P-ISSN 2664-0422	Pakistan Social Sciences Review	Jul-Sep 2024, Vol. 8, No. 3
O-ISSN 2664-0430	https://doi.org/10.35484/pssr.2024(8-III)28	[378-388]

Pakistan Social Sciences Review
www.pssr.org.pk

RESEARCH PAPER

A Study on the Position of Emergency Exits in the Spatial Configuration of Hostel Buildings based on Safety Standards through Space Syntax

[1]Muhammad Bilal, [2]Ubaid Ullah* and [3]Salman Jamil

1. Master Student, Department of Architecture, University of Engineering & Technology Peshawar, KP, Pakistan
2. Lecturer, Department of Architecture, University of Engineering & Technology Peshawar, KP, Pakistan
3. Assistant Professor, Department of Architecture, University of Engineering & Technology Peshawar, KP, Pakistan

***Corresponding Author:** drubaidullah@uetpeshawar.edu.pk

ABSTRACT

The aim of this research is to validate safety standards and to analyze the position of emergency exits in the spatial configuration of hostel buildings using spatial indices. Current building design standards provide important guidelines to achieve safety in buildings during emergencies but doesn't have sufficient information for the emergency exit design in terms of spatial layout and users' flow pattern. In the design of buildings along with other systems (Structural, HVAC, Mechanical, Materials, firefighting), it is important to focus on enhancing the Spatial Layout and, Circulation design for safe evacuation during emergency. This research utilized space syntax, Autodesk Revit for the analysis of visibility, accessibility, travel path and time analysis of emergency exits. The Depthmap identified the potential areas for the correct placement of emergency exits where the visibility, and accessibility are higher than the existing location of emergency exits. The results also validate a safety standard that emergency exit should be accessible from main corridors instead of dead ends. Based on the analysis, the emergency exits of some buildings can be relocated to potential areas to improve safety and standardize the evacuation system without damaging the physical structure of the building, which will reduce the travel distance and improve the visibility of the targeted area.

KEYWORDS Connectivity, Emergency Exits, Safety Standards, Space Syntax, Visibility

Introduction

The aim of the evacuation system in buildings is to safely evacuate the inhabitants during the emergency (Lo and Fang, 2000). Pakistan has suffered from some natural disasters and waves of terrorism in the last two decades and the deadly terrorist attacks on educational institutes raised some serious concerns among the people about their safety and security inside the building. After the 2005 earthquake, Pakistan introduced building codes and guidelines related to the structural design of the buildings. Similarly, after the fire-catching incidents in most of the public buildings, the state sensed the need for new building codes related to the fire emergency event and the design of the emergency exits in the buildings. Therefore, new building codes were developed in 2016. These Building codes provide important guidelines to improve safety during emergencies in the buildings with less information for the emergency exit design in terms of spatial layout and user flow pattern in the building.

Literature Review

A research conducted in public buildings at the Loughborough University Campus to study human behavior during the evacuation in emergency events (Sagun et al., 2013), utilized the approach of an Observation case study and a Simulation to investigate the user's preferences in case of emergency. The research found that "distance" and "familiarity" with the building are the two most important factors determining exit preference in office buildings (Sagun et al., 2013). Another study conducted at Jeju University South Korea summarized that Evacuation efficiency can significantly differ according to ecological features inside the building such as visibility, the distance between the emergency exit symbol and the evacuees, and the spatial arrangement(Jeon et al., 2019). Recent studies developed important guidelines and had significance for specific buildings such as offices, and commercial buildings. Yet, their conventional method of research over the factors of visual findings, limited to specific buildings and does not apply to other populated public buildings(Sagun et al., 2013, Jeon et al., 2019).

Emergency exits are continuous, unobstructed evacuation routes from anywhere in the building to a safe place(Danial et al., 2019). One of the building's most significant purposes is the safe exit for all inhabitants from the building in the happening of an emergency(Jeon et al., 2019). The design method for safe buildings covers the three foremost zones of building layout and user's flow pattern design specifically: ways of access, Flow pattern, ways of exit(Sagun et al., 2013). Research suggest that the number and placement of emergency exits in a buildings depend on the geometry and size of the building (Sagun et al., 2013). Evacuation efficiency can significantly differ according to the kind of way out services and ecological features inside the building(Jeon et al., 2019). The four ecological aspects are visibility, the distance between the emergency exit symbol and the evacuees, the spatial arrangement, and the size and illumination of the emergency exit symbol(Jeon et al., 2019). The common medium of exits are Stairs, ramps, Doorways, passageways, and elevators(Fairbank and Kellers, 1966). Typically, the building requires a minimum of two evacuation routes to instantly evacuate building residents in case of an emergency. However, if residents cannot evacuate safely due to increased number of residents, the size of the building, or the layout of the building, more than two exits are recommended (Danial et al., 2019).

