Stellar Solutions

Canadian Consulting Company

Info@NimaYoung.ca
647.909.2733
North York, ON

Re: York University
Wabagishik Dam Reconstruction Project

Dear Dr. Isojeh,

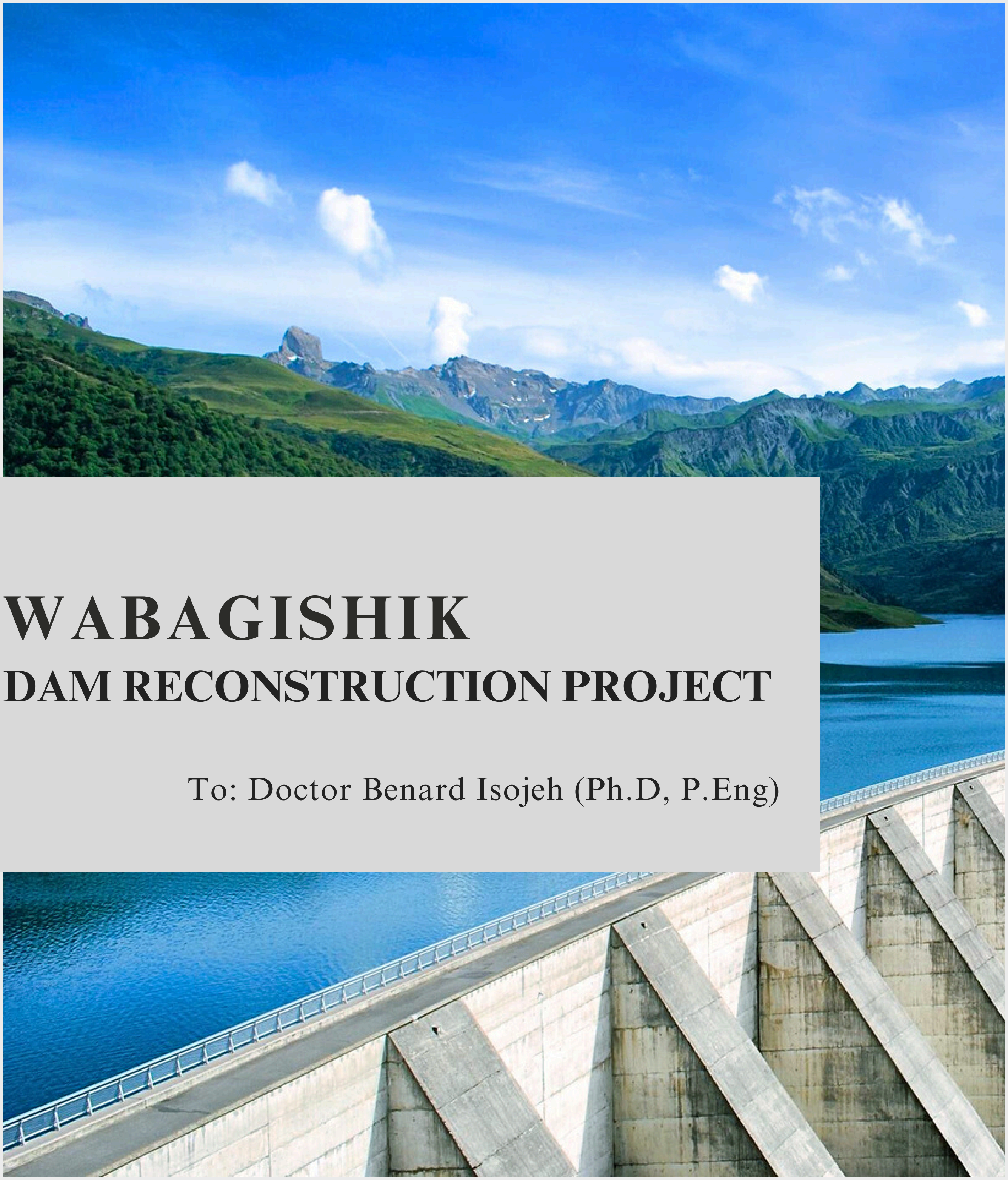
Stellar Ltd is proud to submit the following report for
The Wabagishik Dam Reconstruction Project.
Appreciating the significance of the dam in Sudbury's regional infrastructure, our team is delighted to be a party in contributing to your success.

Please find on the following pages, our final report, all generated designs, and discussions around the selected solution. Please do not hesitate to reach out with any questions or concerns.
Our offices have been instructed to handle your call with agility and importance.

Cordially,

Nima Nojavan

Nima Nojavan
Project Manager
Stellar Solutions



WABAGISHIK
DAM RECONSTRUCTION PROJECT

To: Doctor Benard Isojeh (Ph.D, P.Eng)

Stellar Solutions Ltd
Prioritizing Sustainability

647.909.2733 | info@nimayoung.ca | North York, ON

Executive Summary

The Wabagishik Dam Reconstruction Project Report comprehensively covers all essential aspects of the project, providing an overview of the design process and the designs rendered. Stellar Solution Ltd. (hereinafter referred to as "*The Company*") has been engaged in a consultative capacity, contributing to the development of a concrete mix and sustainability design.

Section one (1) of the report encompasses the primary design and needs assessment, including estimated design weight and stress calculations used to determine design requirements. Moreover, it addresses sliding, uplifting, and overturning forces, presenting solutions generated through the utilization of Python, Civil 3D, and graphing software in section 3.5.

The report introduces four potential concrete types for the project and identifies the optimal choice using a decision matrix outlined in section 3.5: Designs Rendered.

All supporting figures, charts, diagrams, and calculations are included in the appendices. Stellar expresses gratitude for the opportunity and invites any questions or concerns regarding this report.

