

1. INTRODUCTION

1.1. Project Overview

Civil Engineering Insight Studio is an AI-powered structural analysis web application designed to analyze civil engineering structures from uploaded images. The system allows users to upload an image of a structure (bridge, building, dam, road, etc.) and optionally provide a description. Using the Google Generative AI API and the Gemini model (gemini-flash-latest), the application analyzes the structure and provides, safety and design features.

The application is developed using Streamlit for the frontend interface and integrates AI-based image + text analysis for intelligent structural interpretation.

This project demonstrates the practical use of multimodal generative AI in civil engineering education and structural analysis.

1.2. Objectives

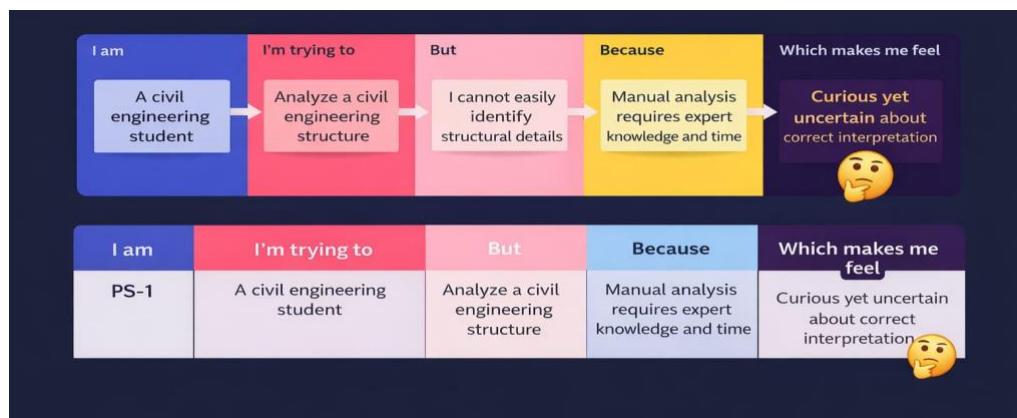
The main objectives of the Civil Engineering Insight Studio project are:

- To develop an AI-powered web application for structural image analysis
- To enable users to upload civil structure images for automated explanation
- To integrate a multimodal AI model for image and text-based analysis
- To provide fast, structured, and professional civil engineering insights
- To create an intuitive and modern UI using Streamlit
- To support engineering students and professionals with instant structural understanding

2. Ideation Phase

2.1. Problem Statement

Therefore, the problem is to develop a centralized, intelligent, and user-friendly platform Civil Engineering Insight Studio that leverages data analytics and modern technologies to streamline project planning, improve accuracy, enhance decision-making, and optimize overall construction project performance.



Problem Statement (PS)	I am	I'm trying to	But	Because	Which makes me feel
PS-1	A civil Engineering Student	Analyze a civil engineering structure	I cannot easily identify structural details	Manual analysis requires expert knowledge and time	Curious yet uncertain about correct interpretation
PS-2	A civil engineerin g student	Analyze a civil engineering student	Manual analysis requires expert knowledge and time	Manual analysis requires expert	Curious yet uncertain about correct interpretation

