Test Report: Slope Stability analysis Program (SSP)

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1 Revision History

Date	Version	Notes
12/09/18	1.0	First draft of document

2 Symbols, Abbreviations and Acronyms

The symbols, abbreviations, and acronyms used in this document include those defined in the table below, as well as any defined in the tables found in Section 2 of the Software Requirements Specification (SRS) document.

symbol	**description**
MIS	Module Interface Specification
MG	Module Guide
TC	Test Case
VnV	Verification and Validation

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This document outlines the results of testing for SSP. Section 3 reports on the tests for functional requirements and Section 4 reports on the tests for non-functional requirements, all of which are described in the System Verification and Validation (VnV) Plan for this project. Section 5 compares this implementation of SSPto the original implementation. Section 6 reports on the results of the unit tests, which are described in the Unit VnV Plan for this project. Section 7 comments on changes to the project that that came as a result of the testing. Section 8 describes how the tests were implemented with an automated testing framework. Sections 9 and 10 show the traceability between test cases and requirements and modules. Supporting documents and other resources, such as the VnVPlans and original implementation, can be found on the GitHub repository for this project.

3 Functional Requirements Evaluation

The System VnV Plan described TC1 - TC30 for testing the requirement for verifying that inputs meet physical constraints. All of these tests passed.

The next test in the System VnV Plan, TC31 verified the calculation of the factor of safety by comparing it to literature sources for a common example problem. The factor of safety calculated by SSPfor this example problem was 1.3200. The average relative errors between SSPand each literature source are shown in Table 1. The factor of safety calculated by SSPwas within 1 percent of all but one of the literature sources. The relative tolerance was retroactively set as 0.1 for these tests to pass. Note that this test originally failed due to a bug for the case where there was no water table, which is discussed further in Section 7.

Source	**Factor of Safety**	**Relative Error**
Greco (1 July 1996)	1.3270	0.0086
Malkawi et al. (1 August 2001)	1.2380	0.063
Cheng et al. (27 Decemeber 2006)	1.3250	0.0071
Li et al. (25 June 2010)	1.3270	0.0086

Table 1: Relative error between SSPand literature for calculation of factor of safety

The next test in the System VnV Plan, TC32 verified the determination of the critical slip surface again by comparing it to literature sources. The average relative errors between SSPand each literature source are shown in Table 2. The critical slip surface calculated by SSPwas within 2 percent of all but one of the literature sources. The relative tolerance was retroactively set as 0.1 for these tests to pass.

Source	**Relative Error**
Greco (1 July 1996)	0.013
Malkawi et al. (1 August 2001)	0.072
Cheng et al. (27 Decemeber 2006)	0.013
Li et al. (25 June 2010)	0.013

Table 2: Relative error between SSPand literature for calculation of critical slip surface

The next test in the System VnV Plan, TC33 verified the calculation of the factor of safety by comparing it to the original implementation for a specific example. The factor of safety calculated by SSPfor this example problem was 0.9808, compared to 0.9835 for the original program. The average relative error between SSPand the original program was 0.0027. The relative tolerance was retroactively set as 0.01 for these tests to pass.

The next test in the System VnV Plan, TC34 verified the calculation of the critical slip surface by comparing it to the original implementation for a specific example. The critical slip surface calculated by SSPfor this example problem is shown in Figure 1. The average relative error between SSPand the original program was 0.019 The relative tolerance was retroactively set as 0.05 for these tests to pass.

The next tests in the System VnV Plan, TC35 and TC36 verified the calculation of the interslice normal and shear forces by comparing them the original implementation for a specific example. Originally, the relative error between the current implementation and the original implementation was unexpectedly high, which led to the discovery of a bug in the current implementation,

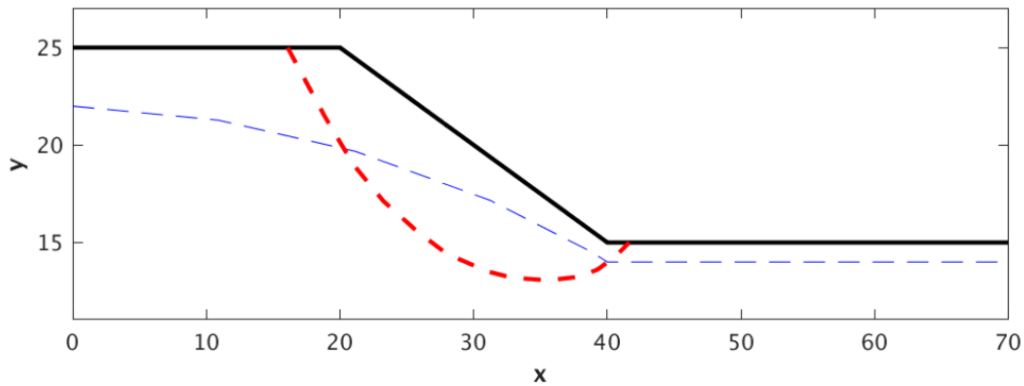

Figure 1: The critical slip surface for TC34 calculated by SSP

which was then fixed. This is discussed further in Section 7. After fixing the bug, the test was performed again. The interslice forces calculated by SSPfor this example problem are shown in Figure 2. The average relative error between SSPand the original program was 0.099 for the normal forces and 0.072 for the shear forces. These relative errors were still higher than expected, but further investigation found that there is a high variance in these calculations, even in the original program. For example, the peak interslice normal force was seen to vary between about 140 kN and 200 kN for different runs of the original program. As a result, the tests were given a relatively high relative tolerance of 0.15 and were compared to outputs from multiple runs of the original program. As long as the relative error is less than the relative tolerance for at least one of the outputs, the tests pass. With these changes, both tests pass on the vast majority of runs.