Buildings that don't possess a sprinkler arrangement must have an extreme travel distance to an exit between 100-150 feet (Fairbank and Kellers, 1966). Buildings that possess a sprinkler arrangement may have a maximum travel distance to an exit under 150-200 feet (Fairbank and Kellers, 1966)**.** The minimum width of the exit stairway shouldn't be less than three feet and six inches"(Fairbank and Kellers, 1966). The slope of the ramp shouldn't be less than the ratio of 1:10 (Fairbank and Kellers, 1966). The minimum width of the exit doorway should be three feet, and if the number of people are more than 100 per floor, then it should be more than three feet (Fairbank and Kellers, 1966). The width of the exit passageways should be at least equal to the width of the doorway(Fairbank and Kellers, 1966).

Space syntax is the concept of space and a set of approaches for analyzing the spatial configuration and human activity pattern in different spaces such as buildings, urban areas (Ahmad et al., 2024; Ammar et al., 2024; Hillier and Hanson, 1989). It was introduced by Bill Hillier, Julienne Hanson, and their fellows at the Bartlett, University College London in the late 1970s and early 1980s(Gomaa et al., 2024; Din et al., 2023; Tarabieh et al., 2019). Space syntax tries to describe anthropological behaviors and societal doings in term of a spatial configuration(Ullah et al., 2023a; Ullah et al., 2023b;

Hillier and Hanson, 1989). Visibility graph analysis (VGA) studies the properties of a visibility graph derived from the spatial environment. Visibility graphs are created by overlaying a grid on a floor plan of a space (such as a CAD drawing) using space syntax software. Visual connectivity is the number of spaces that are directly visible from a given point(Turner et al., 2001). Visual integration measures the visual distance from one room to all other rooms, including rooms that are not directly visible(Ullah and Park, 2016; Turner et al., 2001).

Material and Methods The research begins through data collection of hostel building in terms of plan drawings. The plans were then redrawn in AutoCAD software before visibility and accessibility analysis. The drawings redrawn in AutoCAD were then imported to Depthmap software for analysis. To find the distance and travel time of users to emergency exits, the route analysis/path of the travel plan was carried out in Autodesk Revit. In the last step the level of implementation of safety standards such as number of exit, building size and shape, placement of exits, and signage were carried out. To find the travel distance from any space to emergency exit and speed were measured using Auto Desk Revit's Route analysis. Visual Graph Analysis (VGA) was carried out to find the Visual connectivity, Visual mean depth, and Visual integration in the corridors of hostel buildings. The Depthmap indicates different colors ranging from warm to light with higher values for warm and lower values for light colors.