Cordially,

Nima Nojavan

Nima Nojavan
Director, Project Manager
Stellar Solutions

Table of Contents

2024

List of Figures & Tables

2024

Introduction

1.1 Project Scope

Stellar Solutions has been contracted to design and supervise the remediation of the Wabagishik Dam located in the Region of Sudbury.
The scope of work covers the following primary objectives:

- Structural assessment of existing dam.
- Design of solutions to issues uncovered:
    - Concrete mix design.
    - Sustainability design.
    - Project master plan.
    - Construction oversight.
    - Final inspection.
    - Maintenance plan.

Stellar has been onboarded strictly as a consulting company; both companies have agreed to outsource the construction of the project.

1.2 Needs Assessment

Background: The Wabagishik dam, a critical component of the Wabagishik Power Plant operated by Vale Canada Ltd., has encountered significant structural and operational issues [3].

Objective: Stellar has assumed responsibility of addressing all underlying structural issues impacting the Wabagishik Dam including conducting thorough structural assessment and designing a long-term solution.

Constraints: The construction of the dam has been outsourced, creating sources of uncertainty which must be actively addressed through ongoing risk assessment and risk management.

Function: The assessed structural issues in the dam must be addressed through the design of appropriate concrete mix. The implemented concrete must overcome all short and long term stressed applied primarily by the weight of the fluid and in part by the constant loading and unloading of both pedestrians and vehicles on top of the dam.

Implementation: Stellar aims to implement the desired solutions as follows:

- Assessing the stresses applied from live and dead loads.
- Plan for remediated dam, including selection of appropriate materials.
- Scheduling and oversight of construction.
- Active risk management and budget adjustment.
- Final inspection and project conclusion.

1.3 Deliverables

Stellar must provide the Client with the following:

- Project Proposal:
  - Solutions assessed.
  - Initial resources projected.
  - Initial cost of scope.
- Progress Report:
  - Project progress assessed.
  - Initial risk management.
- Interim Report:
  - Project projections.
  - Drafted solutions.
  - Enhanced cost estimate.
- Final Report:
  - Final project documents.
  - Full solutions assessed and presented.
  - Completed cost report.
  - Risk management strategy outlined.
  - Final Signature Page.

Stellar Solutions is responsible for providing the aforementioned deliverables as well as any and all services necessary for the safe and successful design and implementation of the remediation.

Stellar also agrees to the following:

- An exclusive customer service line dedicated to the Wabagishik Dam Project.
- Access to all files pertaining in any way to the project being considered.
- Weekly meetings scheduled one week in advance:
  - Agendas to be provided.
  - Meeting minutes logged.

Background

2.1 Company Directory

Comprised of five key members, our team is focused on ensuring the satisfaction of your company. Their key roles in the company are as follows:

Nima Nojavan - Project Manager
Five years of management experience.
Successfully managed four projects.
Corporate level proficiency with CAD.

Seyed Hosseini - Project Coordinator
Successfully coordinated eight projects.
Corporate level proficiency with CAD.
Experienced hydrotechnical analyst.

Arian Timsari - Technical Engineer
Experienced hydrotechnical analyst.
Experienced mechanical analyst.
Corporate level proficiency with CAD.

Aryan Momeni - Technical Engineer
Experienced hydrotechnical analyst.
Experienced mechanical analyst.
Corporate level proficiency with CAD.

Mahdis Ghamooshi - Design Engineer
Experienced with AutoDesk Suite.
Successfully designed 10+ solutions.
Experienced hydrotechnical analyst.

2.2 Design Assessment

The Wabagishik dam, a critical component of the Wabagishik Power Plant operated by Vale Canada Ltd., has encountered significant structural and operational issues [3].
This dam, constructed in the year 1908, has experienced several modifications, especially throughout the time it was first installed and 1972. The local mining industry has been the primary benefactor of this dam, experiencing significant growth due to the discovery of major resource deposits and the construction of The Canadian Pacific Railway's Algoma Branch between 1890 and 1910 [4].

Conducting comprehensive examination of the structure, several structural issues have been noted. These include: severe spalling, wide horizontal and vertical cracks, corroded reinforcing steel, silty settlements, and de-bonding at the dam's foundation. These findings have triggered the need for immediate intervention, including the design of a remediation plan.

In this pursuit, Stellar has conducted the following assessments:

- Breakdown of forces acting on the dam:
  - Sliding
  - Uplift
  - Overturning
- Assessing the stresses on the dam using python:
  - Generating input code.
  - Gathering a 2D and 3D model of stress on the dam.
- Cross referencing findings from Python with assessments made by team.
- Verifying results with various scholars and specialists.

Additionally, the following aims to summarize the source code inputted into Python:

This code calculates the stress distribution within a trapezoidal cross-section. It first defines the dimensions of the cross-section and the number of steps in the x and y directions based on the specified step size.

Next, it initializes lists to hold coordinates (X and Y) and a list to store (x, y, stress) triplets. It loops through each point, calculating stress based on the given conditions.

Finally, results are printed, which consist of the coordinates (x, y) and corresponding stress values for each point within the cross-section. The `math` module is used for trigonometric calculations. This code fundamentally provides a systematic approach to analyze stress distribution within a trapezoidal cross-section.

Considerations

3.1 Design Codes

The solutions designed in the reconstruction project have been cross referenced with all relevant design codes pertaining to dam construction using the following resources:

- Guidelines set out by the Canada Dam Association (CDA).
- Ontario Design Standards outlined in the Ontario Ministry of Natural Resources.
- Dam Safety Risk Screening tool by HATCH.

