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STAIR DESIGN AND FLOOR HEIGHT DIFFERENCES IN RELATION TO SAFETY CONCEPTS FOR ELEMENTARY SCHOOL STUDENTS

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ABSTRACT
The need for safe school buildings is further emphasized by the impact of natural disasters, which shows the importance of prioritizing investment in school infrastructure. This study aims to evaluate the suitability of the dimensions of the stairs with student anthropometry, regarding safety aspects in daily use, and provide design improvements to improve the safety of children in the school environment. This research is a descriptive-evaluative qualitative case study at SDN Ketawanggede from August 2023 to May 2024. Data were collected through observation, interviews, and document analysis. The results show that there are disparities in the implementation of safety and accessibility standards in schools with varying infrastructure conditions, focusing on both urban and rural areas, to identify disparities and best practices. The long-term impact of implementing safety measures, such as anti-slip materials, consistent step dimensions, and improved ramps, on the incidence of accidents and injuries among students, is analyzed. The practical outcome of this research includes actionable design solutions to mitigate safety hazards, particularly addressing differences in school floor heights and staircase dimensions. The study provides a valuable resource for policymakers, school administrators, and architects involved in designing and maintaining school facilities.

INTRODUCTION

Children have a high risk of having accidents due to cognitive limitations (Vinje, 1981). Their inability to understand and anticipate hazards makes them more vulnerable to fatal accidents. Injuries from accidents and violence cause the deaths of 4.4 million people worldwide, accounting for 8% of total global deaths (WHO, 2022). In 2019, more than 684,000 deaths were caused by falls, confirming the issue as an increasingly pressing public health crisis. Injury statistics show that falls account for 15% of total injuries. Basic Health Research in 2018 reported that the national injury prevalence reached 9.5%, with 12.1% in children aged 5-14 years. In East Java, the prevalence of injuries reached 9.2%, with 6.5% of such cases occurring in school environments (Kemenkes RI, 2018).

The school environment is very important for children, on par with the influence of the family environment in shaping their experiences and development (Wang et al., 2020). Good infrastructure is essential to ensure a conducive learning environment and protect students from potential hazards (Fernández et al., 2023). Various studies emphasize the importance of safety standards and guidance in school infrastructure, such as the existence of active safety sub-committees and well-maintained physical infrastructure (Muhumed et al., 2023; Xaba, 2012). In addition, the need for safe school buildings is further emphasized by the impact of natural disasters, which shows the importance of prioritizing investment in school infrastructure.

In evaluating it is necessary to know that good infrastructure includes not only sturdy buildings or modern facilities, but also design and environment that ensures the safety of residents from various risks. Architectural designs that are too modern or minimalist can feel less welcoming or boring to students (Bandyopadhyay & George, 2020), which can cause them to neglect their surroundings and increase safety risks (Ndetei et al., 2023).

Research by Zhou et al. (2020) and Purnama et al. (2020) has made a significant contribution to the understanding of the efficiency of the use of stairs. Zhou et al. used an agent-based simulation method to evaluate the influence of various staircase design factors on the evacuation process, finding that the width of the stairs, the orientation of the stairs and corridors, and the design of the angle between the stairs and the corridor had a significant influence on the evacuation efficiency. Purnama et al. discussed the application of staircase design in the school environment. In addition, a study by Prayitno et al. (2019), Rahayu (2016), and Purnama et al. (2020) discusses the selection of the ideal flooring material for outdoor areas that are often passed by children. Based on this review, the research will integrate the ergonomic principles identified by previous research with a holistic focus on evaluating existing conditions at SDN Ketawanggede and providing practical design improvements.

This research attempted to evaluate the suitability of the dimensions of the stairs with student anthropometry, regarding safety aspects in daily use, and provide improvements to the infrastructure owned. Thus, this research will make a unique contribution in the form of practical and implementable design solutions to improve student safety in primary schools. This study focuses on the evaluation of staircase design and differences in school floor height which have the potential to be a safety risk for elementary school children. The goal is to identify risk areas and provide design improvements to improve the safety of children in the school environment.