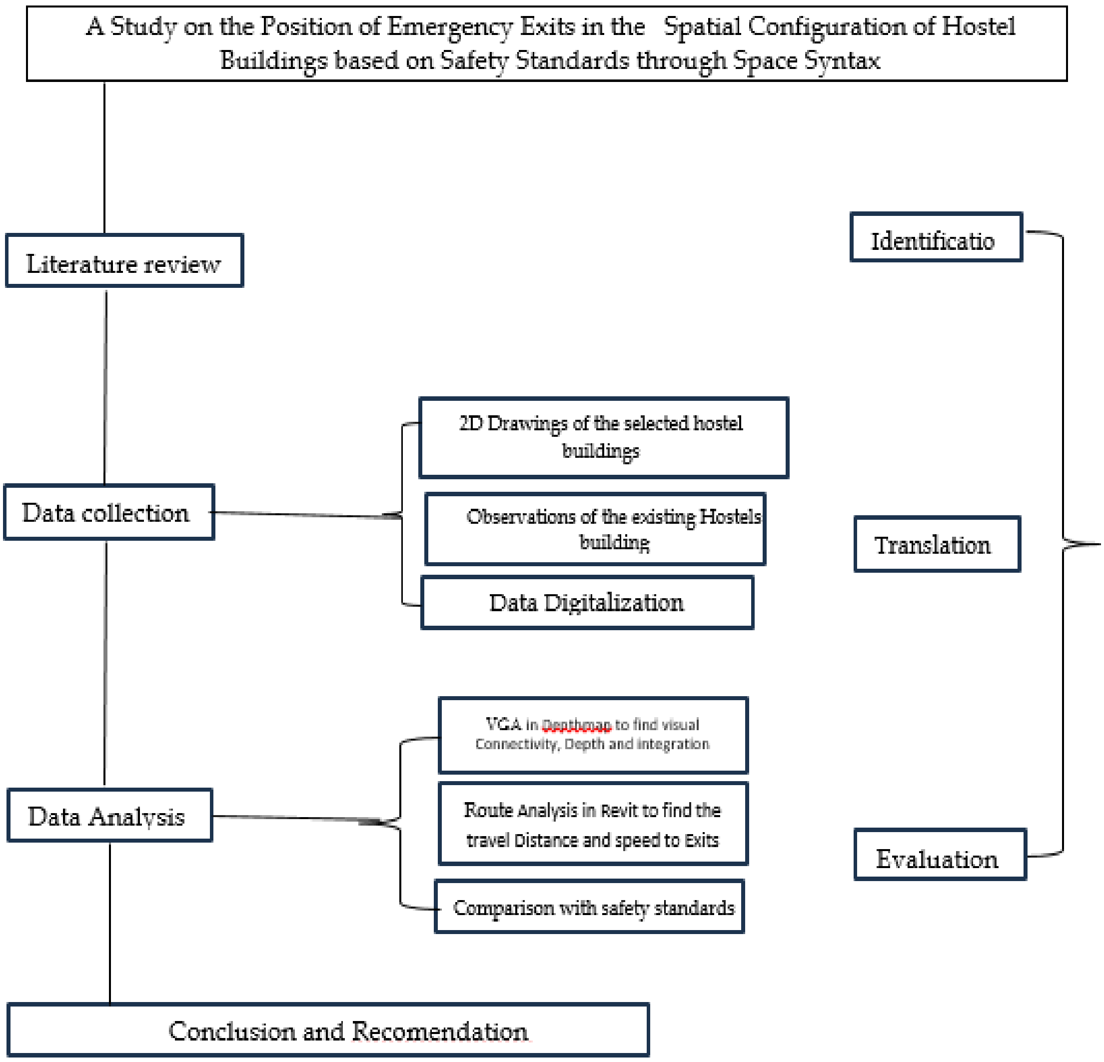

Figure 1 Research Design and Framework

Results and Discussion

The Planning Typology of case-1 is Linear Organization. There are two emergency exits located on the top of left and right ends of corridors encircled as shown in the floor plan. The spaces are planned alongside a linear corridor and connected with the main Lobby of the building as shown in figure 2 below.

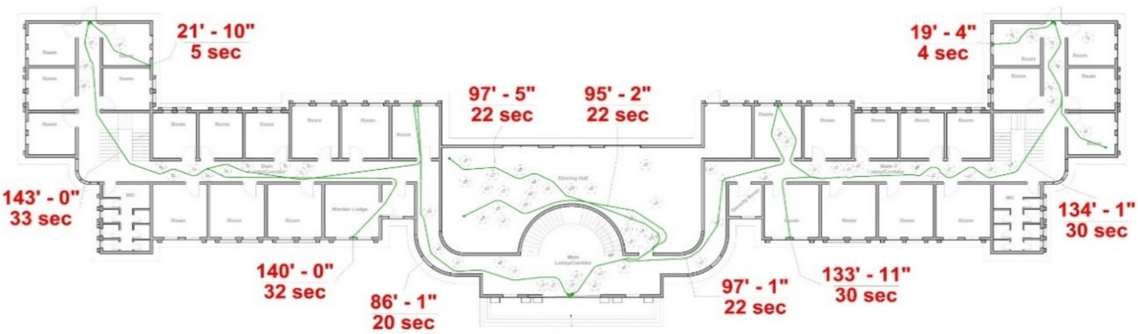

Figure 2 Floor plan of case-1 with travel distance and time

As per the safety standards, the emergency exit should be located on all floors of the building. In this building, the exits are only located on the Ground Floor. The exit should be accessible and visible from all targeted spaces but in this hostel, it is visible from the side corridors. The travel distance should not be more than 100 feet without any obstructions. And for most of the spaces, it's more than 100 feet. The width of the exits meets safety standards and is open towards the outside.