The Lakes and Rivers Improvement Act (LRIA) is the primary legislations impacting dam safety in Ontario, with the main regulation being Ontario Regulation 459/96 Construction. The remediation of the Wabagishik Dam has been designed in accordance to the guidelines set out by these regulatory documents.

According to the Ontario Ministry of Natural Resources and Forestry, the risk factor of the Wabagishik dam is characterized as -LOW- which implies its failure will pose minimal damage to life and the overall economy in the region.

3.2 Material Selection

The material used in this project include:

- Main concrete body (Strength of 30MPa):
    - Cement.
    - Aggregate:
        - Fine.
        - Coarse.
    - Admixtures.
    - Water.
- Friction enhancing rocks.
- Generic project necessities:
    - Vehicles.
    - Construction tools.

The contents of the concrete mix as well as the specifics of the rocks used are outlined within the technical model found below.

3.3 Methodology

To start this project, the Wabagishik Dam was researched thoroughly to ensure all information about its past and current condition was illuminated and taken into account. A brief explanation of the findings can be found in the design assessment section 3.2.
Based on these findings, a set of four solutions were proposed and presented alongside a projected schedule in the proposal.

The selected solution was then developed through an initial cross sectional analysis. The calculation of these assessments can be found below in Appendix B. In summary, the thickest cross section was first selected and four force factors were examined. These are as follows: overturning, sliding, and uplift forces, as well as the force due to stress. Through these initiatives, Stellar was able to derive a stress equation for the dam, which can be further examined in the calculations present in Appendix B. The stress equation was inputted into python as well as a variety of other parameters and a text file containing a triple point set for a specified range of the dam was exported. These points were graphed as 2D models in a graphing application and Civil 3D. The generated models can be found below and serve as visual aid to better understand the stress experienced for the selected cross section of the dam.

The calculations were considered holistically and a strength requirement was established conservatively; conservative engineering practices were used in establishing a strength requirement. The derived strength requirement allowed for the initiation of a mix design process. Stellar has contacted local suppliers and those exclusive to Stellar and four mix designs were outlined based on these consultations. The mix designs were then assessed via the use of carefully selected criteria. These criteria can be found in the decision matrix below, which constitutes all consideration. As a result of the assessment, Stellar has decided on the use of Roller Compact Concrete.

Using the information available from both the mix design and the comprehensive plan for the implementation of our solutions, Stellar finalized the cost analysis first presented during the proposal phase of this project. This cost analysis includes all services - rendered and to be rendered- as well as all materials - used and to be used - allowing for an accurate account of all supplies and services exhausted during the course of this project.

The supply of electricity remains integral to the functionality of the dam during this project. The administrators of the dam have been consulted on the matter of power supply and a consensus has been reached. The agreement of service with the main power supplier prior to the engagement of this project will remain in full effect and they will maintain service to the dam as per prior arrangements.

3.4 Technical Model

The Ministry of Natural Resources and Forestry (MNRF) was consulted to decide on the ideal life span of the dam. Several safety factors were established and applied. 100-year flood and earthquake data was selected.

Stellar has employed a conservative engineering design approach which accounts for all safety factors (i.e. fatigue and creep); these phenomena are not considered in the calculation as they have been factored in using the conservative approach.

The main calculations have been executed as follows:

- The hydrostatic pressure, uplift force, and weight of the dam was measured.
- The static equilibrium of the dam was measured.
- These findings were divided into sliding, overturning, uplifting, and stress forces.
- Assumptions were established based on the earthquake log of the location for the past 75 years and used to calculate the sliding and overturning safety factors concerning the static friction between concrete and a specific rock that will be chosen for the dam's foundation.

Using the aforementioned, a stress equation was derived based on x and y coordinates. This equation can be used to assess stress at any point in the dam. The stress equation was input into Python as code to provide a three-dimensional coordination (i.e. F(x,y, stress)).

Outputs from Python were converted into text format (.txt) and placed into a graphing software software as well as Civil 3D. The generated designs are displayed below and will aid in visualizing the findings, enriching this analysis. The tensile and compressive forces applied on the dam can be understood using these figures.

Concrete Selection

After consulting exclusive and local suppliers, Stellar performed a decision analysis using the decision matrix. The decision matrix concluded that RRC is the optimal choice. Found below within the Designs Rendered section, is the breakdown of our mix design alongside the decision matrix employed.

3.5 Designs Rendered

Three cross sections have been generated for the dam. Below is cross section **B-B** displaying the side profile of the dam and the respective water levels.

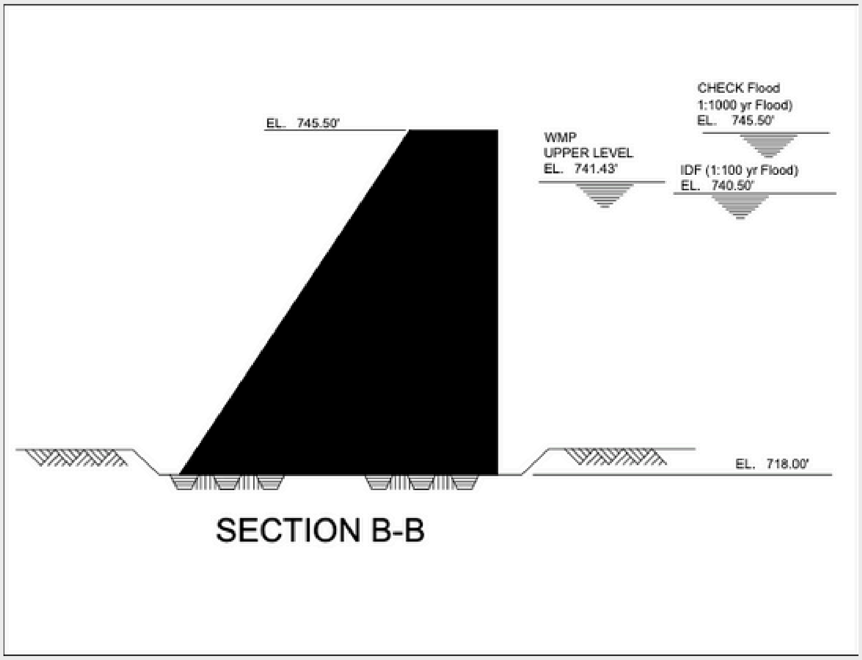


Figure 1: Cross section B-B of the Wabagishik Dam.