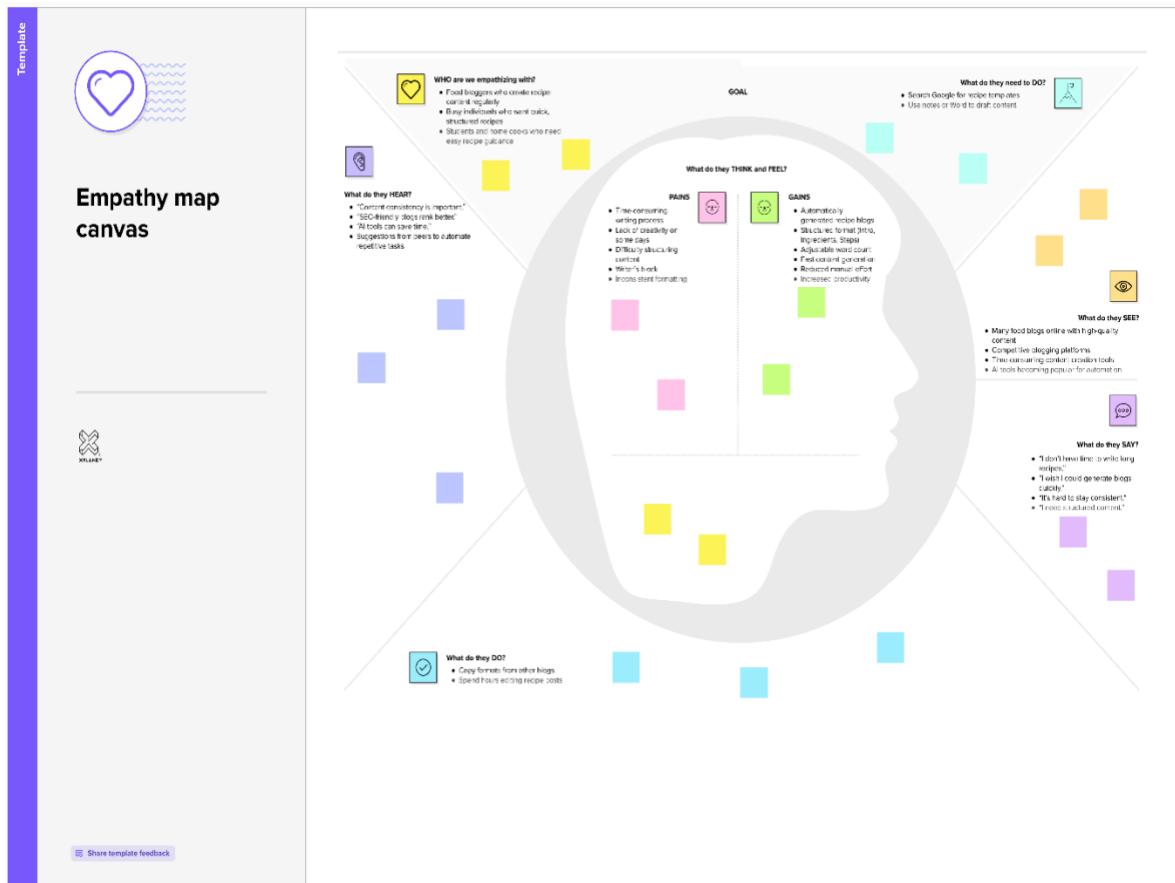
2.2. Empathy Map Canvas

Empathy Map Canvas:

An empathy map is a simple, easy-to-digest visual that captures knowledge about user's behaviours and attitudes. It is a useful tool to help teams better understand their users.

Creating an effective solution requires understanding the true problem and the person who is experiencing it. The exercise of creating the map helps participants consider things from the user's perspective along with his or her goals and challenges.

Example:



2.3 Brainstorming

Brainstorm & Idea Prioritization:

Brainstorming provides a free and open environment that encourages everyone within a team to participate in the creative thinking process that leads to problem solving. Prioritizing volume over value, out-of-the-box ideas are welcome and built upon, and all participants are encouraged to collaborate, helping each other develop a rich amount of creative solutions.

Use this template in your own brainstorming sessions so your team can unleash their imagination and start shaping concepts even if you're not sitting in the same room.

Step-1: Team Gathering, Collaboration and Select the Problem Statement

Step-2: Brainstorm, IdeaListing and Grouping

Step-3: Idea Prioritization

3. Requirement Analysis

3.1. Solution Requirement

Functional Requirements:

Following are the functional requirements of the proposed solution.

