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The Design of Steps: The Correlation to the Danger and Occurrence of Accidents

Alexander Tung[1] and Rohan Dixit[1#]

[1]Brentwood High School
[#]Advisor

ABSTRACT

The purpose of this paper was how the design of steps are connected with the frequency of accidents. Research was conducted to see what issues contribute the most frequently and present the most danger to people. Once those issues were properly identified, we generated 3D concepts that can be manufactured and implemented to combat the liabilities affecting the stairs. Staircase accidents would be decreased through good lighting, a familiar and consistent design, a strong foundation that offers friction and grip, and a way to remove liquid. This would allow for safe use in dark or wet conditions, or when in use by busy workers that are multitasking and not paying attention to the stairs. We conclude that utilizing solutions in safety can save people from injuries and death when on a staircase.

Defining the Problem

Stairs are something we use daily, whether it is for work, school, or home. They are present everywhere, however there may be hidden dangers which are important for everyone to know about: There are flaws to certain staircases, and our project aims to highlight those mistakes - and how to fix them.

Severe and sometimes permanent injuries can happen if one is not careful treading on stairs or ladders. According to the Norwegian Maritime Authority, a crewmate was holding goods while descending a ladder. He missed a step and lost his balance. He hit the ground extremely hard with his right shoulder, and could not even sit up since the pain was unbearable. Thankfully his radio allowed him to call for help and get medical attention. There are many more incidents, and falls are very common. However, many of those falls are preventable. If something is done about it, thousands more lives will no longer be in danger from staircase accidents. There is an extreme rate for staircase accidents: every 20 minutes someone dies from a fall, and many more are injured in one.

The problem with staircase falls is that they are hard to prevent on the human's end since it is difficult to see if there is a physical flaw or if the design is not user-friendly. Although the rates vary among age, it still impacts everybody, and a bad fall can be dangerous.

Why we Came Up with this Idea

In order to prevent more injuries, we are going to highlight the importance of staircase design to ensure less people slip and fall on stairs. Even from the smallest, shortest or shallowest of stairs, many unfortunate incidents have arisen from mistakes. Most people underestimate the devastation effects of falling/tripping on stairs. This does include spilling coffee on your boss's shirt, but that is the least worrisome thing that can happen.

We came up with this idea because we wanted to explore something common and relevant in everyday life that could be a threat. We looked at the numbers and gave a few examples to show how serious stair falls can be. And so, this project will help raise awareness for preventing stairway injuries *and* how to limit stairway injuries. Thankfully, the solutions are relatively simple to create and implement.

Target Population of our Research

Falls can happen to anybody, however extensive data has proven that older adults are *3* times more prone to suffer a physical injury or TBI (traumatic brain injury) while traversing stairs/ladders relative to instead just walking. 27% of fall related TBIs occur on stairs for young and middle-aged adults (20s-40s), with an *additional* 51% of incidents happening on stairs involving older adults (≤50s). (Jacobs, *ScienceDirect*) Over 1 in 4 older adults fall per year, over 800,000 patients are hospitalized per year due to fall-related injuries.

Therefore, our new design of stairs will be engineered to adapt to people especially with a disability either caused by age, physical limitations, and/or the influence of action at a workplace (such as carrying goods, working in icy conditions etc). It will also be engineered to be commonly available and easy to implement in as many places as possible with maximum efficiency in limiting all factors that contribute to accidents.

Topic Research

Now that the problem has been clearly identified, the process of deriving a suitable solution must attend to all of the proceeding factors:

- Suitable for any age
- Easy use and accessibility
- Able to not hinder performance when going both *up* and *down*

However, one type of step cannot work perfectly in *every* environment and circumstance. Therefore, there will be different steps that will each be uniquely designed for different situations. The most common factors that cause falls according to *EHSToday*, are deficiencies in design, lighting, visibility, and human attention. (Maynard & Brogmus)

- Design includes the physical shape and structure of the step. This also includes the material of which the step is made out of.
- Lighting and visibility incorporates how different light levels illuminate the stair *or* how the stair highlights itself in various lighting conditions.
- Human attention is what percent out of the total number of stairs people generally see. EHSToday states that pedestrians view only the first and last three steps, with the rest of the stairs ignored, therefore the steps in the middle are the most crucial to be designed.