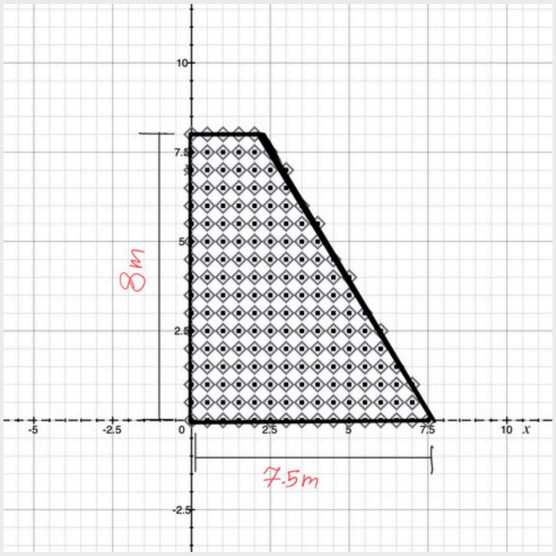


Figure 2: 2D Plot of Pointset

Below is the 3D plot of stress on the dam. The Y and X axis represent the vertical and horizontal dimensions of the cross section shown in figures 1 and 2 with the Z-axis representing the stress values.

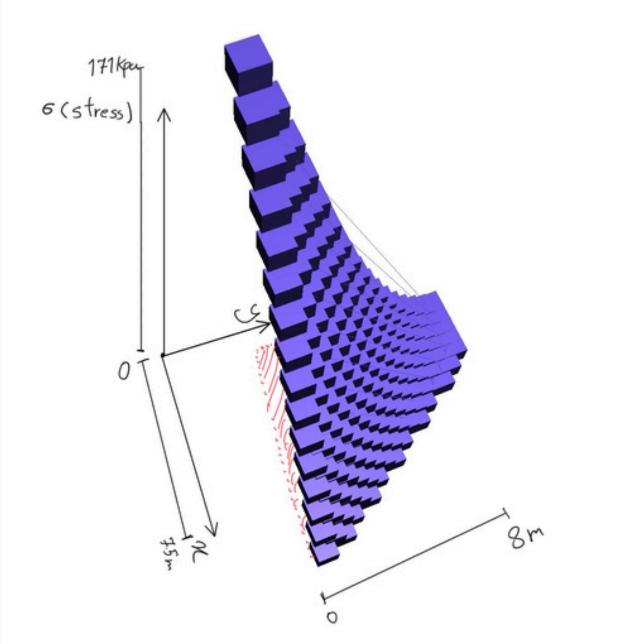


Figure 3: 3D Plot of Stress

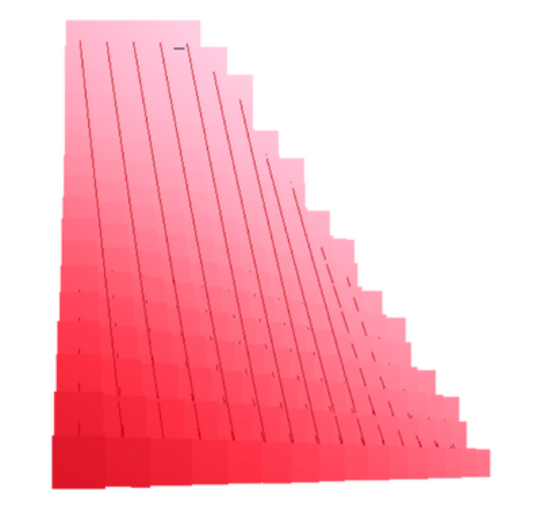


Figure 4: 2D Contour Plot of Stress

Below is the Civil 3D output for stress on the dam.

This figure illustrates the stress, due to hydrostatic forces, that is being distributed toward each point on the dam. Since concrete is weak in tension, red/orange was used to depict the critical points on the cross-section in which concrete was in tension. Furthermore, blue shows which part of the cross-section was in compression. The line between blue and orange shows the centroid line of the cross-section.

