DEVELOPMENT AND VALIDATION OF FALL PROTECTION SYSTEM WIZARD (FPSWIZARD)

WSH Institute

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Workplace Safety and Health Institute
1500 Bendemeer Road, #03-02
Ministry of Manpower Services Centre
Singapore 339946

CONTENT

Executive Summary

This study seeks to develop a prototype Fall Protection System Wizard (FPSWizard) to estimate the parameters of an arrested fall of a worker when the user provided inputs of the Horizontal Lifeline (HLL) and Vertical Lifeline (VLL) systems. These parameters were Total Fall Distance (TFD), Maximum Arrest Load (MAL) and Maximum Arrest Force (MAF). Experiments were then designed and conducted to validate the estimates provided by FPSWizard. It was found that the theoretical results were an adequate estimate of the experimental values. Thus, FPSWizard could be used to estimate post fall clearance, required anchorage strength, and the force experienced by a worker during a fall arrest. It was noted that FPSWizard calculator was based on the energy balance approach which conformed to the requirements of SS607:2015 Specification for design of active fall-protection systems. To improve the accuracy and conservativeness of the calculations, correction factors were introduced. Further research would need to be conducted to ensure that the calculations and correction factors were applicable to a wider range of equipment.

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NUS Research Team

Principal Investigator: Associate Professor Goh Yang Miang
Research Assistant: Mr. Shazed Mohammad Tashrif
Dissertation Student: Mr. Lim Wen Cong
Collaboarator: Dr. Adrian Koh

1 Introduction and Aim

WSH Institute funded National University of Singapore (NUS) for the project: “Prototype FPSWizard: A design support system to improve the selection and design of personal fall protection systems”. Besides developing the FPSWizard, drop tests were also conducted to validate the FPSWizard.

The study objectives were

- to develop a prototype web-based design support system known as the FPSWizard; and
- to validate and calibrate the FPSWizard calculators by introducing correction factors if necessary.

2 Background

According to the Singapore Workplace Safety and Health (WSH) Statistics[1], about one in five workplace deaths in Singapore was caused by falling from height. Many of these fatal falls happened during work on mobile work platform, ladders, formwork, roofs and other structures. Half of the falls were contributed by the construction sector.

Even though personal fall arrest systems (PFAS) was not a preferred form of protection, it was frequently the last line of defence for workers. PFAS was also one of the most commonly adopted form of fall-protection system[2]. A PFAS was a combination of equipment such as personal energy absorbers (PEA), harness, lanyards, connectors and lifeline which when assembled, helped to arrest a fall and could prevent fatality when used correctly. It came in two main forms, Vertical Lifeline System (VLLS) or Horizontal Lifeline System (HLLS). According to a case study evaluation of HLLS in Singapore, the study found that all 11 HLLS designs evaluated were inadequate and did not use proper calculation methods[3].

[1] Singapore Workplace Safety and Health Statistics 2017, WSH Institute.
[2] Goh, Y. M. 2015. “Empirical Investigation of the Average Deployment Force of Personal Fall-Arrest Energy Absorbers” in Journal of Construction Engineering and Management. [Online] Available at https://doi.org/10.1061/(ASCE)CO.1943-7862.0000910
[3] Goh, Y., Wang, Q. 2015. “Investigating the Adequacy of Horizontal Lifeline System Design through Case Studies from Singapore” in Journal of Construction Engineering and Management. [Online] Available at https://doi.org/10.1061/(ASCE)CO.1943-7862.0000989

3 Methodology

The FPSWizard is an engineering calculation program that could be used to estimate the effects of a fall arrest so that users could assess if the PFAS was suitable for use. Users would provide inputs on parameters defining the HLLS or VLLS configuration.

The FPSWizard used the energy balance approach in its calculations which conformed to the requirements of SS607:2015 specification for design of active fall-protection systems. The energy balance suggested that the gravitational potential energy (E_p) lost by the worker during the fall must be absorbed by the PFAS in the form of work done (W_d). W_d could come in various forms depending on the configuration of the PFAS, such as energy dissipated by the tearing of PEA, energy absorbed by the lanyard and energy absorbed by the lifeline. With this approach, the FPSWizard would be able to estimate the total fall distance (TFD), extension of PEA (X_{pea}) and maximum arrest load (MAL). For illustration, the HLLS was used as an example in Figure 1 below.

