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ORIGINAL RESEARCH PAPER

The practical implementations of axes in the design of a systematic office layout

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ABSTRACT

In the ever-changing realm of the contemporary workplace, adaptability and flexibility have emerged as crucial attributes for office buildings. The method of axes system design, in conjunction with modular structures, fosters a workspace that can seamlessly adapt to the evolving needs of offices. This system embodies a comprehensive approach to office design, emphasizing the integration of four important principles: modularity, adaptability, interconnectedness, and flexibility. The modular nature of the structural axes design allows for swift and cost-effective adjustments, facilitating customer needs. The dynamism of this system ensures that office spaces are in a perpetual state of evolution, reflecting the changing dynamics of the contemporary workplace as to be shown in this paper.

KEYWORDS

offices, adaptation, axes modules, flexibility, after use, design method, modularity, raster system, reuse

1. INTRODUCTION

The requirements for office spaces are contingent on the specific nature of the work involved. For tasks dominated by administrative responsibilities and paper documents, static workspaces are common, whereas digital development allows for more flexible arrangements, potentially beyond traditional office buildings. The significance of accommodating diverse work environments is emphasized, acknowledging that employees equipped with laptops and internet access can work effectively from various locations, like parks, cafes, or homes. As office jobs demand a high level of mental output, it is important to address health concerns arising from one-sided employment, especially in roles with minimal physical movement. Consequently, office environments are subject to extensive research in work psychology and occupational safety and health, leading to regulatory frameworks that include specifications for ergonomics, workplace health and safety, room climate, acoustics, and more [1, 2]. The evolution of office settings aims at diversification and high quality to prioritize the health and well-being of workers, considering the dynamic requirements of different work scenarios, from communication to focused individual tasks. Health and ergonomics are identified as vital criteria, involving strategies rooted in organizational and job psychology as well as physical design to address potential long-term health issues associated with computer-based work. Elements of indoor environmental quality, including visual comfort, acoustic comfort, air quality, and thermal comfort, are highlighted as crucial factors influencing office workers' comfort and health, as it is shown in Fig. 1. Beyond physical attributes, achieving worker happiness involves considerations of corporate and interpersonal characteristics, emphasizing transparent communication, diverse tasks, and a strong sense of teamwork. The discussion extends to the importance of designing environments that facilitate both focused individual work and team communication, allowing for various work scenarios. Additional

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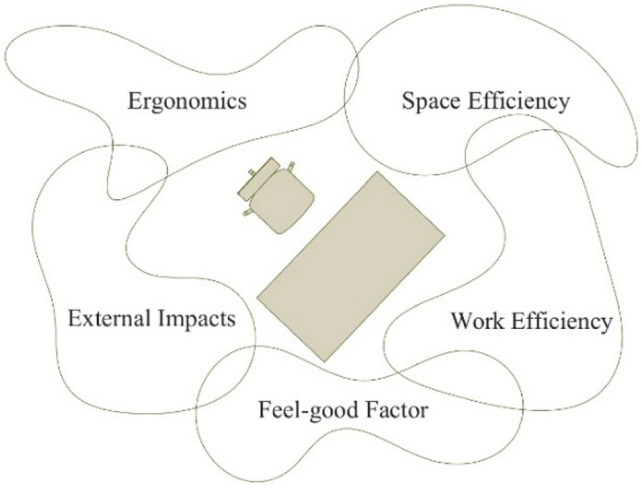

Fig. 1. Office requirements

elements like thermal comfort, ventilation, sound insulation, room acoustics, and lighting are detailed, with an emphasis on creating an atmosphere conducive to concentration and well-being. Overall, the comprehensive approach to office design considers the multifaceted needs of workers, recognizing the interplay of physical, organizational, and psychological factors in fostering a productive and satisfying work environment [1, 2].

2. THE SYSTEMATIC AXES AND RASTER LAYOUT

Once construction begins, the building depth and facade axes have a lasting and irreversible impact on the efficiency of user-oriented space. It is remarkable that the evolution of building axes continues to be characterized by the idea of individual rooms, which are, at most, still visible everywhere in combi offices and cellular offices. The combination of open spaces and enclosed rooms are the primary characteristics of contemporary office designs. But whatever approach the architect uses when designing and creating an office building, the individual workplace and user comfort are always the first things to consider and build a plan form as there is a clear connection between the space and the human experience [3]. The applicable rules and standards when designing an office space require that minimum widths for access areas and escape routes, as well as size and distance restrictions around the workplaces, those mainly are among the main factors that influence the design process [4, 5].