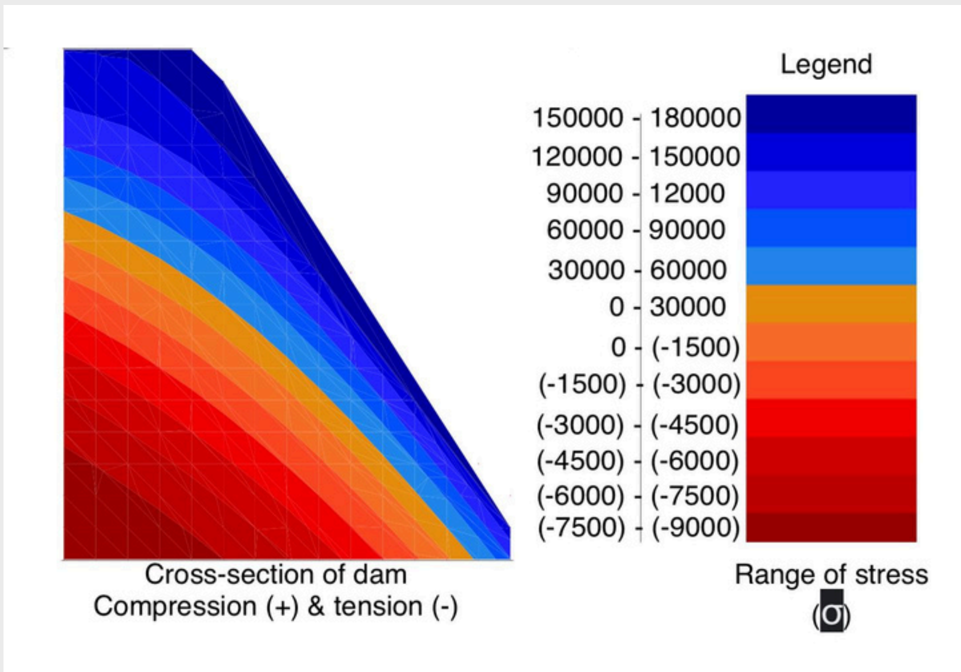


Figure 5: Civil 3D Output for Stress

$$\sigma_{(x,y)} = \frac{\left[\left(\frac{B+\left(\frac{(H-Y)}{\tan\theta}\right)}{2}\right)-X\right]}{\left(B+\frac{H-Y}{\tan\theta}\right)^{3}} 2\gamma_{w}(H-y)^{3}$$

Formula 1: Stress Distribution Formula

Below is the mix design generated for the Wabagishik Project.

Type	1	2	3	4
ID	Standard	High-Strength	Light Weight	RCC
Cement Kg/(CAD)	380/(60.80 - 76)	420/(67.20 - 84)	320/(51.20 - 64)	200/(160 - 200)
Water Kg/(CAD)	171/(NA)	189/(NA)	144/(NA)	10/(NA)
Fine Aggregate Kg/(CAD)	750/(35 - 70)	800/(28 - 56)	720/(25.20 - 50.40)*	1900/(35 - 70)
Coarse Aggregate Kg/(CAD)	1150/(40 - 80)	1200(48 - 96)	900/(90 - 180)	120/(40 -80)

*Light Weight Coarse Aggregate used in Lieu of Gravel

Table 1: Concrete Mix Design Proportions

	Workability	Strength	Cost	Curing Time	Availability	Envir. Impact	Permeability	Total Weigh
Workability		0	0	1	1	0	0	2
Strength	1		1	1	1	1	0.5	5.5
Cost	1	0		1	1	0	0	3
Curing Time	0	0	0		0.5	0	0	0.5
Availability	0	0	0	0.5		0	0	0.5
Envir. Impact	1	0	1	1	1		0.5	4.5
Permeability	1	0.5	1	1	1	0.5		5

Table 2: Weight Table for Decision Matrix

Mix	1	2	3	4
ID	Standard	High-Strength	Light Weight	RCC
Strength	9	10	7	9
Permeability	7	8	4	9
Envir. Impact	6	5	7	9
Cost	9	7	9	6
Workability	8	7	9	6
Curing Time	9	9	9	9
Availability	9	9	8	9
Total	163.5	161.5	134.5	183

Table 3: Decision Matrix to Assess Concrete Mix Design

Schedule

The project has been scheduled according to the chart outlined below. The following schedule has been shared with all stakeholders and is regularly updated according to the progress made throughout the project.

For a more detailed view, the expanded chart (GANNT format) can be found in the appendix and the shared file can be referenced online.

TASK ID	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION IN DAYS	PCT OF TASK COMPLETE
1	Project Proposal					
1.1	Client Introduction	Nima	01-30-24	01-31-24	1	100%
1.1.1	Initial Needs Assessment	Seyed	01-30-24	02-01-24	2	100%
1.2	Research	Nima	02-01-24	02-04-24	3	100%
1.3	Projections	Nima	02-04-24	02-06-24	2	100%
1.4	Stakeholder Consideration	Nima	02-04-24	02-08-24	4	100%
1.5	Proposal Draft	Nima	02-04-24	02-09-24	5	100%
1.6	Present Project Proposal	Nima	02-09-24	02-10-24	1	100%
2	Project Definition and Planning					
2.1	Scope & Goal Setting	Nima	02-12-24	02-19-24	7	100%
2.2	In-Depth Budget	Aryan	02-12-24	02-19-24	7	100%
2.3	Progress Report Initiation	Nima	02-19-24	02-22-24	3	100%
2.4	Risk Management Initiation	Nima	02-19-24	02-28-24	9	100%
3	Project Preperation	Nima				
3.1	Prepare Equipment Purchase Lis	Nima	02-28-24	02-29-24	1	100%
3.2	Initial Design Preperation	Nima	02-12-24	02-26-24	14	100%
3.3	Prepare Labour Reqruitment Sp	Aryan	02-12-24	02-29-24	17	100%
3.4	Resource Pooling	Seyed	02-26-24	03-11-24	14	100%
3.5	Plan Kick Off Meeting	Nima	02-26-24	02-28-24	2	100%
3.6	Purchase Email Accounts	Seyed	02-26-24	02-28-24	2	100%
3.7	Create Teams Rooms	Seyed	02-26-24	02-28-24	1	100%
4	Project Launch	Stellar				
4.1	Kickoff Meeting	Nima	02-26-24	02-28-24	2	100%
4.2	First Progress Assessment	Seyed	02-26-24	03-04-24	7	100%
4.3	First Risk Assessment	Seyed	02-26-24	03-04-24	7	100%
5	Project Monitoring	Stellar				
5.1	Weekly Group Meetings	Seyed	02-26-24	04-08-24	42	100%
5.2	Weekly Supervisor Meetings	Nima	02-26-24	04-08-24	42	100%
6	Project Execution	Stellar				
6.1	Environmental Protection	Arian	02-26-24	04-08-24	42	100%
6.2	Design Presentation	Mahdis	02-26-24	04-08-24	42	100%
6.3	Interim Assessment	Seyed	02-09-24	02-26-24	17	100%
6.4	Infrastructure Preperation	Aryan	02-26-24	04-08-24	42	100%
6.5	Concrete Design	Arian	02-26-24	04-08-24	42	100%
6.6	Design Amalgamation	Nima	03-04-24	04-08-24	35	100%
6.7	Interim Assessment	Seyed	03-11-24	03-16-24	5	100%
6.8	Stakeholder Meeting	Stellar	03-18-24	04-08-24	21	100%

Figure 6: Project Schedule.