Four steps will be designed to fix the most common issues contributing to falls, and each one will meet at least one of the following criteria and circumstances. Each step will also be following the current building code recommendations of 4-7 inches in height (for this project it will be 5.5”), minimum of 11 inches in depth (for this project it will also be 11”), and any value of width (for this project it will be 7”). Any exceptions will be specified. The criteria and circumstances of the 4 steps are:

- Poor lighting/visibility (1)
- Frequent use by pedestrians not paying attention. (2)
- Frequent use by workers multitasking/preoccupied (3)
- Frequently wet conditions (4)

Solutions

Step 1 is designed to address the problem of poor lighting and visibility. Our sources suggest the following points to build on:

1. Lights and reflective tape strongly assists with visuals (especially in the dark).
2. Automatic triggers such as motion sensors make the system autonomous, which also make maintenance easier and continuous use longer.

With these in mind, we created a rendering of a possible design that can be implemented:

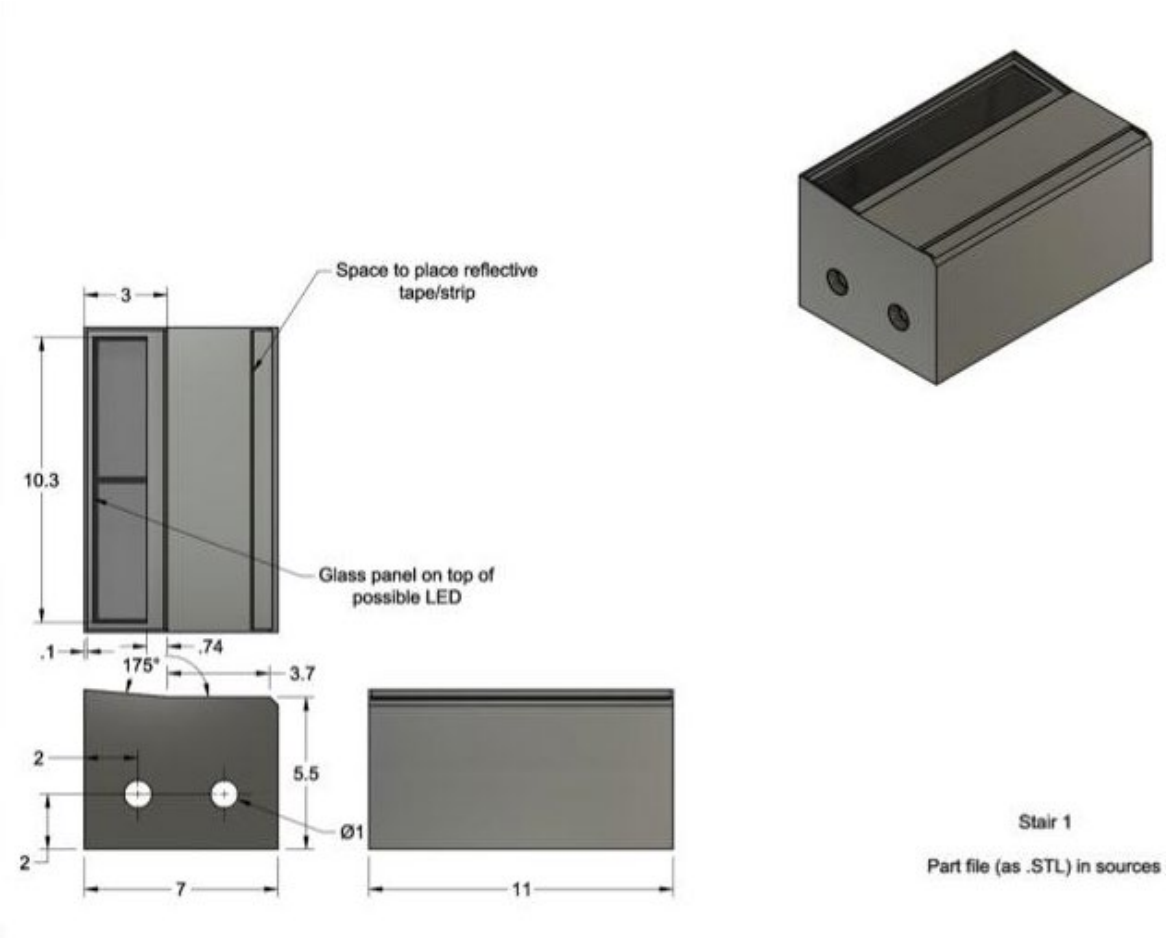

Figure 1. Step 1 is shown above.

The step will have a slot to add an LED strip on the top, front facing edge. Space for circuitry that will house motion sensors will also be available. That can also be rigged to LEDs to turn on/off the light strip when people come near.