There are general requirements for offices spaces when it comes to calculating the minimum space needed. The general tabletop size required is 160 × 80 cm for permanent workers' office desks, which results in a minimum desk space of 1.28 m^2. In addition, tables typically had to be arranged at least 30 cm deep away from the façade due to reasons like maintenance and cleaning of that area; while also a distance of 60 cm away from the window is the minimum viewing distance requirements due to the computer monitors glare and visibility issues, it is to maintain interior visual comfort regardless of the type of shading or façade system [4, 5]. A worker's personal space for movement with the office chair is a minimum of 100 cm (the desk width) that results in 1.60 m^2 of space. A sideboard may be added for the worker for storage purposes and the minimum recommended depth of it is 45 cm [5]. In Fig. 2 the color code for each zone in an office building demonstrated in this paper is shown. Figure 3 shows four types of offices which are the cellular office vs combi office and the open plan office vs the activity-based office, demonstrating the differences between each, the spatial divisions needed using the 125 × 125 cm axes system, and the minimum number of axes each zone needs.

A width of 80 cm (table depth) + 100 cm (depth of the free movement area) + 45 cm (sideboard depth) = 225 cm needed if it is to be accommodated in a closed room as a

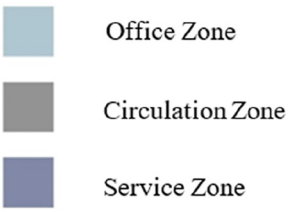

Fig. 2. Zoning color code

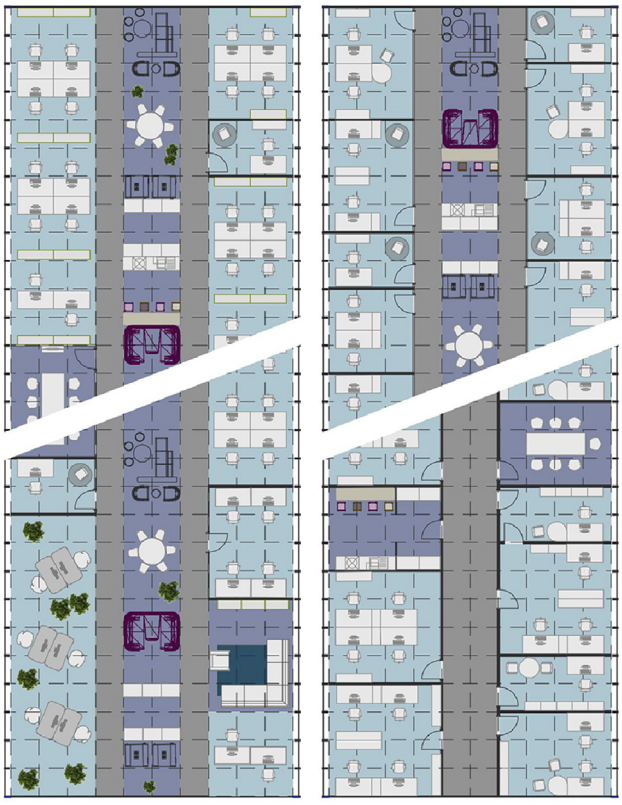

Fig. 3. Offices different spatial requirements

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single workstation as it is shown in Fig. 4; hence a double workstation room needs more space. This workstation's width is 235 cm if you add half of a partition thickness, resulting in a total of 10 cm (5 cm from each side). To allow for trouble-free furniture placement as height adjustment, an additional 5 cm is added as a buffer space. This is mainly because of the sideboards, which, for example, always push them slightly further into the space.

It is impossible to guarantee this dimension with facade axes smaller than 125 × 125 cm. Despite the need for well-proportioned spaces and the previously indicated distance reserves for furnishing options, a 125 cm axes division is advised as a sufficient and yet space-saving minimum size. This is true for both single rooms in combi offices and, more so, single rooms in cellular offices mainly.

