Project Title: System Verification and Validation Plan for Concrete Remaining Life Prediction

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Revision History

Date	Version	Notes
February 19	1.0	Initial Documentation
March 4	1.1	Changes based on feedback

Contents

List of Tables

1 Symbols, Abbreviations, and Acronyms

Table 1 lists the symbols, abbreviations, and acronyms used in this document. For other symbols used in this project, they are organized in the first section of the SRS document (1).

symbol	**description**
CI	Continuous Integration
CRLP	Concrete Remaining Life Prediction program
MIS	Module Interface Specification
MG	Module Guide
SRS	Software Requirements Specification
VnV	Verification & Validation
UI	User Interface

This document provides an overview of the Verification and Validation (VnV) process for the Concrete Remaining Life Prediction program (CRLP), ensuring adherence to the program's specifications outlined in the SRS document (1). It begins with general information about CRLP in section 3. The subsequent sections will discuss the verification plan and the process of system tests.

2 General Information

2.1 Summary

This document reviews the VnV process for the CRLP program. By inputting weather data or the condition of the concrete, CRLP can predict the remaining service life of concrete structures, thereby helping to prevent hazards to buildings.

2.2 Objectives

The objectives of CRLP will primarily focus on accuracy and usability. In other words, the priority of this program is to ensure that the output is correct and that users can operate the program effortlessly. The program will utilize certain Python external libraries, which we assume to be functioning correctly in this case.

2.3 Relevant Documentation

The relevant documentation for CRLP comprises the Problem Statement, which delineates the proposed idea; the System Requirements Specifications, which furnish information about the requirements of the proposed system; the VnV Report, dedicated to validation and verification; and the MG and MIS design documents.

3 Plan

The following section outlines the testing plan for CRLP. It begins with addressing the verification and validation team in section 3.1. Subsequently, these sections discuss various plans, such as the SRS verification plan, design

Name	Responsibility
Dr.Spencer Smith	As the instructor of the team, the role is to supervise and provide professional assistance to the author.
Yi-Leng Chen	As the author of the team, responsibilities include composing documents, implementing the program, and testing it.
Atiyeh Sayadi	As the Domain Expert of the team, responsibilities include reviewing all documents related to the project.
Waqar Awan	As the Secondary Reviewer of the team, responsibilities include reviewing the VnV plan.
Kim Ying Wong	As the Secondary Reviewer of the team, responsibilities include reviewing MG and MIS documents.

Table 1: Verification and Validation Team

verification plan, and implementation verification plan. Section 3.6 describes automated testing and verification. Finally, section 3.7 mentions the Software validation plan.

3.1 Verification and Validation Team

3.2 SRS Verification Plan

The SRS document can be verified by following these steps:

1. Documentation: The document should adhere to the SRS template (2) and be uploaded to GitHub.

2. Review: The author create separate issues for the instructor, domain expert, and secondary reviewer (specifically designated for SRS). These three individuals are responsible for reviewing the SRS document using the SRS checklist(4), one by one.

3. Modify: Make adjustments to the document based on the feedback received from the reviewers. Then, repeat the aforementioned steps.

3.3 Design Verification Plan

The design documents, such as the Module Guide (MG) and the Module Interface Specification (MIS), can be verified by following these steps:

1. Documentation: Unlike previous documents, there are no templates for design documents. The MG should provide a high-level overview of the architecture and structure of the software system, while the MIS should provide interface details about the modules. These documents need to be uploaded to GitHub once they are finished.

2. Review: The author create separate issues for the instructor, domain expert, and secondary reviewer (specifically designated for specific review). These three individuals are responsible for using checklist (6) (7) to review the documents, one by one.

3. Modify: Make adjustments to the document based on the feedback received from the reviewers. Then, repeat the aforementioned steps.

3.4 Verification and Validation Plan

The VnV plan can be verified by following these steps:

1. Documentation: There is also no restricted format for the document, but there's a template (3) that can be referred to, and the document needs to be uploaded to GitHub once it is finished.