The Visual graph analysis (VGA) of this building indicates the poor visibility and accessibility in the area/corridor where current emergency exits are located due to less integrated corridor and higher depth. The Visual Connectivity and Visual Mean depth are higher in the junctions of corridors and the main Lobby instead of the end of a corridor as shown in Figure 3-5 below.

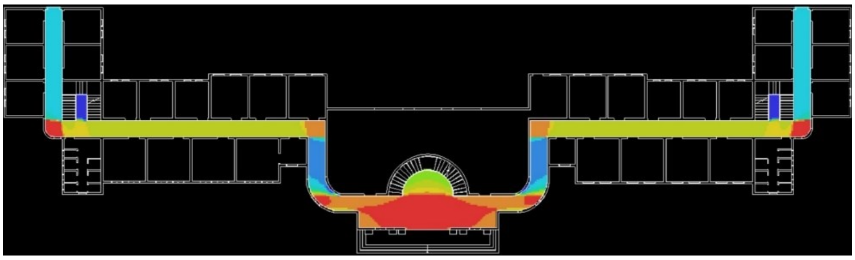
Figure **3** Visual Connectivity

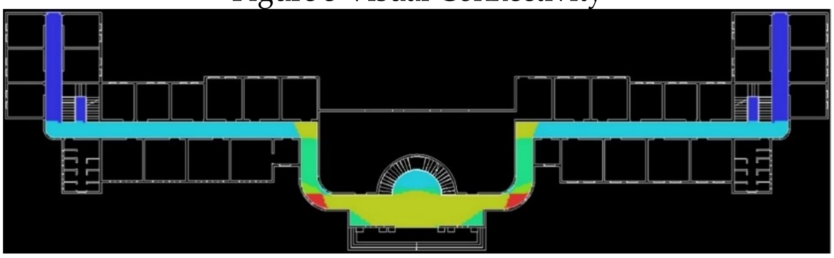
Figure **4** Visual Integration

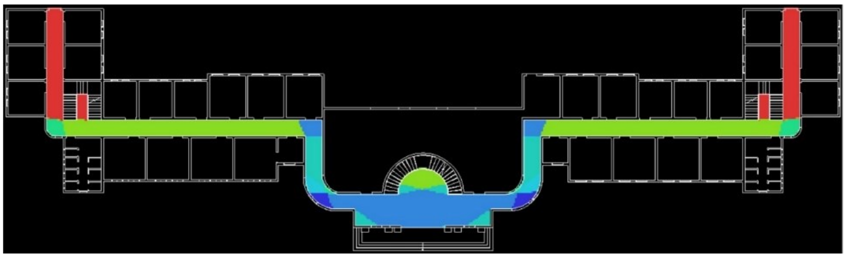

Figure **5** Visual Mean depth

Table 1
Comparison with Depthmap results

Case Number	Visual Connectivity			Visual depth			Visual Integration		
	At Exit	Low	High	At Exit	Low	High	At Exit	Low	High
Case-1	7.86	1.97	24.45	4.02	2.1	4.02	3.43	3.43	8.77

To meet safety standards, the values of Visual connectivity (VC) and Visual integration (VI) should be near or match with high values. The values of VC and VI are more than half of the low value and less than triple the high value which consider is low as shown in table 1.

In case-2 there only emergency exit is located on the top right end of the corridor in the floor plan. The spaces are planned alongside a linear corridor that's connected with all rooms, the dining hall, and the main Lobby of the building as shown in figure 5 below. As per the safety standards, the emergency exit should be located on all floors of the building. In this building, the exit is only located on the Ground Floor. The exit should be accessible and visible from all targeted spaces, but in this building, it is visible from the right-side corridor. The travel distance should not be more than 100 feet without any obstructions. The maximum distance is 151 feet. The width of the exits meets safety standards but it opens towards inside which is not in line with safety standards as shown in figure 6.