The next test in the System VnV Plan, TC37, verified that changing the type of the function f to a constant has an impact on the result. This was done by visual inspection of the critical slip surface and interslice forces for the case where *const_f* is true. These plots are shown in Figure 3. The factor of safety was 0.8363 for this test. The results were similar overall to the case where *const_f* was false, with some notable differences: A slightly higher exit x-value for the slip surface, associated with notably different interslice forces near the exit, and an approximately 14 percent difference in factor of safety. These slight differences give confidence that SSPactually

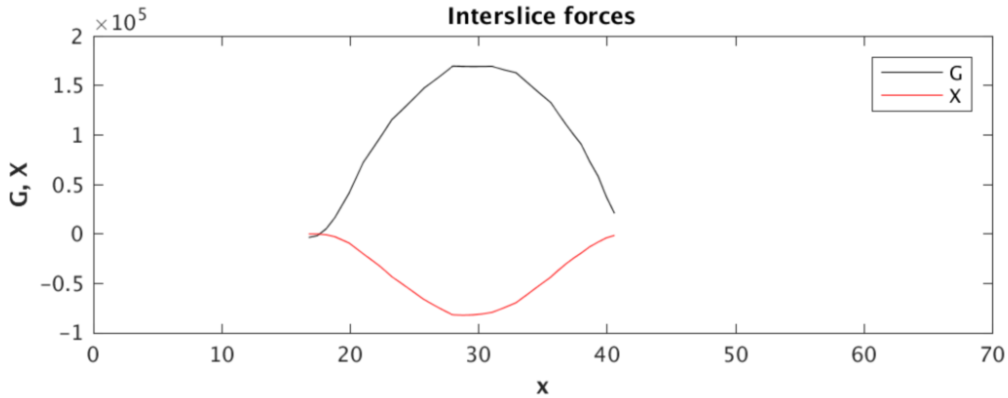

Figure 2: The interslice normal and shear forces for TC35 and TC36 calculated by SSP

translated the *const_f* input to a different f function, which is what this test was checking for, and thus the test was considered a pass.

The final tests in the System VnV Plan, TC38 - TC49, were for verifying the requirements for verifying and delivering output. These tests all passed.

4 Nonfunctional Requirements Evaluation

4.1 Maintainability

4.2 Reusability

5 Comparison to Existing Implementation

This section will not be appropriate for every project.

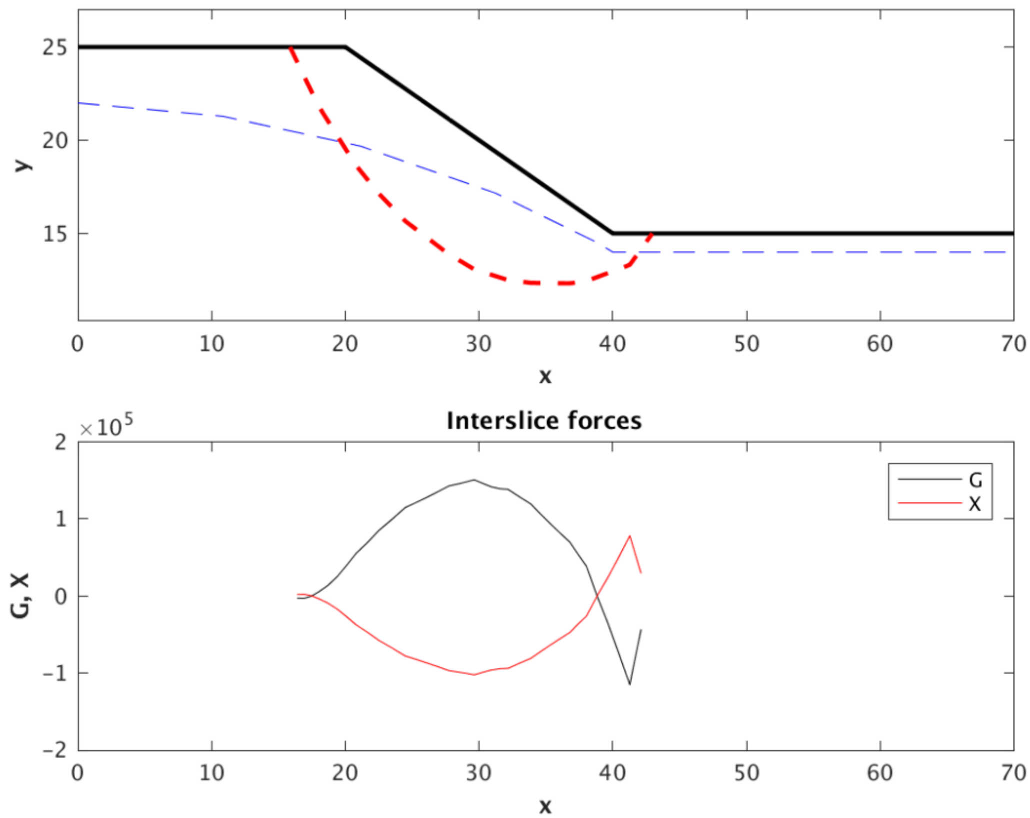

Figure 3: The critical slip surface (top) and interslice normal and shear forces (bottom) for TC?? calculated by SSP

6 Unit Testing

7 Changes Due to Testing

- bug with NoWT and constraint (found by system test) - bug with mirrored forces (found by last system test) - bug with indivisible slices (found by slice tests)

8 Automated Testing

9 Trace to Requirements

10 Trace to Modules

11 Code Coverage Metrics

Not applicable for SSP.

References

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