Step 2 is designed to address the problem of the frequent use of pedestrians not paying attention. Our sources suggest the following points to build on:

1. Bright colors (especially green) are something that catches our eye and make us focus.
2. The material should be something that cushions possible impact but also remains structurally strong.
3. A unique design that stands out, something that is different and not commonly seen.

With this in mind, we've engineered a step that attests to the previous points.

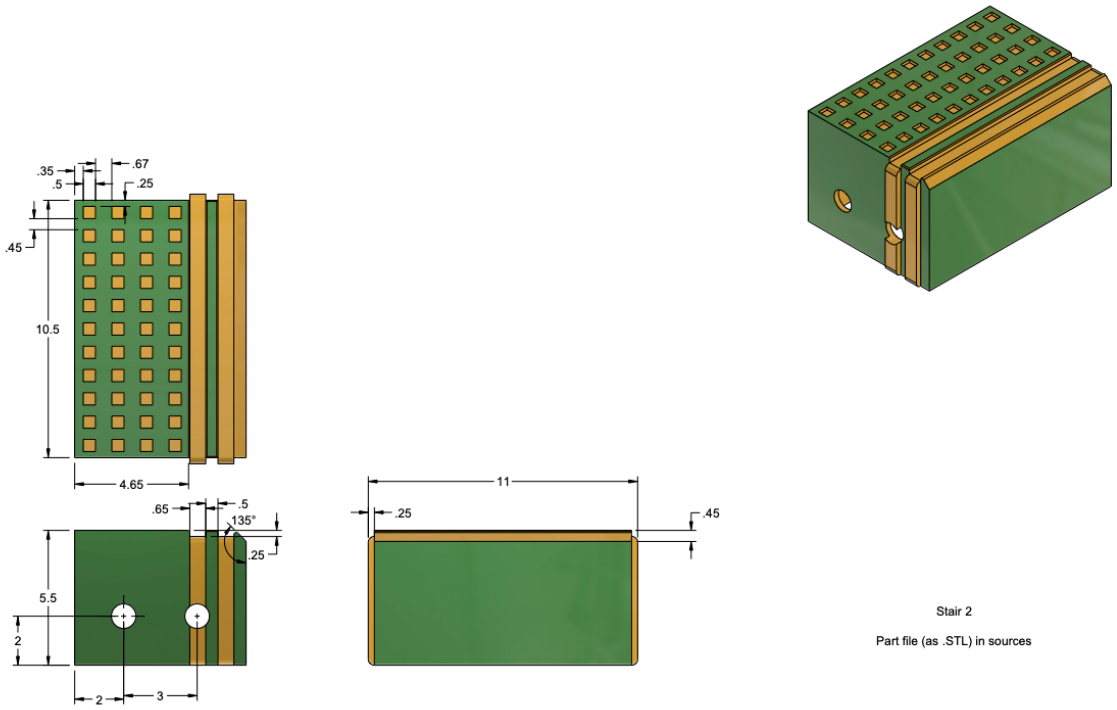

Figure 2. Step 2 is shown above.

This step will have green as its dominant color, since it's the color humans see best and it has also been proven to calm one down. Also, since yellow/orange is its opposite color, a part of the step will also be colored yellow/orange to create a contrast. The material of the step will be hardened rubber or compressed rubber mulch, since it bridges the gap between rigidly firm and soft. This material is also commonly seen on playgrounds with a similar use in mind, so it also makes sense to implement it with stairs. Finally, a pattern of square holes is slightly reminiscent of trypophobia, and will likely make the average person slightly uncomfortable, which usually results in increased awareness and focus.

Step 3 is designed to address the possibility of workers multitasking while going up. Our sources suggest the following points to build off of:

1. A design that workers frequently use should be common throughout the facility.
2. It should be a design workers can easily familiarize themselves with.

With this in mind, we created a step that attests to the previous points.