Note: GANNT chart is available live for all major stakeholders. For a more detailed view, please refer to the shared file. For access to new accounts, please contact the front desk. We are happy to help you.

Budget

A cost for services has been generated according to the table below:

Cost Estimation - Pre Construction		Length of the design stage is around 6 months or 0.5 of a year		
Row No.	Amount	Annual Income (CAD)	Length of Design Stage (Annual)	Total Cost (CAD) (Pre-Tax)
Structural Engineer	1	87,000	0.5	$ 43,500.00
Civil Engineer (Concrete)	1	76,000	0.5	$ 38,000.00
Enviromental Engineer	1	94,000	0.25	$ 23,500.00
Geotechnical Engineer	1	71,000	0.25	$ 17,750.00
BIM Modelling Engineer	1	65,000	0.4	$ 26,000.00
Project Manager	1	106,000	0.5	$ 53,000.00
Accumulate Cost				$ 201,750.00
Total Cost + Tax (13%)				$ 227,977.50
Total Cost + Profit (10%)				$ **250,775.25**
Cost Estimation - Construction Supervision		Length of the dam construction is around 30 months or 2.5 of a years		
Row No.	Amount	Annual Income (CAD)	length of Construction Stage (Annual)	Total Cost (CAD) (Pre-Tax)
Structural Engineer	1	87000	2	$ 174,000.00
Civil Engineer (Concrete)	1	76000	1	$ 76,000.00
Enviromental Engineer	1	94000	1	$ 94,000.00
Geotechnical Engineer	1	71000	0.25	$ 17,750.00
BIM Modelling Engineer	1	65000	0	$ -
Project Manager	1	106000	2.5	$ 265,000.00
Accumulate Cost				$ 626,750.00
Total Cost + Tax (13%)				$ 708,227.50
Total Cost + Profit (10%)				$ **779,050.25**
Total Project Cost				$ 1,029,825.50

Table 4: Cost for Services Rendered.

Type/Cost (CAD)	Standard	High Strength	Light Weight	Roller Compact
Cement	60.80 - 76.00	67.20 - 84	51.20 - 64.00	160.00 - 200.00
Sand	26.25 - 52.50	28.00 - 56.00	25.20 - 50.40	35.00 - 70.00
Gravel	46.00 - 92.00	48.00 - 96.00	90.00 - 180.00 *	40.00 - 80.00
Total Cost	133.05 - 220.50	143.20 - 236.00	166.40 - 294.40	130.00 - 220.00

*Light Weight Coarse Aggregate used in Lieu of Gravel

Table 5: Cost of Concrete.

Discussion

In addressing the critical condition of the Wabagishik Dam, Stellar Solutions opted for a comprehensive reconstruction strategy, utilizing the latest in technological and engineering advancements. Central to this approach was the utilization of detailed site plans and survey data to create precise AutoCAD drawings with scaled dimensions. This meticulous process ensured that every aspect of the dam's design was accurately captured and considered in the reconstruction plans.

A pivotal element of our solution involved the development of a custom Python script designed to analyze stress within a trapezoidal cross-section of the dam. This innovative approach began with the delineation of the cross-section boundaries, establishing a clear definition of its geometric properties. We then integrated the stress equation into the Python code, allowing for the calculation of stress at various points within the cross-section. The stress values obtained were exported as triplets of x, y coordinates, and corresponding stress levels into a text file, which was subsequently imported into a graphing application for visualization.

The utilization of a color map feature in the graphing app settings was instrumental in representing the stress levels within the cross-section. This visual representation employed darker colors to indicate areas of higher stress and brighter colors for lower stress regions, providing a clear and intuitive depiction of stress distribution. The resulting images and renders, included in our report, not only enhanced the clarity of our findings but also highlighted critical zones of maximum stress, both compressive and tensile.

This advanced analytical approach enabled us to precisely identify areas requiring reinforcement and to tailor the concrete mix design specifically for those zones. By doing so, we ensured that the reconstructed dam would exhibit optimal structural performance and resilience, addressing both the immediate and long-term demands placed upon it.

Conclusion

Based on conducted analysis, it has been determined that the safest course of action for the Wabagishik Dam reconstruction is to prepare for the worst-case scenario. This means designing a concrete mix that can handle the extreme stresses it might face, including hydrostatic pressures and the weight of the concrete itself. The goal is to ensure the dam remains stable under any conditions, preventing future failures. The specifics of the concrete mix will be established in the final report. Stellar is focused on safety and durability to secure the dam's long-term integrity.

A thank you is extended to the client for entrusting this critical project to Stellar Solutions. We will continue this effective working partnership, delivering solutions that not only meet but exceed expectations.

Signature Page

We thank you for your on going cooperation through our collaborations on The Wabagishik Dam Reconstruction Project.

Please contact Nima with any questions concerning the information enclosed.