The research contributes to the field of infrastructure design and safety in educational environments by providing a unique evaluation of staircase dimensions in relation to student anthropometry. This study highlights critical safety risks posed by poorly designed staircases in primary schools and emphasizes the importance of aligning infrastructure with the physical characteristics of its primary users—elementary school children. The practical outcome of this research includes actionable design solutions to mitigate safety hazards, particularly addressing differences in school floor heights and staircase dimensions. By focusing on these aspects, the study aims to enhance child safety and create safer school environments, offering a valuable resource for policymakers, school administrators, and architects involved in designing and maintaining school facilities.

METHODS

This research is a descriptive-evaluative qualitative case study at SDN Ketawanggede, carried out from August 2023 to May 2024. According to data from the Malang City Education Office and BPS Malang City, in 2023, Lowokwaru District has the highest concentration of elementary schools with 46 public schools and 15 private schools. SDN Ketawanggede in Lowokwaru District was chosen as the research locus because it is an inclusive and superior school that has a lot of distribution of stairs in its environment (Aini, 2004).

Involving the principal, six teachers, and one staff, data was collected through observation, interviews, and document analysis. This study evaluates the physical condition of the stairs and the difference in floor height to provide appropriate design improvements. SDN Ketawanggede was chosen because of its status as a superior inclusion school, but there are still many children spread out of stairs in its environment. The data analysis method uses an interactive qualitative approach by Miles et al. (2014), with research instruments in the form of field observations and structured interviews.

RESULTS

Existing Conditions

In this study, the layout of SD Negeri Ketawanggede is divided into four areas to make it easier to explain. The division of the layout area is explained in the following Figure 1.

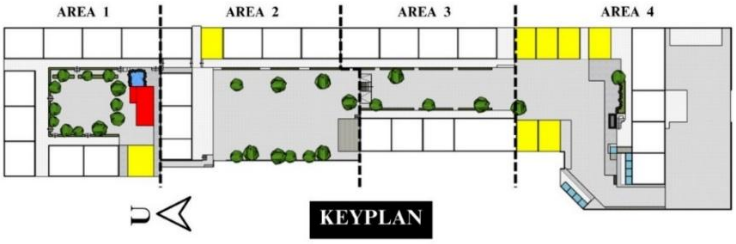

Figure 1. Division of SDN Ketawanggede Layout Area

The division of this area is done to facilitate explanation and ensure that every aspect is clearly visible. In this way, each section can be explained in detail and easier to understand, so that the whole concept can be interpreted comprehensively and systematically. SDN Ketawanggede has a significant variation in floor elevation, so there are many stairs around the school. These stairs are not only in the hallways and in front of classrooms, but also have different design variations, as shown in Figure 2.

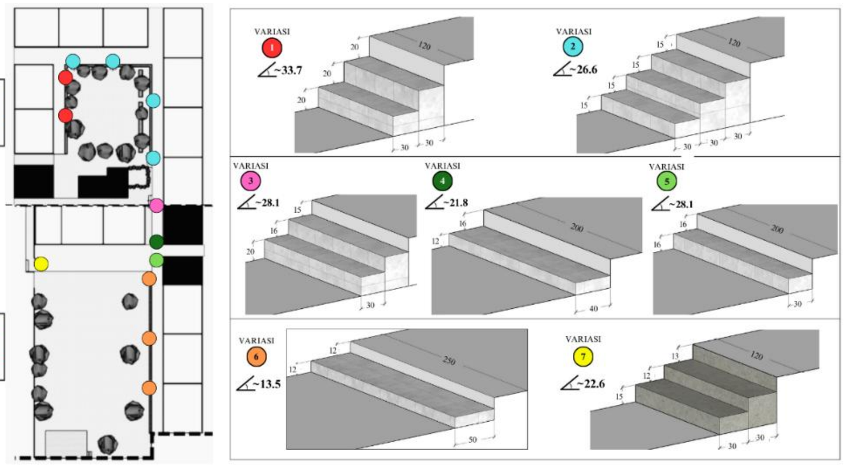

Figure 2. Distribution of stairs variation at SDN Ketawanggede (in cm)

The image shows two areas, Area 1 and Area 2, which are equipped with a variety of staircases. Each area has a placement of colored dots that indicate the location of the stairs. There are seven variations of the stairs in the picture. Variation 1, in front of classes 1A and 1B, has an angle of inclination of 33.7 degrees with dimensions of steps 20 cm high, 20 cm deep and 120 cm wide. Variation 2, in front of classes 2A, 2B, 2C, and Library, has a tilt angle of 26.6 degrees with the dimensions of the steps 15 cm high, 15 cm deep, and 120 cm wide. Variation 3, connecting the 1st and 2nd grade terraces with the Secretariat hallway, has a slope angle of 28.1 degrees with the dimensions of the steps 16 cm high, 20 cm deep, and 120 cm wide.