As for the building's total depth, buildings must be deep enough to accommodate up to three different zones of varying depths for common areas or workplaces. For cellular offices, a building depth of around 13.00 m is ideal. Communication spaces (conference rooms, team areas, project offices) in addition to service areas and main offices are all mainly located at significant locations on the façade in this office type, which is highly space-consuming and outdated [5].

Functions like service areas and communication zones are pushed to the center of office buildings with three-area zoning like as combi offices, open plan offices, and activity-based offices, that even allow natural light to reach the central zone of the building when using the correct building dimensions, which may account as a significant amount of the area and space that is now efficiently used. The depth of office buildings like that can start from 12.50 m using a 125 cm axis module - a minimum width of 3 × 125 cm (office zone depth) + 1 × 125 cm (corridor - circulation zone depth) + 2 × 125 cm (central service area depth) = 12.50 m; and is only recommended to go up to 15.00 m maximum to keep the building at an optimal and sustainable level as more than that can lead to increased investment cost, higher energy consumption in the building, as well as higher operating cost for mechanical ventilation and artificial lighting as those spaces need continuous circulation of fresh air and natural light for the worker's wellbeing [6]. In conclusion, the ideal size for axes modules is minimum 125 × 125 cm to ideally not more than 150 × 150 cm, the 125 × 125 cm axes system for open plan, combi and activity-based offices is demonstrated in Fig. 5 [5, 6].

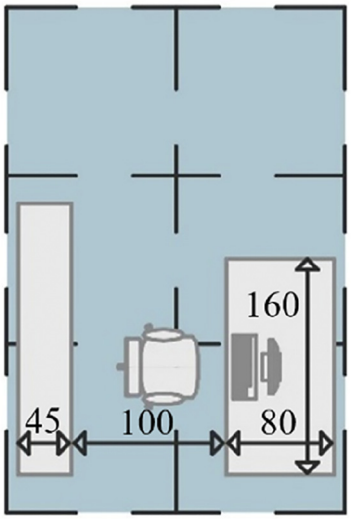

Fig. 4. Minimum space requirements for a workstation

3. MODULARITY IN A STRUCTURAL WAY IN OFFICES

In order to provide flexible and adaptable workplaces, modular components and spatial arrangements are used in office design architecture. The office structure is divided into more manageable components by this design approach, making it easier to construct, reconfigure, and customize to meet changing user requirements. As this saves resources during construction, protects the environment, saves energy and material, in addition to offering a faster and better quality manufacture, as the new ecological demands are moving towards a global and integrated approach to thinking and building [7, 8].

Beyond its practical application, modularity in office design allows for the exploration of new aesthetics while providing effective use of space, encouraging collaboration, and making layout extension or modification easier. This idea has been researched and effectively used in a number of

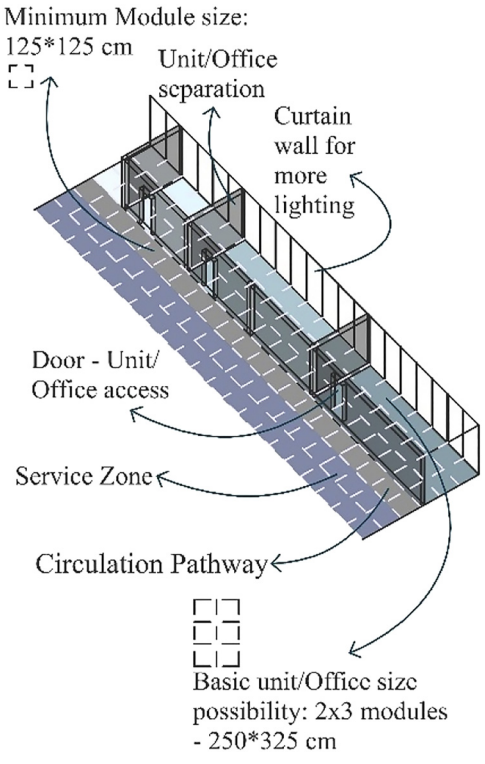

Fig. 5. The axes and structured modularity

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sectors, showing increases in output, improved creativity, and economical solutions.