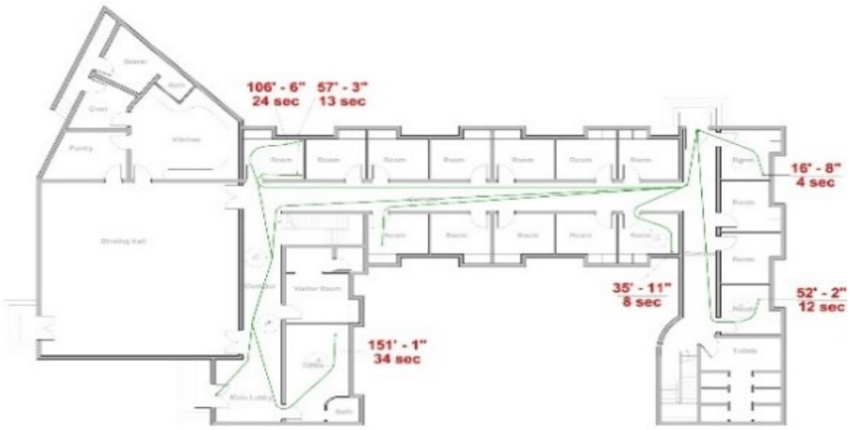

Figure 6 Floor plan of case-2 with travel distance and time

The Visual Graph Analysis of this building indicates poor visibility and accessibility in the corridor where current emergency exits are located due to less integrated and higher depth. The Visual Connectivity and Visual Mean depth is higher in the junctions of corridors instead of the end of a corridor as shown in figure 7-9.

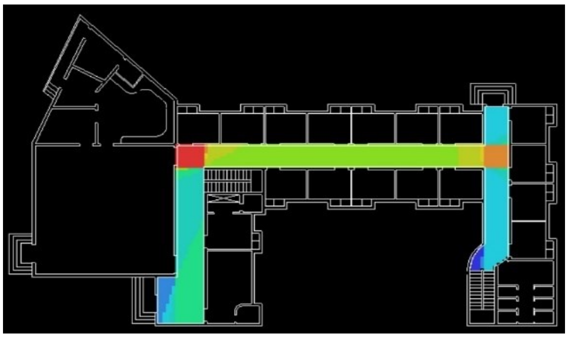

Figure 7 Visual Connectivity

Figure 8 Visual Mean Depth

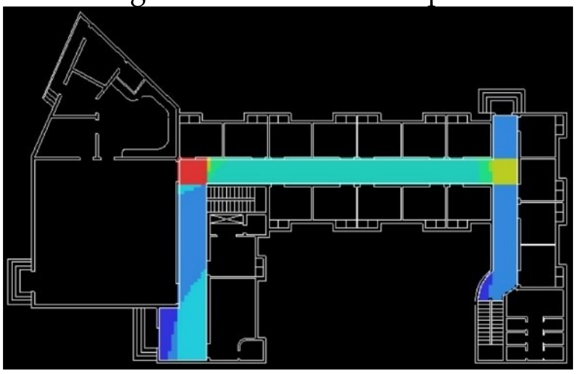

Figure 9 Visual Integration

Table 2
Comparison with Depthmap results

Case Number	Visual Connectivity			Visual depth			Visual Integration		
	At Exit	Low	High	At Exit	Low	High	At Exit	Low	High
Case-2	4.42	1.45	13.24	2.11	1.28	3.02	7.37	4.0	29.29

To meet safety standards, the values of Visual connectivity and Visual integration should be near or match with high values. The value of Visual mean depth should be near or match to Low value. The values of VC and VI are more than half of the low value and less than triple the High value which consider is low as shown in table 2.

The Planning Typology of case-3 is Linear Axial Organization. There are no emergency exits defined in this building. The two Entrances on the top of the left and right corridors are used as emergency exits. The spaces are planned alongside a linear corridor that's connected with all rooms, the dining hall, and the main Lobby of the building. The accessibility to these exits is matching the safety standards and the travel distance is less than 100ft. But the visibility is only found on 2 sides of corridors. The width of the exits meets safety standards but it opens towards inside which is not in line with the safety standards as shown in figure 10.