2. Review: Once the VnV plan is done, the author create separate issues for the instructor, domain expert, and secondary reviewer (specifically designated for VnV). These three individuals are responsible for using VnV checklist (5)to review the document, one by one.

3. Modify: Make adjustments to the document based on the feedback received from the reviewers. Then, repeat the aforementioned steps.

3.5 Implementation Verification Plan

This project will only conduct dynamic testing. The testing plans for functional and non-functional requirements are mentioned in section 4, while unit tests are listed in section 5.

3.6 Automated Testing and Verification Tools

- Pytest: The test framework for Python, can execute test cases and provide test results.

- Flake8: A Python linter tool that standardizes the style and quality of Python code.
- GitHub Actions: A Continuous Integration (CI) tool which can automate the execution of tests whenever changes are pushed to a repository.

3.7 Software Validation Plan

Due to the lack of an external supervisor for this project and time constraints, a software validation plan will not be conducted.

4 System Test Description

4.1 Tests for Functional Requirements

In Section 5.1 of the SRS document (1), four functional requirements were listed. R1 and R2 primarily emphasize the input and output functions. R3 involves testing the calculated function, while R4 verifies its results.

4.1.1 Input function test

The core of this project involves prediction using various theories, each of which has different equations. The test plans are designed based on these theories.

1. Theory 1: Chloride concentration and depth: R.D. Browne (8) forecasted the remaining service life by using the chloride concentration and its depth.
2. Theory 2: Carbonation cover: C.J. Hookham(9) forecasted the remaining service life using the time to full cover carbonation.
3. Theory 3: Chloride attack: C.J. Hookham(9) forecasted the remaining service life using using chloride attack level.
4. Theory 4: Weather data: C. Andrade et al (10) used humidity data from weather records to predict the remaining service life of concrete.

5. Theory 5: Degradation factors: J.R. Clifton (11) forecasted the remaining service life using various degradation factors.

Parameters	Input		
Theory 1			
Constant chloride concentration (C_0)	1000	None	-1000
Chloride ion diffusion coefficient (D_{cl})	1x10^{-10}	None	1x10^{-10}
Chloride depth (x)	0.01	None	0.01
Chloride concentration	899.8	None	899.8
Output	Success	Error	Error
Theory 2			
Remaining Uncarbonated Cover	0.95	None	0.95
Chloride concentration	0.028	None	-0.028
Output	Success	Error	Error
Theory 3			
Quality coefficient of concrete(K_c)	7.59	None	7.59
Coefficient of environment(K_e)	0.028	None	0.028
Thickness of concrete cover(K_R)	0.95	None	-0.95
Coefficient of active corrosion(K_a)	4	None	4
Output	Success	Error	Error
Theory 4			
Months that relative humidity is below 70%(M_1)	4	None	1
Months that relative humidity is between 70% and 100%(M_2)	6	None	1
Months that rain occurs(M_3)	2	None	1
Output	Success	Error	Error
Theory 5			
Degradation Category	Carbonation	None	Carbonation
Years of Concrete Usage	36	None	-1
Average Depth of Carbonation	24	None	24
Amount of damage at failure	48	None	48
Output	Success	Error	Error

*Success means CRLP output the predict result successfully.

*Error means rejecting input and popping error message: Please enter the value!

Table 2: input data test

Case ID	Input	Output	Theory
1	Input random valid value of data	Success	All theories
2	Input nothing for input data	Nothing	All theories

*Success means CRLP output the predict result successfully.

Table 3: Output data test

Case ID	Input	Output	Theory
1	Input random valid value of data	Success	All theories
2	Input nothing for input data	Nothing	All theories

*Success means CRLP starting to calculate result.

Table 4: calculated data test

4.1.2 Output function test

test-output-functions
Control: Automatic
Initial State: Uninitialized
Input: Listed in Input column in the table 3.
Output: Listed in Input column in the table 3.
Test Case Derivation: This case aims to test the different behaviors after inputting data and conducting calculations.
How test will be performed: This test will be conducted through Pytest and GitHub Actions.