Modularity in office environments allows for simple adaptation and flexibility in a variety of spaces. Offices can quickly adapt to changing demands by using modular components within the office axes layout design implemented. This guarantees effective use of available space and enables various arrangements and configurations. Future flexibility is further ensured by the modularity idea, which makes it simple to rearrange or reuse workplaces once they are no longer used as typical office spaces. Office buildings that use modular designs benefit from increased operational efficiency, lower costs, and more sensible means of expansion and evolution. Divisions, walls, and doors may all be seamlessly built to create the floor plans that a tenant needs. A flexible and dynamic design approach is made possible by the incorporation of modular architecture into office buildings, which enables the blending of homogenous and diverse functional zones.

The raster and axes architectural layout design serves as a foundational framework for achieving modularity in offices, offering a structured approach to organizing various components within the workspace. This framework makes it easy to reconfigure and change the office layout in order to effectively meet changing demands and requirements. By using modular elements like moveable walls and furniture, the axes system allows for variable office space configurations that promote employee cooperation. The modular axes systematic design enhances space usage by offering an organized framework that makes the most of the available area. Furthermore, the raster system's fundamental flexibility enables the easy integration of modern technologies and infrastructure, like power and data connections, which can be easily improved or changed as needed, as well the ease of integration of Building Information Models (BIM) to support the design process [9, 10]. Essentially, in dynamic workplace contexts, the axes architectural layout design fosters efficiency, adaptation, and collaboration [10].

The environmental advantages of modular office design, which emphasizes material economy, flexibility, and reuse potential, are often praised. However, this approach is unlikely to work smoothly in high-end office buildings because the user's need for a current, original design may outweigh modularity's environmental benefits. Hence this may propose some limitations to consider when it comes to modularity, and it can fall in the following categories in Table 1 [11].

Modularity may lead to better recycling and component reuse, however if modular office buildings are intended to have a sustainable life cycle, these limitations must be addressed [11].

Table. 1. Possible limitations and challenges in modular office

Phase	Possible limitations and challenges
Initial Design Phase	- Limited selection of methods - The capacity to restrict innovation. - Extended time and complexity of development
Usage Stage	- Issues with user acceptance and perception - Problems with performance (overdesign, bad interfaces) - Varying user situations and actions - Encouragement of early decomposition
After Use	- Insufficient support for the re-adaptation process

4. THE AFTER-USE OF OFFICE BUILDINGS

Office building after-use involves considering location, building features, functional flexibility, and economical factors into account. Geographically speaking, office buildings in commercial complexes usually stay like that, although buildings in city centers or on the outskirts may be converted into residences, which would help the already-existing residential estates. The offices in single-use business parks, however, could be difficult to convert. A building's potential for conversion is influenced by its features, like its historical or cultural value; listed monuments are often examples of successful conversions. Functional flexibility is essential for viability since post-World War II office buildings with specialized designs may be difficult to convert to residential use. This is especially true with regard to office building adaptability - particularly with regard to structural raster module sizes and functional flexibility - is essential for a successful conversion. Legal factors, like stricter construction codes for residential properties rather than commercial properties since the regulations for residential buildings and other structures that allow overnight stays are more serious than those for day-use purposes, may have a detrimental impact on conversions' financial sustainability and even make them expensive [12–16]. The determination of the viability of office after-use is dependent upon the evolution of rent gaps as well, which reflects the difference between present and prospective land prices. Property owners could be more inclined to remodel or convert office buildings if the gap grows. Opportunities for transformation are many; they include turning into flats, sale/rental markets, ateliers, and studios to compete in the market. There are still issues, however, like the need of a more flexible system for designing and building structures to account for unanticipated changes in usage; the reuse and remodeling process could also facilitate the usage of the BIM system, which could help in some cases [12–16]. A growing number of office buildings are expiring due to the past practice of building to satisfy consistent user needs without taking changing use dynamics into consideration. This has an impact on how future office buildings must be constructed to properly handle possible conversions. Challenges related to architecture and technology might restrict the conversions' potential applications or financial sustainability. All things considered, the post-use of office buildings involves an intricate combination of structural, legal, economic, and location-specific issues [12–16].

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5. AFTER-USE EXAMPLE – CASE STUDY

5.1. The conversion of the "Thyssen Trade Center" into the "Living Circle" residential project Düsseldorf, Germany, 1991–2018

In terms of architecture, there are potentials, and challenges associated with converting office space to residential use, as it is shown by the conversion of the "Thyssen Trade Center" into the "Living Circle" residential project.