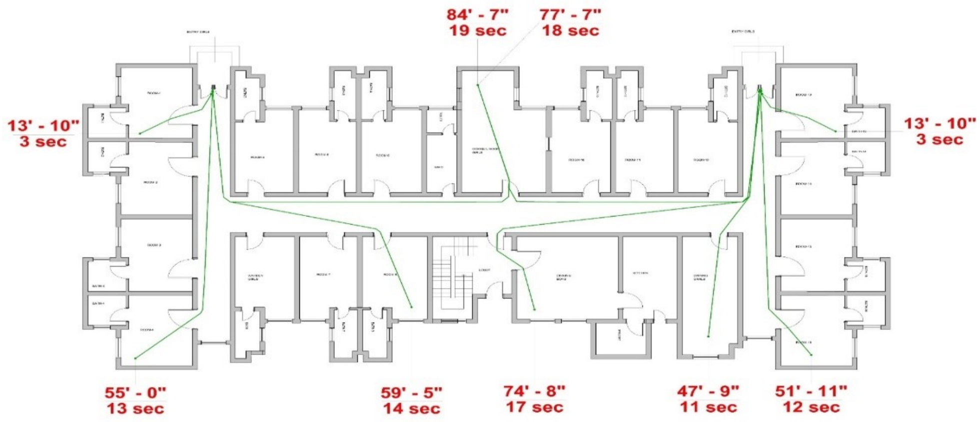

Figure 10 Floor plan of case-3 with travel distance and time

The VGA in the spatial configuration of this building indicates poor visibility and accessibility in the corridor where the emergency exits are located due to lower integration and higher depth. The Visual Connectivity and Visual Mean depth are higher in the junctions of corridors instead of the end sides as shown in figure 11-13.

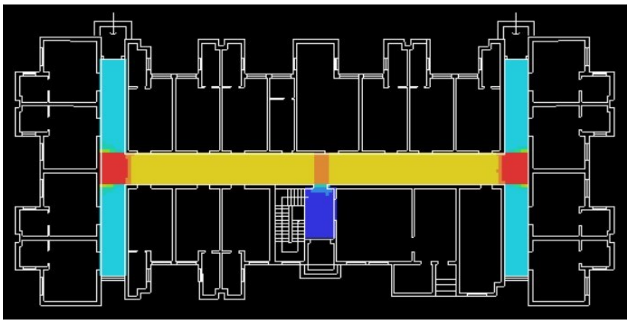

Figure 11 Visual Control

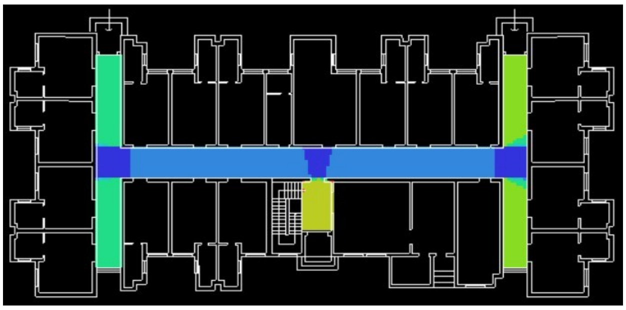

Figure 12 Visual Mean Depth

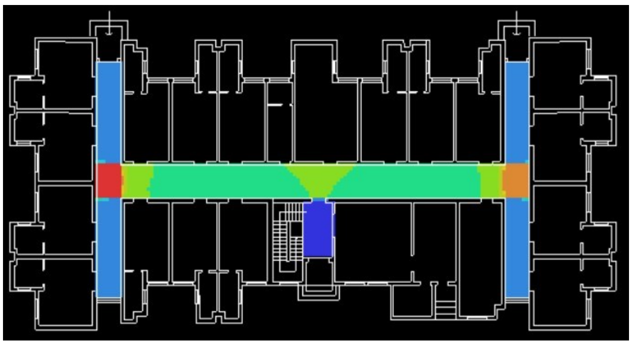

Figure 13 Visual Integration

Table 3
Comparison with Depthmap results

Case Number	Visual Connectivity			Visual depth			Visual Integration		
	At Exit	Low	High	At Exit	Low	High	At Exit	Low	High
Case-3	5.27	2.47	19.36	2.05	1.26	2.2	8.30	6.95	37.2

To meet safety standards, the values of Visual connectivity and Visual integration should be near or match with high values. The value of Visual mean depth should be near or match to Low value. The values of VC and VI are more than half of the low value and less than triple of the High value which consider is low as shown in table 3.

The Planning Typology of case-4 is centralized radial Organization. Due to its geometry, placement of emergency exits and spatial organization, it shows different results compared to the first three cases. There are four emergency exits, two on the left side and two on the right side as shown in the floor plan. The spaces are planned around a central courtyard which act as a focal point as shown in figure 14. The geometry and spatial organization of this building is different from other three buildings and due to planning typology this building shows good visibility and accessibility. In this building, the exits are only located on the Ground Floor. The emergency exits are visible from all targeted spaces. The travel distance is less than 100 feet without any obstructions. The width of the exits meets safety standards and opens towards outside.