Variation 4, connecting the Secretariat hallway with the Terrace of the tool room, presentation room, and multipurpose building, has an angle of inclination of 21.8 degrees with the dimensions of the stairs 12 cm high, 15 cm deep, and 200 cm wide. Variation 5, connecting the Secretariat hallway with the Terrace of the tool room, presentation room, and multipurpose building with terraces of classes 3B, 4A, and 4B, has a slope angle of 28.1 degrees with the dimensions of the steps 16 cm high, 15 cm deep, and 200 cm wide. Variation 6, in front of the terraces of classes 3B, 4A, and 4B, has a slope angle of 13.5 degrees with the dimensions of the steps 12 cm high, 12 cm deep, and 250 cm wide. Finally, Variation 7, connecting the Terrace of the tool room, presentation room and multipurpose building with the field, has an angle of inclination of 22.6 degrees with the dimensions of the steps 15 cm high, 13 cm deep and 120 cm wide. The placement of this variety of stairs is adjusted to the needs of accessibility and user safety.

Meanwhile, the dimensions of the main staircase have a step height of 20 cm, a width of 30 cm, a length of 100 cm, and a height of 85 cm from the floor, in accordance with the guardrail of the second floor. All stairs use ceramic tile material which can become slippery when wet. In addition, SDN Ketawanggede has a 40 cm elevation difference between the field level in area 2 and area 3. In the transition between these areas, there are two ramps with stairs in the middle, as illustrated in Figure 3.

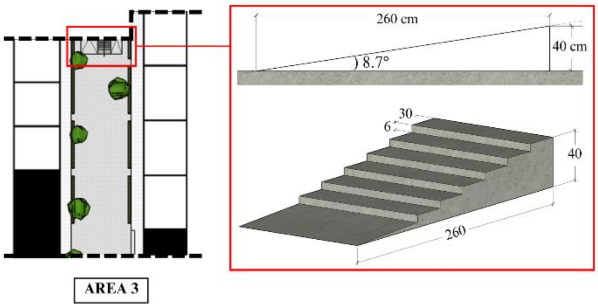

Figure 3. Staircase and ramp design at SDN Ketawanggede

This school also has a terrace that is quite high from the field level, which is 60 cm in area 1 and 52 cm on the front terrace of the tool room, presentation room, and multipurpose warehouse in area 2. This difference in height indicates significant elevation variation in different parts of the school. In the transition between the terrace and the interior space, there is a height difference in area 1, where the classroom has a height difference of 14 cm with the hallway. Meanwhile, in area 2, there is a height difference of 8 cm between the terrace and the tool room, presentation room, and multipurpose warehouse. The school also has a stage with a height of 80 cm from the floor, with a staircase leading to the stage that has a step height of 20 cm, a width of 30 cm, and a length of 120 cm. The overall design of the staircase at this school shows a variety of dimensions and heights, which requires special attention to ensure safety for all its users.

Design Improvements

Stairs repairs include adjusting the height of the stairs to 13-15 cm, the width of the steps to 25-28 cm, and the width of the stairs to 100-150 cm, to meet the needs of children and adults at school. The main staircase follows SNI standards for the safety of all users, while the connecting staircase is adapted to children's anthropometry.

All stairs at SDN Ketawanggede need to be equipped with anti-slip stepnosing and non-slip materials such as rubber, replacing slippery ceramic tiles. The consistency of the dimensions of the steps is important to prevent accidents. The design of stairs at SDN Ketawanggede also needs to be standardized. In area 1, the height of the steps will be equalized to 15 cm to adjust for a height difference of 60 cm, with a stair width of 120 cm and a step width of 25 cm.