The massive Thyssen Trade Center once had around a thousand workers, but for seven years, the complex was unoccupied.

An eight-to-ten-story residential building with an outstanding façade, spacious stainless-steel balconies, and little gardens in front of the ground level have grown into a contemporary, green neighborhood. There are around 340 two-to five-room flats in the project [17, 18].

First the floor plans and layouts, it takes some planning to convert current floor plans intended for office use into residential spaces. Large, open areas in office buildings are often ideal for workstation arrangements, but they could need to be reconfigured to make room for residential uses. The 343-unit Living Circle building is a prime example of how carefully planned floor plans allowed formerly office-oriented interior areas to be repurposed. To maximize the floor layouts for residential living, issues including the existence of office-specific zones like cafeterias, Information technology (IT) areas, and conference rooms had to be solved [17, 18].

As for the stairs and circulation, reorganizing circulation systems is a necessary part of conversion efforts. Long corridors found in office buildings could make them unsuitable for residential construction. It was necessary to build nine more stairwells in the Living Circle in order to facilitate vertical circulation and provide access to the underground parking lot. Strategic planning was necessary for the integration of these components to provide smooth communication while respecting the limitations set by the current structure [17, 18].

The conversion of an office building into a residential space creates concerns about outdoor amenities and common spaces while considering the after-use period. As mentioned, the difficulty is in turning places like conference rooms and canteens that were originally intended for office-related functions into aesthetically pleasing open spaces appropriate for residential usage. A community-focused living environment may be fostered, as shown by the Living Circle, which creates widely accessible green spaces and allows private garden areas to ground level units [17, 18].

In addition to the economic issues, it is important to draw attention to the ecological component as well. Sustainability is enhanced by the conservation of energy during conversion that is ingrained in the current structure. But the ecological advantages are sometimes overshadowed by the economic debate [17, 18].

In conclusion, the transformation of office facilities into residential units requires a careful examination of floor plans, deliberate design choices, and well-thought-out circulation planning. The architectural change becomes more difficult when after-use options, like outdoor areas, and inner layouts, are taken into consideration. Requiring conversion like those initiatives in the housing market to be sustainable over the long run calls for finding a balance between ecological and economic factors [17, 18].

5.2. Results/personal project, adaptable multi-tenant office buildings in the city of Pecs

According to the studies made and the research done, a concept plan was developed designing an adaptable use multi-tenant office building in the city of Pecs, the concept of the project is providing adaptable office space in the sense of different office plan possibilities and allowing the adaptability of this space for the after use.

5.2.1. The site. The project site is located in the downtown district of the city of Pecs and is considered to be a transitional point towards the historical part of the city; therefore the location has a huge impact on the value of the designed building. The total area of the site is 6090.26-meter square. The site is surrounded by 4 streets allowing access to be from all directions to the site, which makes the site more approachable.

5.2.2. Concept development idea. The concept consists of 3 main buildings located along the site; the buildings are shaped in a way that allows them to act as separate units while 2 of them can still be connected and act as one bigger unit. The shapes are formed in a way that allows the integration of the public surrounding into the project, as this will give the indication of welcoming space and allow people to explore the site, as this prompts the factuality of the services places on the ground floor.

5.2.3. The spatial divisions. The ground floor of the building is designed for the purpose of public utilities; it serves the community around and provides additional services to the area. As for the first floor onwards, it has been designed as adaptable office space systems, the space has been designed according to an axes layout with the size 135 × 135 cm, the office space as well as the corridors where strictly designed and aligned with the axes system implemented, as of the middle part acting as the service area it was adapted in a freer way to accommodate the shape of the building.

5.2.4. Circulation. The main vertical circulation access acts as a core unit to each building, as it is a load bearing structure that connects all the floor together all the way from the underground car park up until the last floor of each building. The vertical circulation unit also act as a main element in the horizontal circulation possibilities, as the location of the core unit allows access to several horizontal directions on each floor of the building, this allows the space to have uninterrupted divisions while still having direct access to the core service unit all made possible using the axes.