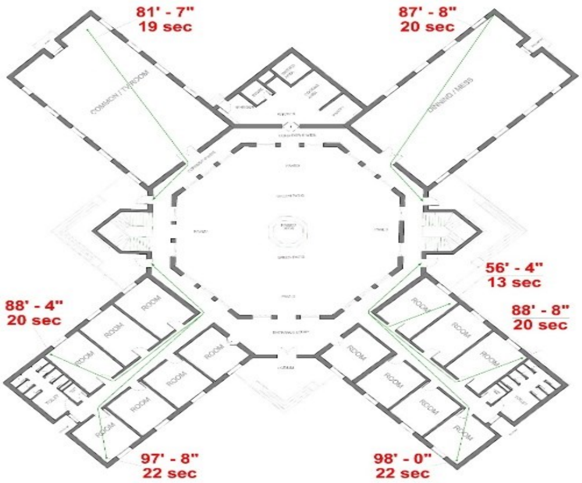

Figure 14 Floor plan of case-4 with travel distance and time

The VGA in the spatial configuration of this building indicates the good visibility and accessibility in the corridors where the emergency exits are located due to higher integration and lower depth as shown in figure 15-17.

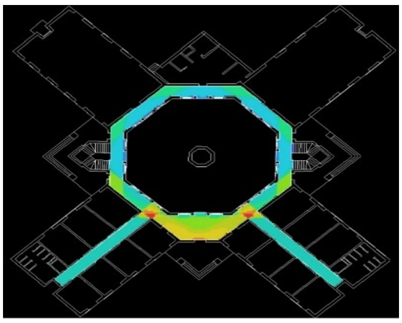

Figure 15 Visual Connectivity

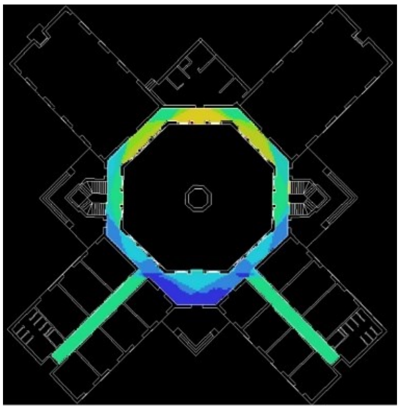

Figure 16 Visual Mean Depth

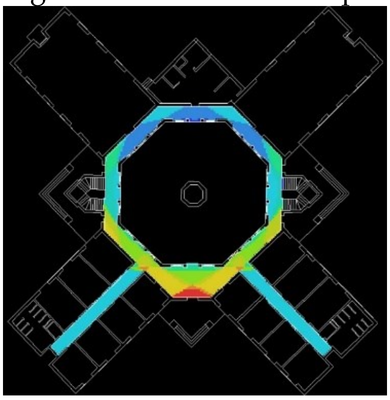

Figure **17** Visual Integration

Table 4
Comparison with Depthmap Result

Case Number	Visual Connectivity			Visual depth			Visual Integration		
	At Exit	Low	High	At Exit	Low	High	At Exit	Low	High
Case-4	8.56	3.95	14.25	2.17	1.95	3.50	7.97	3.71	9.77

To meet safety standards, the values of Visual connectivity and Visual integration should be near or match with high values. The value of Visual mean depth should be near or match to Low value. The values of VC and VI are more than double the low value and less than half of the High Value which is considered near to it

Conclusion

The Depthmap results identified the potential areas where the visibility and accessibility are higher than the existing placement of Emergency exits. It indicates maximum visibility at the junction of corridors and lobbies rather than at the end of a corridor. According to safety standards, emergency exits in the building should be accessible from the main corridors of the building instead of dead ends. Comparative analysis of the cases shows the major issues of Visibility and accessibility in the spatial organization of case-1, 2 and 3. The travel distance can be significantly reduced in the areas where the visual connectivity, integration, and depth value is higher than the existing location of emergency exits in the selected buildings. The results of this may help the Architects, Designers, and Researchers to adopt the framework for analysis of buildings to improve safety and security during emergencies. Based on the analysis, the emergency exits of some buildings can be relocated to potential areas to improve safety and standardize the evacuation system without damaging the physical structure of the building, which will reduce the distance and improve the visibility of the target area. Due to the hierarchy of the spaces and spatial function, the Dining Hall in each hostel building should have separate emergency exits. To ensure safe planning and construction in case of emergency, the architect should analyze, the building plans and designs about emergency exit placement before construction begins, by adopting the proposed framework and tools based on appropriate safety standard.