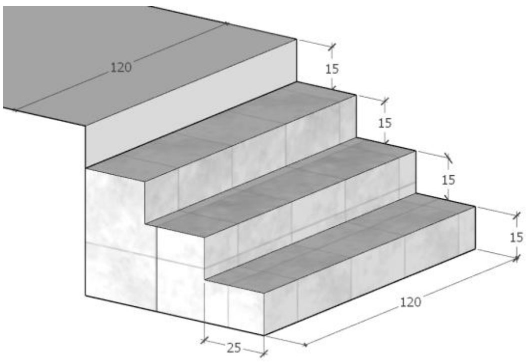

Figure 4. Dimensions of the stairs for the height of the terrace 60 cm (Area 1)

Next, the terrace in front of the secretariat is lowered, so that the two stairs in front of it (variation 4 removed and combined with variation 3) can be combined into one, making it easier for users and providing sufficient circulation distance from the variation 5 staircase. The difference in the height of the stairs will be 79 cm, with three steps 13 cm high and two steps 13.5 cm high which are depicted as follows.

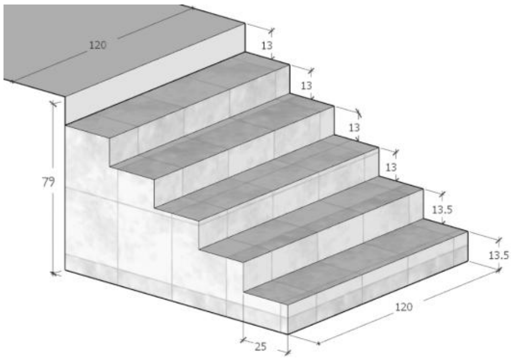

Figure 5. Dimensions of the stairs in front of the secretariat

The stairs in front of the official house that are connected to the terrace of the Multipurpose Building should be closed and leveled with the height of the terrace. The stairs can be moved parallel to the door of the Multipurpose Building so as not to disturb the residents of the official house and reduce the risk of collisions with students, especially during breaks. The dimensions of the new ladder are equated with the dimensions of the ladder in front of the tool room, as shown in the following image.

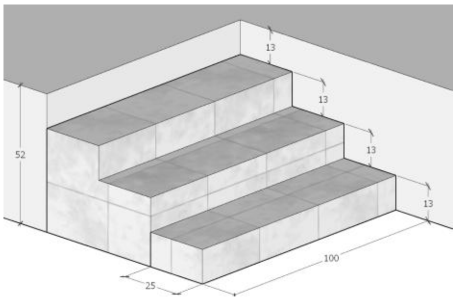

Figure 6. Dimensions of the stairs in front of the tool room

The difference in floor height from class 3B, 4A, and 4B terraces is 24 cm from the field. The best solution is to divide it into two steps with a height of 12 cm each, as it is today. However, the width of the steps should be fixed to 25 cm, so the repair of the stairs will be in accordance with the picture below.

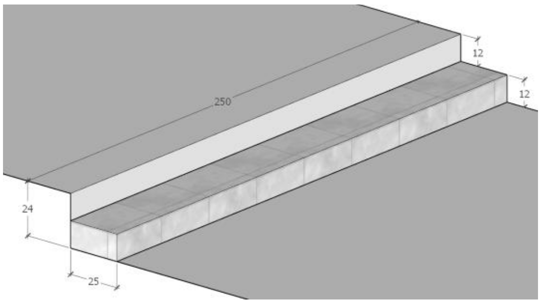

Figure 7. Dimensions of stairs in front of classes 3B, 3C, and 4A

In transitions between areas with elevation differences, such as between area 2 and area 3, ramps and stairs are redesigned. The stairs are placed on one side of the ramp with a width of 100 cm, a step height of 13.5 cm, and a step width of 25 cm. The ramp that was formed now has a width of 250 cm, a length of 460 cm, and a slope of less than 5 degrees. This ramp is equipped with handrails with a height of 80 cm and 60 cm. The design of the repair can be seen in Figure 8.