4.1.3 Calculated function test

1. test-output-functions
   Control: Automatic
   Initial State: Uninitialized
   Input: Listed in Input column in the table 4.
   Output: Listed in Input column in the table 4.
   Test Case Derivation: This case aims to test calculate process.
   How test will be performed: This test will be conducted through Pytest and GitHub Actions.

Case ID	Input	Output	Theory
1	Input random valid value of data	Success	All theories

*Success is defined as the accurate calculation of results by CRLP.

Table 5: result test

4.1.4 Result check test

1. test-output-functions
   Control: Manual
   Initial State: Uninitialized
   Input: Listed in Input column in the table 5.
   Output: Listed in Input column in the table 5.
   Test Case Derivation: The objective of this case is to verify the accuracy and conformity of the calculated results with the specified equations.
   How test will be performed: This test will involve comparing the calculated results with manually calculated values.

4.2 Tests for Nonfunctional Requirements

In Section 5.2 of the SRS document (1), three functional requirements were listed.

4.2.1 Nonfunctional Requirements Test

Usability Test

1. Test Usability
   Type: Manual
   Initial State: None
   Input/Condition: Survey for users
   Output/Result: The survey result from users
   How test will be performed: Administering the survey (based on appendix section) to users. Following practical usage of the system's UI, sending the survey to users to gather feedback from them.

2. test-accuracy

   Control: Manual
   Initial State: Uninitialized
   Input: Listed in Input column in the table 5.
   Output: Listed in Input column in the table 5.
   Test Case Derivation: The objective of this case is to verify the accuracy and conformity of the calculated results with the specified equations.
   How test will be performed: This test will involve comparing the calculated results with manually calculated values.

3. test-reusable

   Control: Manual
   Initial State: Uninitialized
   Input: elements in each equations.
   Output: generate different predict result
   Test Case Derivation: The objective of this case is to ensure that this program can flexibly extend its functions.
   How test will be performed: This test will change some coefficients of the current equation to prove that the program can maintain a state-of-the-art view.

4.3 Traceability Between Test Cases and Requirements

	R1	R2	R3	R4	NFR1	NFR2	NFR3
4.1.1	X						
4.1.2		X					
4.1.3			X				
4.1.4				X			
4.2.1					X		
4.2.2						X	
4.2.3							X

Table 6: Traceability between test Cases and requirements

5 Unit Test Description

5.1 Unit Testing Scope

This section will not be completed until after the MIS and MG are finished.

5.2 Tests for Functional Requirements

This section will not be completed until after the MIS and MG are finished.

5.2.1 Module 1

The following content will not be completed until after the MIS and MG are finished.

1. test-id1

   Type: TBD
   Initial State: TBD
   Input: TBD
   Output: TBD
   Test Case Derivation: TBD
   How test will be performed: TBD

5.3 Tests for Nonfunctional Requirements

This section will not be completed until after the MIS and MG are finished.

5.3.1 Module 1

The following content will not be completed until after the MIS and MG are finished.

1. test-id1

   Type: TBD
   Initial State: TBD
   Input/Condition: TBD
   Output/Result: TBD
   How test will be performed: TBD

References

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[10] C. Andrade, C. Alonso, and J.A. Gonzalez.(1989). *Approach to the Calculation of the Residual Life in Corroding Concrete Reinforcement based on Corrosion Intensity Values*.9th European Congress on Corrosion: Life Time Expectancy of Materials and Constructions, Vol. 2, Ultrect, Netherlands.

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6 Appendix

6.1 Usability Survey Questions

The following questions comprise the survey, which will be conducted through Google Forms. Users can rate their feelings on a scale from 1 to 5, with 1 representing ”extremely disagree” and 5 representing ”extremely agree”.

1. The interface is easy to understand and operate.
2. How satisfied are you with the speed and efficiency of our experts in conducting math calculations?
3. The program is equipped with useful tools to aid in research.
4. The program provides the results I want to know.
5. Does the program meet your expectations in terms of accuracy and reliability?
6. How would you rate the overall quality of CRLP?
7. Do you have any suggestions or feedback for improving our website or services? (An input section will be provided for this question.)