Recommendations

Based on the results of this study, the following are points are recommended:

1. **Relocate Emergency Exits**: Reposition emergency exits from the ends of corridors to locations with higher visibility and accessibility, such as the junctions of corridors and lobbies. This will ensure that exits are more easily seen and reached during emergencies.

2. **Implement Visibility and Accessibility Standards**: Align the placement of emergency exits with safety standards that prioritize visibility and accessibility from main corridors. Avoid placing exits in dead-end areas to enhance safety.

3. **Conduct Spatial Analysis in Design Phases**: Architects and designers should integrate Depthmap or similar spatial analysis tools during the early design phases to assess visibility and accessibility. This can help identify optimal exit locations, improving overall safety.

4. **Optimize Travel Distances**: Reduce travel distances to emergency exits by placing them in areas with higher visual connectivity, integration, and depth value. This can enhance the speed and efficiency of evacuations.

5. **Adopt a Comprehensive Framework for Safety**: Encourage the adoption of a standardized framework for analyzing building safety and security during emergencies. This can serve as a valuable tool for architects, designers, and researchers in improving the spatial organization of buildings.

References

Ahmad, A., Ullah, U., & Ammar, M. F. (2024). A Planning Study on the Spatial Configuration of Buss Rapid Transit Stations-Focused on Sustainable Mobility. *Journal of Development and Social Sciences*, *5*(2), 577-585.

Ammar, M. F., Ullah, U., & Iftikhar, S. (2024). Development of Predictive Model for the Number of Public Park Visitors: A Case of Rawalpindi, Punjab Pakistan. *Pakistan Languages and Humanities Review*, *8*(2), 555-563.

Danial, S. N., Smith, J., Khan, F., & Veitch, B. (2019). Human-like sequential learning of escape routes for virtual reality agents. *Fire technology*, *55*, 1057-1083.

Din, M., Ullah, U., Saqib, M. Z., & Ahmad, J. (2023). Objective Evaluation Of Cpted Principles In Urban Context: A Syntactic Analysis Of Hayatabad Peshawar. *International Journal of Contemporary Issues in Social Sciences*, *2*(4), 123-140.

Fairbank, W. M., & Kellers, C. F. (1966). National Bureau of Standards Miscellaneous Publication.

Gomaa, M. M., Ullah, U., & Mehr Afroz, Z. (2024). The Impact of Spatial Configuration on Perceived Accessibility of Urban Parks based on Space Syntax and Users' Responses. *Civil Engineering and Architecture*, *12*, 2395-2402.

Hillier, B., & Hanson, J. (1989). *The social logic of space*. Cambridge university press.

Jeon, G. Y., Na, W. J., Hong, W. H., & Lee, J. K. (2019). Influence of design and installation of emergency exit signs on evacuation speed. *Journal of Asian Architecture and Building Engineering*, *18*(2), 104-111.

Lo, S. M., & Fang, Z. (2000). A spatial-grid evacuation model for buildings. *Journal of Fire Sciences*, *18*(5), 376-394.

Sagun, A., Anumba, C. J., & Bouchlaghem, D. (2013). Designing buildings to cope with emergencies: Findings from case studies on exit preferences. *Buildings*, *3*(2), 442-461.

Tarabieh, K., Nassar, K., Abdelrahman, M., & Mashaly, I. (2019). Statics of space syntax: Analysis of daylighting. *Frontiers of Architectural Research*, *8*(3), 311-318.

Turner, A., Doxa, M., O'sullivan, D., & Penn, A. (2001). From isovists to visibility graphs: a methodology for the analysis of architectural space. *Environment and Planning B: Planning and design*, *28*(1), 103-121.

Ullah, U., Amin, M., & Park, J. S. (2023 a). An objective evaluation of emergency plan types using space syntax and users' responses. *Mehran University Research Journal Of Engineering & Technology*, *42*(2), 46-53.

Ullah, U., Ullah, S., & Sajjad, I. (2023 b). Syntactic Comparison of Traditional Courtyard and Modern Houses of Khyber Pakhtunkhwa, Pakistan. *Annals of Human and Social Sciences*, *4*(2), 10-17.

Ullah, U., & Park, J. S. (2016). A Genotypical Analysis of Korean REMCs and Generation of Base Line Data for the Analysis and Evaluation for Future (REMCs) Designs Using Space Syntax. *Journal of The Korea Institute of Healthcare Architecture*, *22*(1), 17-28.