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5.2.5. Unit separations. The systematic modular space can be divided into separate office units with various sizes to accommodate different company spatial needs, it is possible to have smaller separate unit and also combined larger units, when larger units are needed horizontal spaces on the same floor are preferred mostly were as vertical space as in having an office with multi levels is still also possible in this building.

5.2.6. The different office possibilities. As mentioned previously, the space has been designed to adapt to different office unit possibilities, the plan can be divided freely according to the need of the customer as the axes layout and systematic modules used provides flexibility in all directions as it is marked in Fig. 6 the darkest grey color is for the office zones, the middle toned grey color is for the circulation and the lightest grey color is the service zone according to the zoning color code in Fig. 2. Individual/cellular offices, group offices, open-plan offices, combi-offices and non-territorial spaces are all possible to have in this building. The area of the first building from the top shown in Fig. 6 is 746.33 m^2, the second building is 1092.26 m^2 and the third building is 1025 m^2. As the design is flexible, different office zones can be proposed as it has been marked in Fig. 7, furthermore Fig. 8 proposes how the system allows the same zone to be used for different kinds of offices.

5.2.7. The after-use possibilities. The building has been designed to have the possibility of a different use after it is no longer used as an office building, the circulations provided and building services placed using the axes layout allow that. The main possible after-use of this building would be apartments, as it has an important location with great neighborhood services. This building has the possibility to change from a day use only building to also a night use place. The possibility of having different apartment unit sizes to accommodate diverse needs of buyers is available, while still having all functional requirements for an apartment space as it is demonstrated in Fig. 9.

Fig. 6. Personal project offices axes plan

Fig. 7. Personal project offices separations possibilities

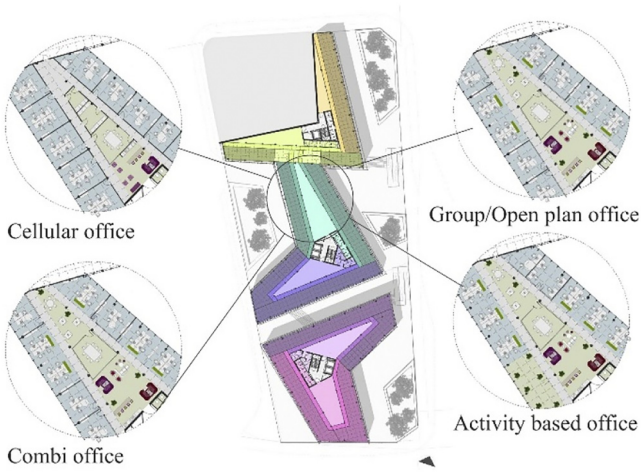

Fig. 8. Personal project offices different possibilities

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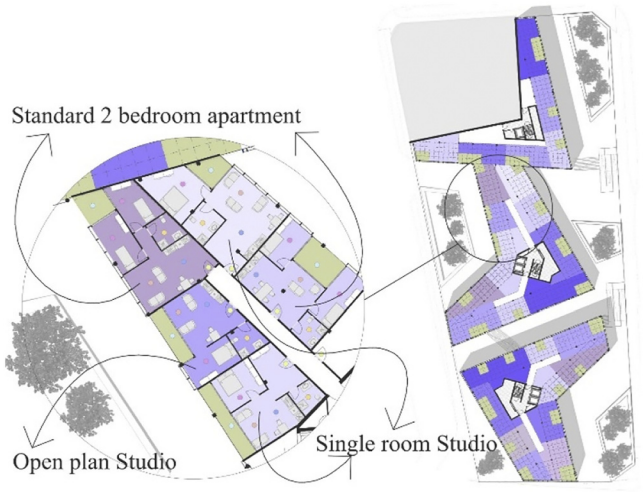

Fig. 9. Personal project after use approach

6. CONCLUSION

The use of modular axes layouts in design forms the essential foundation for the concept plan of a flexible multi-tenant office building. It establishes a structured layout that facilitates easy adjustments and adaptations within office spaces. This approach ensures that the office building can be promptly customized to meet the specific needs of diverse clients, both during its initial utilization as an office and in potential future scenarios. By seamlessly integrating the 125 × 125 cm - 150 × 150 cm axes system and contemplating future uses, the design strategy for upcoming office systems is focused on creating spaces adept at accommodating the ever-evolving needs and expectations of the dynamic work environment.

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