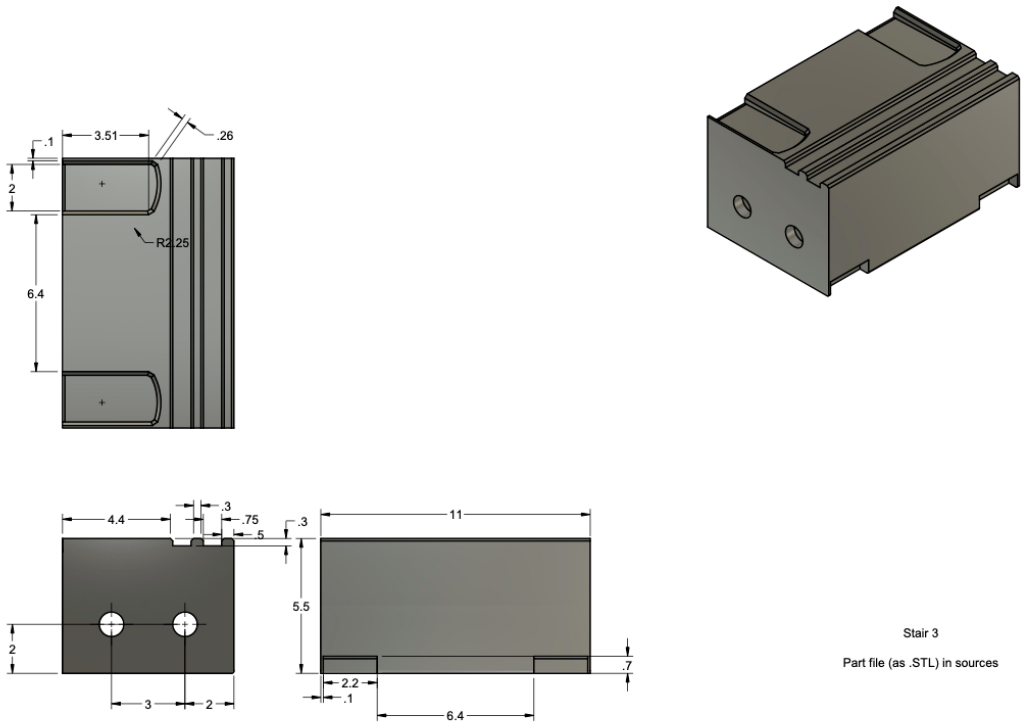

Figure 3. Step 3 is shown above.
[1]

This step is designed with simplicity in mind. This makes it easier to understand and learn. It's designed to mimic bricks; how they all are the same, and can be added or removed to fit different conditions. Once workers get comfortable and used to the design of the step, muscle memory kicks in, allowing one to traverse the steps without much thought.

Step 4 is designed to address the possibility of frequently wet/slippery conditions. Our sources suggest the following points to build off of:

1. The surface of the step should have plenty of friction and grip.
2. A way to remove water off of the surface that is stepped on.

With this in mind, we have derived a step that presents a solution to this problem.

[1] The two foot grooves on the side offer an optional space for workers to tuck their feet in for extra balance. The grooves work both ways, going both up and down.