Nima Nojavan
Project Manager

Prepared by
Stellar Ltd

Nima Nojavan

Stellar Solutions

2024

References

[1] “Archive for the WABAGISHIK GS spillway category.” vermilionriverstewards.ca. (n.d.). https://vermilionriverstewards.ca/category/concerns/dams/wabagishik-gs-spillway/ (accessed Feb. 22, 2024).

[2] “Classification and inflow design flood criteria,” ontario.ca, https://www.ontario.ca/page/classification-and-inflow-design-flood-criteria (accessed Mar. 22, 2024).

[3] “Dam Safety Risk Screening Tool,” Canadian Consulting Engineer, https://www.canadianconsultingengineer.com/awards/pdfs/2015/F1_HatchDamSafetyRisk.pdf (accessed Mar. 22, 2024).

[4] “EXP completes concrete gravity dam for Vale in Sudbury.” Canadian Consulting Engineer. https://www.canadianconsultingengineer.com/energy/exp-completes-concrete-gravity-dam-for-vale-in-sudbury/1003415205/ (accessed Feb. 22, 2024).

[5] “Generous concrete use stabilizes Sudbury’s new Gravity Dam.” Construction Canada. https://www.constructioncanada.net/generous-concrete-use-stabilizes-sudburys-new-gravity-dam/ (accessed Feb. 22, 2024).

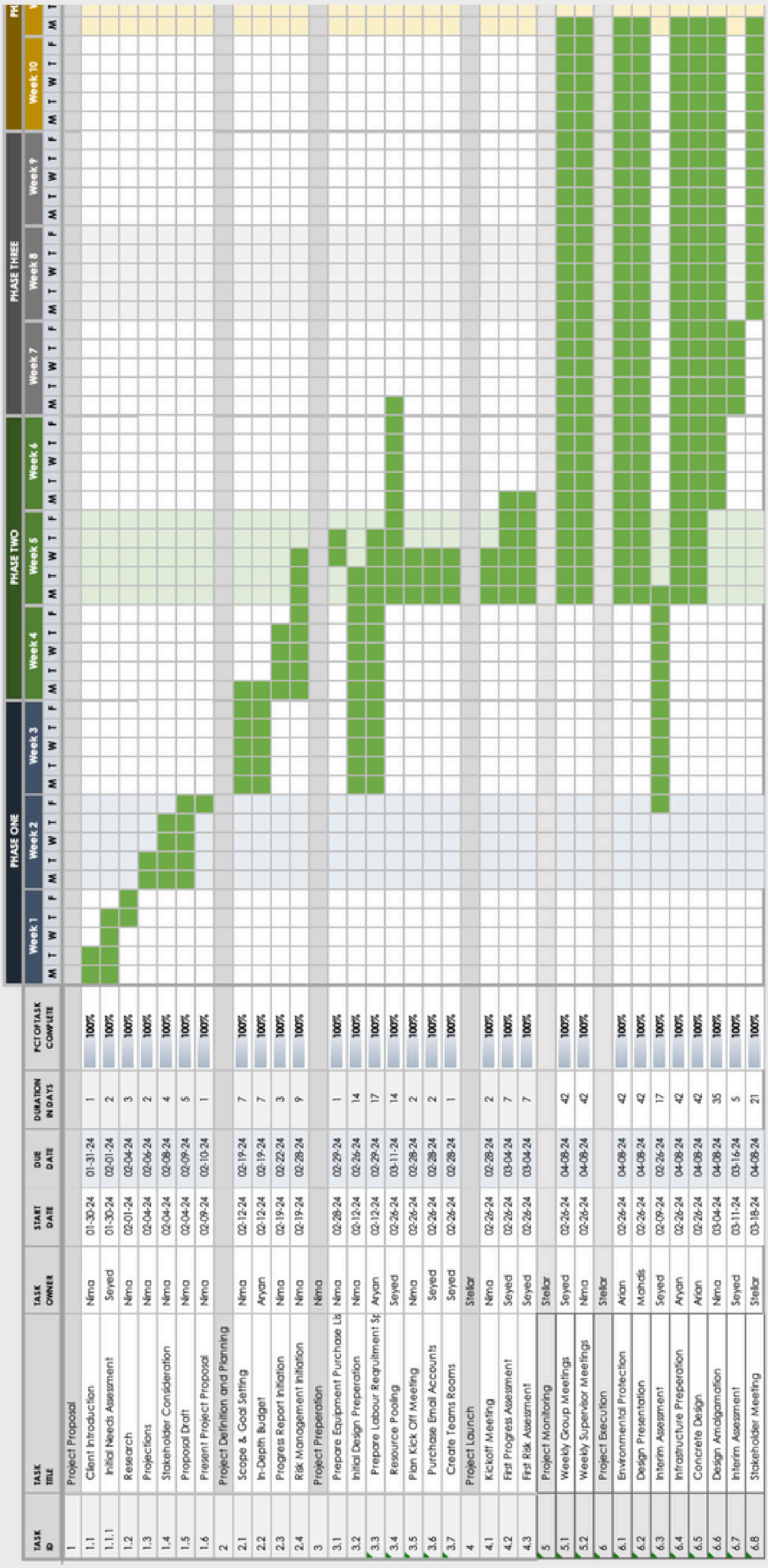
[6] “Regulation of dams in Canada,” Regulation - Canadian Dam Association (CDA-ACB), https://cda.ca/dams-in-canada/regulation (accessed Feb. 22, 2024).

[7] “Wabagishik Rapids GS ER.” (n.d.-a). http://www.ontarioriversalliance.ca/wp-content/uploads/2013/11/2013-10-29-Wabagishik-ORAtoXeneca.pdf

[8] “Wabagishik side dams A + b replacement. EXP.“ (n.d.). https://www.exp.com/experience/wabagishik-side-dams-a-b-replacement/ (accessed Feb. 22, 2024).