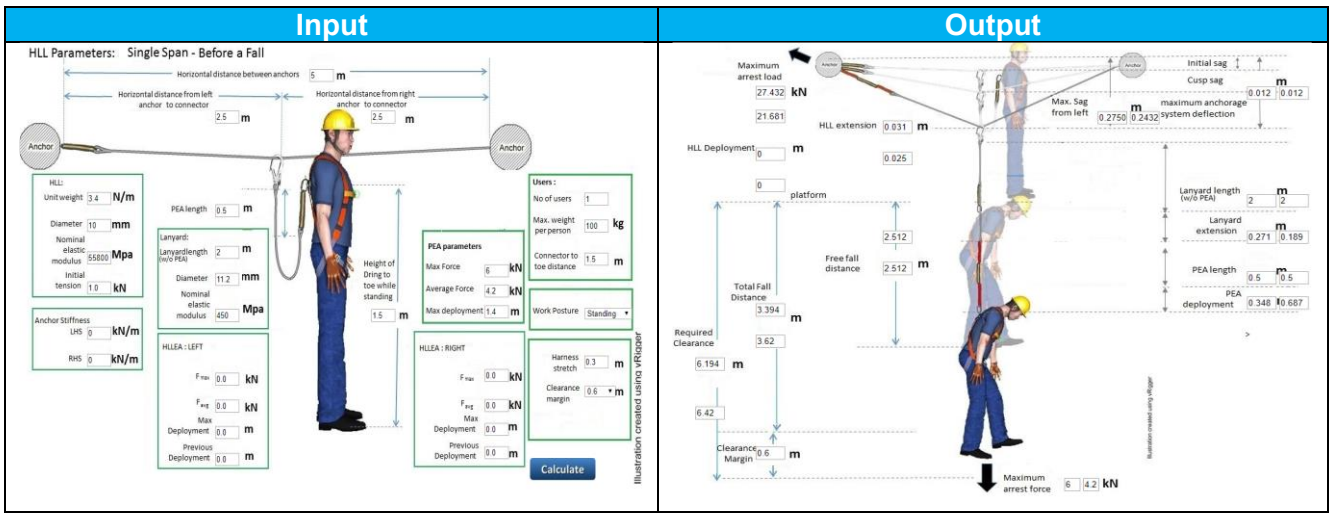

Figure 1: Sample illustration of FPSWizard for HLLS

4 Validation of FPSWizard results

Experiments were designed and conducted for both HLLS and VLLS to validate the results of FPSWizard. In this example, the HLLS experimental setup was illustrated in Figure 2.

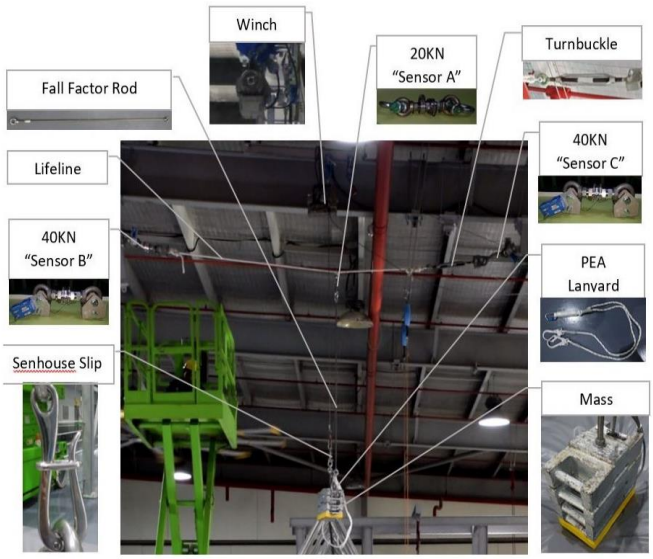

Figure 2: HLLS experimental set-up

The experimental parameters in Table 1 were then compared with the FPSWizard empirical results described in Section 3.

Table 1: Experimental parameters to be compared with FPSWizard results

HLLS	VLLS
Maximum Arrest Force	Maximum Arrest Force
Maximum Arrest Load	Total Fall Distance
Extension of Personal energy absorber due to deployment	Extension of Personal energy absorber due to deployment
Total Fall Distance	

5 Results

The empirical results obtained by FPSWizard using the energy balance method provided an adequate estimate to the experimental values of MAL and TFD. However, to improve the accuracy and conservativeness of the calculations, correction factors were introduced.

6 Conclusion

The FPSWizard was an empirically validated calculator to assist professional engineers and fall protection specialist in designing and evaluating adequacy of vertical and horizontal lifeline systems. The calculator was based on the energy balance approach which conformed to the requirements of SS607:2015 Specification for design of active fall-protection systems. FPSWizard could provide an estimation of the post fall clearance and required anchorage strength so that workers could be protected should a fall happen. To improve the accuracy and conservativeness of these calculations, correction factors were introduced. Further research would need to be conducted to assure that the calculation method and correction factor covered a wider range of equipment.

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