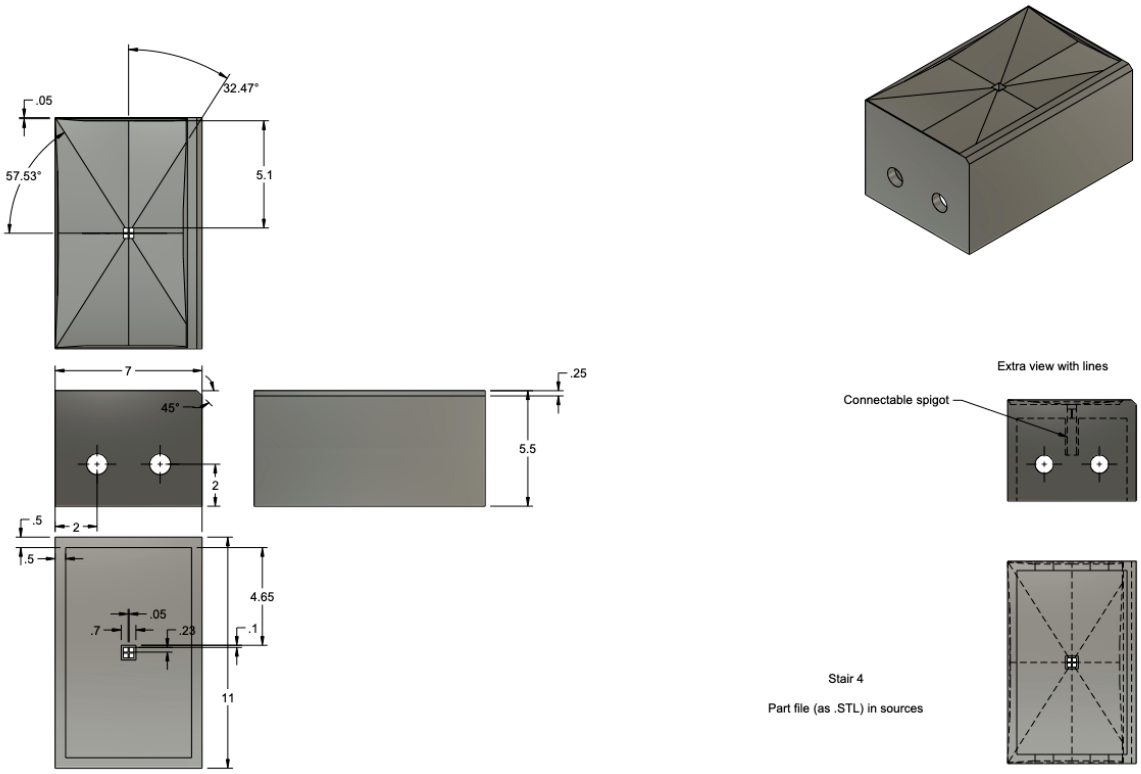

Figure 4. Step 4 is shown above.

The lower surface will have a slight angle towards the center. The angle can vary, but ideally it should be between 15˚ - 25˚ from the horizontal. This will allow the water to flow towards a small opening in the center and be drained into a pipe or out of the step. The various angles on the top surface also function as a slightly angled space for people to step on.

Conclusion

The design of a staircase has a clear correlation to accident occurrence. We figured out by adding on and uniform the design of steps, we could reduce fall hazard, a common risk for children and the elderly. We have designed a staircase that is uniform and makes it safer for everybody, with each step being uniform and proper lighting and a design to remove liquid that can increase slips. This would overall decrease the rate of falls and increase the observance of stairs. This would help reduce the number of falls caused by these main problems: poor lighting/visibility, frequent inattention while on stairs, multitasking while walking, and wet conditions. Some experimental error is that all rates are estimations. These numbers will vary among different groups and locations. A follow-up study could be done to see the effect of a railing on staircase fall rates.

References

Franco, José Tomás. “How to Calculate Staircase Dimensions and Designs.” *ArchDaily*, ArchDaily, 23 Apr. 2018, https://www.archdaily.com/892647/how-to-make-calculations-for-staircase-designs .

Government of Canada, Canadian Centre for Occupational Health and Safety. "Stairways - Fall Prevention." *Canadian Centre for Occupational Health and Safety*, 2 Mar. 2023, https://www.ccohs.ca/oshanswers/safety_haz/stairs_fallprevention.html .

Hörauf, Jason-Alexander, et al. "Injury Patterns after Falling down Stairs-High Ratio of Traumatic Brain Injury under Alcohol Influence." *Journal of Clinical Medicine*, U.S. National Library of Medicine, 28 Jan. 2022, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8836855/ .

Jesse V. Jacobs, et al. "A Review of Stairway Falls and Stair Negotiation: Lessons Learned and Future Needs to Reduce Injury." *Gait & Posture*, Elsevier, 24 June 2016, https://www.sciencedirect.com/science/article/pii/S0966636216301096 .

Jimison, Article by Robert, and Rafael Mayani. "Why We All Need Green in Our Lives." *CNN*, Cable News Network, 5 June 2017, https://www.cnn.com/2017/06/05/health/colorscope-green-environment-calm/index.html

"Ladders 101 - American Ladder Institute." *American Ladder Institute*, https://www.americanladderinstitute.org/page/Ladders101 .

Maynard, Wayne, and George Brogmus. "Reducing Slips, Trips and Falls in Stairways | EHS Today." *EHS Today*, 30 Sept. 2007, https://www.ehstoday.com/ppe/fall-protection/article/21908140/reducing-slips-trips-and-falls-in-stairways .

"Older Adult Falls." *National Safety Council*, https://www.nsc.org/community-safety/safety-topics/older-adult-falls .

Sjøfartsdirektoratet. "Learning from Incidents – Falling / Tripping in Stairs / Ladders." *Norwegian Maritime Authority*, https://www.sdir.no/en/shipping/accidents-and-safety/laring-av-hendelser/learning-from-incidents--falling--tripping-in-stairs--ladders/ .

Tenge, J. Todd. "Stairway Injury Statistics and Their Hazards - Tenge Law Firm, LLC." *Tenge Law Firm*, 26 May 2022, https://tengelaw.com/blog/six-stairway-safety-hazards-that-injure-the-public/ .