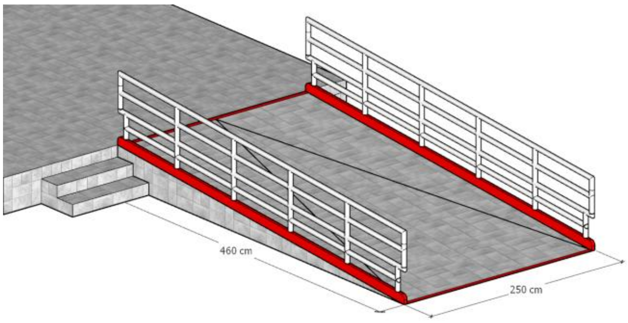

Figure 8. Staircase and ramp design at SDN Ketawanggede

The height difference between the terrace and the interior space, such as 14 cm in area 1 and 8 cm in area 2, needs to be leveled. As a practical solution, schools can mark height differences with anti-slip markers on the edges. These markers should have striking colors to provide clear visual boundaries.

For stage design, the stairs to the stage with a step height of 20 cm, a width of 30 cm, and a length of 120 cm need to be equipped with handrails on one side for safety, without obstructing the view of the audience. The material of the steps also needs to be changed to a textured floor with stepnosing to ensure the safety of the user.

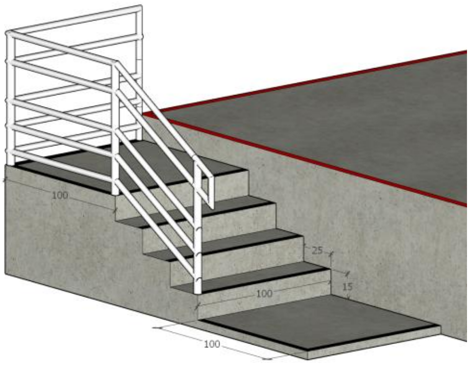

Figure 9. Design of stairs to the stage

The height of the steps is 15 cm, with a tread width of 25 cm and an overall width of 100 cm. This staircase is equipped with a 100 x 100 cm bordes to make it easier for stage users, especially performers. The bottom rung, with a height difference of only 5 cm, is made wider with a size of 100 x 100 cm and is equipped with visual markers to make it easier for users to see the height difference.

The main staircase has undergone major improvements. Previously, the height of the stairs was 20 cm, which was considered too high by SNI and the Minister of PUPR No. 14/PRT/M/2017. This staircase is often used by adults because the second floor is a hall space for activities involving guardians. The new staircase design has a step height of 15 cm and a width of 25 cm. The remaining 5 cm in height is given a visual marker and 40 cm wide as shown in the picture.

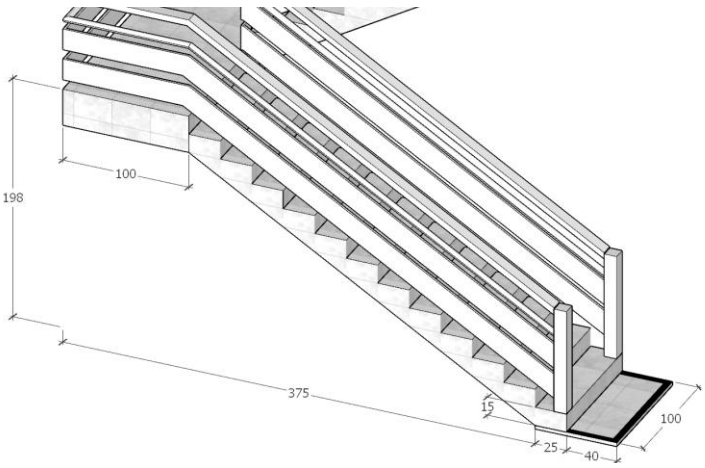

Figure 10. Dimensions of the main staircase

The ladder is equipped with handrails 80 cm and 60 cm high and a cover board to prevent children from slipping. There are 24 steps separated by a bordes measuring 100 x 210 cm. This staircase repair uses coarse granite material that is not slippery, but still looks elegant as the main staircase.