[9] “Year in - ontario waterpower association.” (n.d.-b). https://owa.ca/wp-content/uploads/2018/12/OWA-2018-Year-in-Review-%C6%92-web.pdf (accessed Feb. 22, 2024).

Appendix



TASK ID	TASK TITLE	TASK OWNER	START DATE	DUE DATE	DURATION IN DAYS	PCT OF TASK COMPLETE
1	Project Proposal					
1.1	Client Introduction	Nima	01-30-24	01-31-24	1	100%
1.1.1	Initial Needs Assessment	Seyed	01-30-24	02-01-24	2	100%
1.2	Research	Nima	02-01-24	02-04-24	3	100%
1.3	Projections	Nima	02-04-24	02-06-24	2	100%
1.4	Stakeholder Consideration	Nima	02-04-24	02-08-24	4	100%
1.5	Proposal Draft	Nima	02-04-24	02-09-24	5	100%
1.6	Present Project Proposal	Nima	02-09-24	02-10-24	1	100%
2	Project Definition and Planning					
2.1	Scope & Goal Setting	Nima	02-12-24	02-19-24	7	100%
2.2	In-Depth Budget	Aryan	02-12-24	02-19-24	7	100%
2.3	Progress Report Initiation	Nima	02-19-24	02-22-24	3	100%
2.4	Risk Management Initiation	Nima	02-19-24	02-28-24	9	100%
3	Project Preperation	Nima				
3.1	Prepare Equipment Purchase Li	Nima	02-28-24	02-29-24	1	100%
3.2	Initial Design Preperation	Nima	02-12-24	02-26-24	14	100%
3.3	Prepare Labour Requirement Sp	Aryan	02-12-24	02-29-24	17	100%
3.4	Resource Pooling	Seyed	02-26-24	03-11-24	14	100%
3.5	Plan Kick Off Meeting	Nima	02-26-24	02-28-24	2	100%
3.6	Purchase Email Accounts	Seyed	02-26-24	02-28-24	2	100%
3.7	Create Teams Rooms	Seyed	02-26-24	02-28-24	1	100%
4	Project Launch	Stellar				
4.1	Kickoff Meeting	Nima	02-26-24	02-28-24	2	100%
4.2	First Progress Assessment	Seyed	02-26-24	03-04-24	7	100%
4.3	First Risk Assessment	Seyed	02-26-24	03-04-24	7	100%
5	Project Monitoring	Stellar				
5.1	Weekly Group Meetings	Seyed	02-26-24	04-08-24	42	100%
5.2	Weekly Supervisor Meetings	Nima	02-26-24	04-08-24	42	100%
6	Project Execution	Stellar				
6.1	Environmental Protection	Arian	02-26-24	04-08-24	42	100%
6.2	Design Presentation	Mahdis	02-26-24	04-08-24	42	100%
6.3	Interim Assessment	Seyed	02-09-24	02-26-24	17	100%
6.4	Infrastructure Preperation	Aryan	02-26-24	04-08-24	42	100%
6.5	Concrete Design	Arian	02-26-24	04-08-24	42	100%
6.6	Design Amalgamation	Nima	03-04-24	04-08-24	35	100%
6.7	Interim Assessment	Seyed	03-11-24	03-16-24	5	100%
6.8	Stakeholder Meeting	Stellar	03-18-24	04-08-24	21	100%

Figure 6.1: Extended GANNT Chart.

Appendix

```python
import math

H = 8.39  # Height of the trapezoidal cross-section
B_lower = 7.73  # Lower base length
B_upper = 2.14  # Upper base length
b = B_lower - B_upper  # Width of the trapezoidal cross-section
dh = 7.01  # Depth of the trapezoidal cross-section (same as height)
step = 0.5  # Step size for calculating stress every 0.5 meters

# Calculate the number of steps in x and y directions
nx = int(B_lower // step + 1)
ny = int(H // step + 1)

# Initialize X and Y lists to hold coordinates
X = [i * step for i in range(nx)]
Y = [i * step for i in range(ny)]

# Initialize a list to store (x, y, stress) triplets
results = []

# Define the value of x (if needed)
x = 0  # Placeholder value, replace with actual value if needed

# Loop through each point (i, j) within the trapezoidal cross-section
for i in range(nx):
    for j in range(ny):
        if 0 <= X[i] <= ((H*B_lower/b)-Y[j])*2/3 and 0 <= Y[j] <= H:  # Include (0, 0) and endpoints
            A = (19620 * ((H - Y[j]) ** 3))
            V = (B_upper / 2 + (H - Y[j]) / 2*math.tan(0.9827)) - X[i]
            M = ((H - Y[j]) / math.tan(0.9827) + B_upper) ** 3
            stress = (A * V) / M
            results.append((X[i], Y[j], stress))

# Print the results
for result in results:
    print(result)
```

Figure 3.1: Python Source Code.

0.0	0.0	184350.05686806832
0.0	0.5	166071.05055056151
0.0	1.0	148284.52074651615
0.0	1.5	131045.87062768736
0.0	2.0	114418.51726636117
0.0	2.5	98475.18050028225
0.0	3.0	83299.3274024686
0.0	3.5	68986.7256231684
0.0	4.0	55646.982848392516
0.0	4.5	43404.7996062293
0.0	5.0	32400.369528636016
0.0	5.5	22787.789164723883
0.0	6.0	14729.22032049571
0.0	6.5	8380.355702018403
0.0	7.0	3858.486068859212
0.0	7.5	1176.588860152812
0.0	8.0	114.6959323154904

Figure 3.2: Generated txt File from Pythom.