	2	No
Pantry	9	1 (GF)	No
	36	1 (1st floor)	Yes
Musala	9	2	No
Toilet	9	2 (GF)	Yes
	9	2 (1st floor)	No

Other rooms require either a longer span for a wider space or a shorter one for a small space such as the pantry, toilet. Approximately the same results were obtained from the RISHA application in residential spaces based on several previous studies. The components of RISHA are considered unsuitable for a room size with the smallest grid 2.4 m x 2.4 m [12]. In fact, residential spaces using RISHA technology are considered to only meet the expected needs of 50% of users in South Sumatra, West Java, and West Nusa Tenggara [8].

4. Conclusion

Based on the analysis of the eight space functions programmed in the LBKP building, it can be concluded that the current RISHA component size cannot effectively accommodate the required spatial dimensions. The 3 m x 3 m structural grid with columns on each intersecting point of the grid is proven to have cause ineffective spatial arrangement. Thus, it is highly recommended to review the RISHA modules to develop further alternative component sizes to accommodate the functions requiring large space such as workshop, office, residential area, minimarket, and others. It will be valuable also to develop structural components smaller than 3 m to accommodate smaller spaces such as pantries and toilets. The results of this research are expected to be taken into consideration for developing the size of the RISHA components for various uses in the future.

Acknowledgment

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