CONCLUSION

To enhance safety at SDN Ketawanggede, modifications to stairs and floor height differences must align with safety and accessibility standards, including the use of anti-slip stepnosing, non-slip materials, and consistent step dimensions. Improvements should also include adding or enhancing sloper ramps and standard ramps for transitions between elevation differences, as well as incorporating handrails and textured materials on stage stairs to ensure user safety. These changes aim to create a safer and more inclusive environment for all students. Future research could expand on these findings by evaluating the implementation of safety standards across diverse school settings, assessing the long-term impact of safety measures on student well-being, and exploring how students perceive and utilize these improvements. Additionally, studies could investigate integrating cost-effective smart technologies, addressing the needs of students with disabilities, conducting cost-benefit analyses of safety interventions, examining policy effectiveness, and encouraging parental and staff involvement in maintaining safe school environments. These efforts can collectively contribute to improving safety and inclusivity in educational settings.

REFERENCES

Aini, N. (2004). *SDN Inklusi di Malang Dimana Saja? Cek Deretan Sekolah yang Terima Siswa Berkebutuhan Khusus*. Malang Terkini.

Bandyopadhyay, A., & George, A. (2020). INTERIOR DESIGN CONSIDERATIONS TO ENHANCE STUDENT SATISFACTION IN CLASSROOMS. *PEOPLE: International Journal of Social Sciences*, *5*(3), 676–687. https://doi.org/10.20319/pijss.2020.53.676687

Fernández, R., Correal, J. F., D'Ayala, D., & Medaglia, A. L. (2023). A decision-making framework for school infrastructure improvement programs. *Structure and Infrastructure Engineering*. https://doi.org/10.1080/15732479.2023.2199361

Kemenkes RI. (2018). *Hasil Utama Riskedas 2018*.

Miles, M. B., Huberman, A. M., & Saldaña, J. (2014). *Qualitative analysis: A methods sourcebook*. SAGE Publications, Inc.

Muhumed, M. H., Justus, G. M., & Stephen, R. (2023). RELATIONSHIP BETWEEN SAFETY SUB-COMMITTEE AND PHYSICAL INFRASTRUCTURE AND IMPLEMENTATION OF SAFETY STANDARDS AND GUIDELINES IN PUBLIC SECONDARY SCHOOLS IN GARISSA TOWNSHIP SUB-COUNTY, KENYA. *International Journal of Advanced Research*, *11*(03), 390–396. https://doi.org/10.21474/IJAR01/16435

Ndetei, D. M., Nyamai, P., & Mutiso, V. (2023). Boredom–understanding the emotion and its impact on our lives: an African perspective. *Frontiers in Sociology*, *8*. https://doi.org/10.3389/fsoc.2023.1213190

Prayitno, S. H., Mite, Y. M., Umar, S., Padeng, Y. E., Kaleka, S. R., Hormat, A. C., & Failasuf, M. S. (2019). Pemanfaatan Batu Koral Sebagai Bahan Alternatif Pembuatan Alat Therapy Batu Refleksi. *Penamas Adi Buana*, *3*(1).

Purnama, S., Jannah, R. R., Jazariyah, J., & Sabi'ati, A. (2020). *Desain Interior dan Eksterior Pendidikan Anak Usia Dini*. Pustaka Egaliter.

Rahayu, T. (2016). Penggunaan Material Granit Pada Penampilan Dinding Luar Bangunan Penunjang Estetika. *Jurnal Ilmiah ARJOUNA*, *1*(1).

Vinje, M. P. (1981). Children as pedestrians: Abilities and limitations†. *Accident Analysis and Prevention*, *13*(3). https://doi.org/10.1016/0001-4575(81)90006-3

Wang, M. Te, Henry, D. A., & Degol, J. L. (2020). A development-in-sociocultural-context perspective on the multiple pathways to youth's engagement in learning. In *Advances in Motivation Science* (Vol. 7). Elsevier. https://doi.org/10.1016/bs.adms.2019.11.001

WHO. (2022). *Preventing injuries and violence: An overview*.

Xaba, M. I. (2012). A qualitative analysis of facilities maintenance - a school governance function in South Africa. *South African Journal of Education*, *32*(2). https://doi.org/10.15700/saje.v32n2a548

Zhou, J., Jia, X., & Jia, J. (2020). Effects of different staircase design factors on evacuation of children from kindergarten buildings analyzed via agent-based simulation. *Healthcare (Switzerland)*, *8*(1). https://doi.org/10.3390/healthcare8010056