FR No.	Functional Requirement (Epic)	Sub Requirement (Story / Sub-Task)
FR-1	Project Input Module	Enter Project/ topic Select analysis type
FR-2	Input Validation	Validate empty input Validate file format
FR-3	AI Integration	Connect to Gemini Flash Lite API Send structured prompt to model process user queries
FR-4	Analysis & Report Generation	Generate structured engineering report Include Introduction,Methodology,Calculations, results
FR-5	Output Display	Display generated report in UI Allow user to copy content
FR-6	Additional Feature	Generate civil engineering tips / insights (optional feature)

Non-functional Requirements:

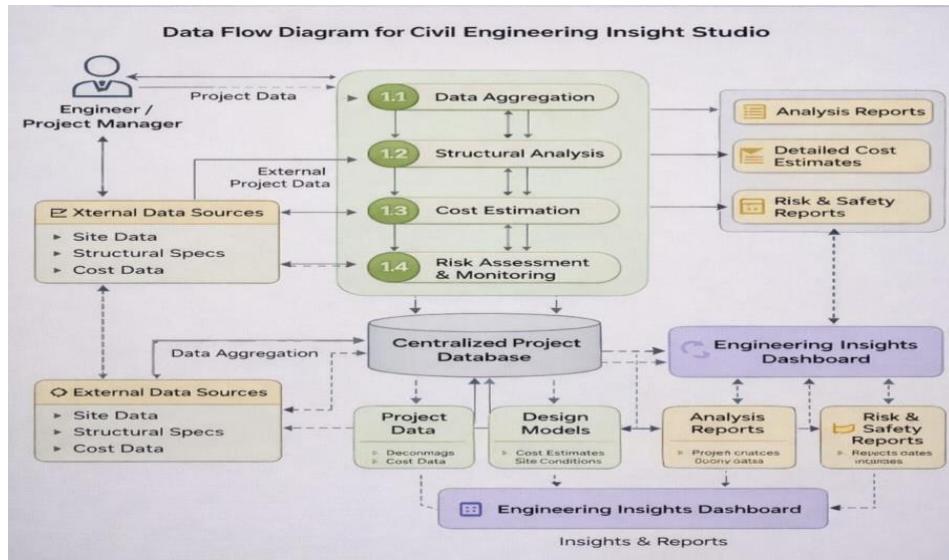
Following are the non-functional requirements of the proposed solution.

FR No.	Non-Functional Requirement	Description
NFR-1	Usability	The application must have a simple and intuitive Streamlit interface that is easy to use.
NFR-2	Security	API keys must be securely stored and not exposed in the frontend.
NFR-3	Reliability	The system should generate consistent and structured outputs for valid inputs.
NFR-4	Performance	Report generation should complete within a few seconds.
NFR-5	Availability	The application should handle multiple users simultaneously without performance degradation.
NFR-6	Scalability	The system should handle multiple users without significant performance degradation.

3.2. Data Flow Diagram

Data Flow Diagrams:

A Data Flow Diagram (DFD) is a traditional visual representation of the information flows within a system. A neat and clear DFD can depict the right amount of the system requirement graphically. It shows how data enters and leaves the system, what changes the information, and where data is stored.



User Stories

Use the below template to list all the user stories for the product.

User Type	Functional Requirement (Epic)	User Story Number	User Story / Task	Acceptance criteria
Student/Engineer	User Interface Setup	USN-1	As a user, I can access a Streamlit-based interface to enter a project details.	I can access mydashboard
Administrator	Input Validation	USN-2	As a user, I want the application to validate my inputs.	I can validate the inputs
System	AI Model Integration	USN-3	As a user, I want the system to calculate load stress, and material estimation using integrated engineering.	I can calculate model
Administrator	Material Estimation & Cost Analysis	USN-4	As a user, I want to generate a cost estimation reports for construction projects.	I can generate a reports for user interaction
Student/Engineer	Output Display	USN-5	As a user, I want to view graphs and charts representing structural strength, cost and project progress.	I can see the output of graph generated
Deployment Team	Deployment	USN-6	As a user, I want the application to be deployed and accessible through the internet.	I can deploy in the system

3.3. Technology Stack

Technical Architecture:

The Deliverable shall include the architectural diagram as below and the information as per the table1 & table 2

Table-1 : Components & Technologies:

S.No	Component	Description
1.	User Interface	Web-based interface where users upload site images, input project details, and request analysis
2.	Application Logic-1	Input validation and preprocessing of civil engineering data
3.	Application Logic-2	Structural analysis, quantity estimation, and report generation logic
4.	Application Logic-3	AI request handling and response processing
5.	File Storage	Local storage for uploaded images, reports, and logs
6.	External API-1	Generative AI and recommendations for civil projects
7.	Machine Learning Model	Pre-trained generative AI model for text generation
8.	Infrastructure (Server / Cloud)	Deployment of application

Table-2: Application Characteristics:

S.No	Characteristics	Description	Technology
1.	Open-Source Frameworks	Web framework and development tools used for building civil engineering analysis platform	Streamlit, Python
2.	Security Implementations	Secure storage of API keys and environment variables	Environment Variables (.env), Streamlit Secrets
3.	Scalable Architecture	Web-based architecture supporting multiple users And scalable deployment	Cloud-based deployment (Streamlit Cloud)
4.	Availability	Application accessible online after deployment for project analysis and reporting	Streamlit Cloud Hosting
5.	Performance	Fast response generation using lightweight AI model and efficient data processing	Gemini Flash Lite (optimized for low latency)

4. PROJECT DESIGN

4.1. Problem Solution Fit

Problem – Solution Fit Template:

The Problem-Solution Fit simply means that you have found a problem with your customer and that the solution you have realized for it actually solves the customer's problem. It helps entrepreneurs, marketers and corporate innovators identify behavioral patterns and recognize what would work and why

Purpose:

- Solve complex problems in a way that fits the state of your customers.
- Succeed faster and increase your solution adoption by tapping into existing mediums and channels of behavior.
- Sharpen your communication and marketing strategy with the right triggers and messaging.
- Increase touch-points with your company by finding the right problem-behavior fit and building trust by solving frequent annoyances, or urgent or costly problems.
- Understand the existing situation in order to improve it for your target group.

Template:

1. CUSTOMER SEGMENT(S) Who is your customer? I.e. working parents of 0-5 y.o. kids	CS 6. CUSTOMER CONSTRAINTS What constraints prevent your customers from taking action or limit their choices of solutions? I.e. spending power, budget, no cash, network connection, available devices.	CC 5. AVAILABLE SOLUTIONS Which solutions are available to the customers when they face the problem or need to get the job done? What have they tried in the past? What pros & cons do these solutions have? I.e. pen and paper is an alternative to digital notetaking	AS Explore AS, differentiate
2. JOBS-TO-BE-DONE / PROBLEMS Which jobs-to-be-done (or problems) do you address for your customers? There could be more than one; explore different sides.	J&P 9. PROBLEM ROOT CAUSE What is the real reason that this problem exists? What is the back story behind the need to do this job? I.e. customers have to do it because of the change in regulations.	RC 7. BEHAVIOUR What does your customer do to address the problem and get the job done? I.e. directly related: find the right solar panel installer, calculate usage and benefits; indirectly associated: customers spend free time on volunteering work (I.e. Greenpeace)	BE Focus on J&P, tap into BE, understand RC
3. TRIGGERS What triggers customers to act? I.e. seeing their neighbour installing solar panels, reading about a more efficient solution in the news.	TR 10. YOUR SOLUTION If you are working on an existing business, write down your current solution first, fill in the canvas, and check how much it fits reality. If you are working on a new business proposition, then keep it blank until you fill in the canvas and come up with a solution that fits within customer limitations, solves a problem and matches customer behaviour.	SL 8. CHANNELS OF BEHAVIOUR 8.1 ONLINE What kind of actions do customers take online? Extract online channels from #7	CH Extract online & offline CH or BE
4. EMOTIONS: BEFORE / AFTER How do customers feel when they face a problem or a job and afterwards? I.e. lost, insecure > confident, in control - use it in your communication strategy & design.	EM	8.2 OFFLINE What kind of actions do customers take offline? Extract offline channels from #7 and use them for customer development.	

4.2. Proposed Solution

Proposed Solution Template:

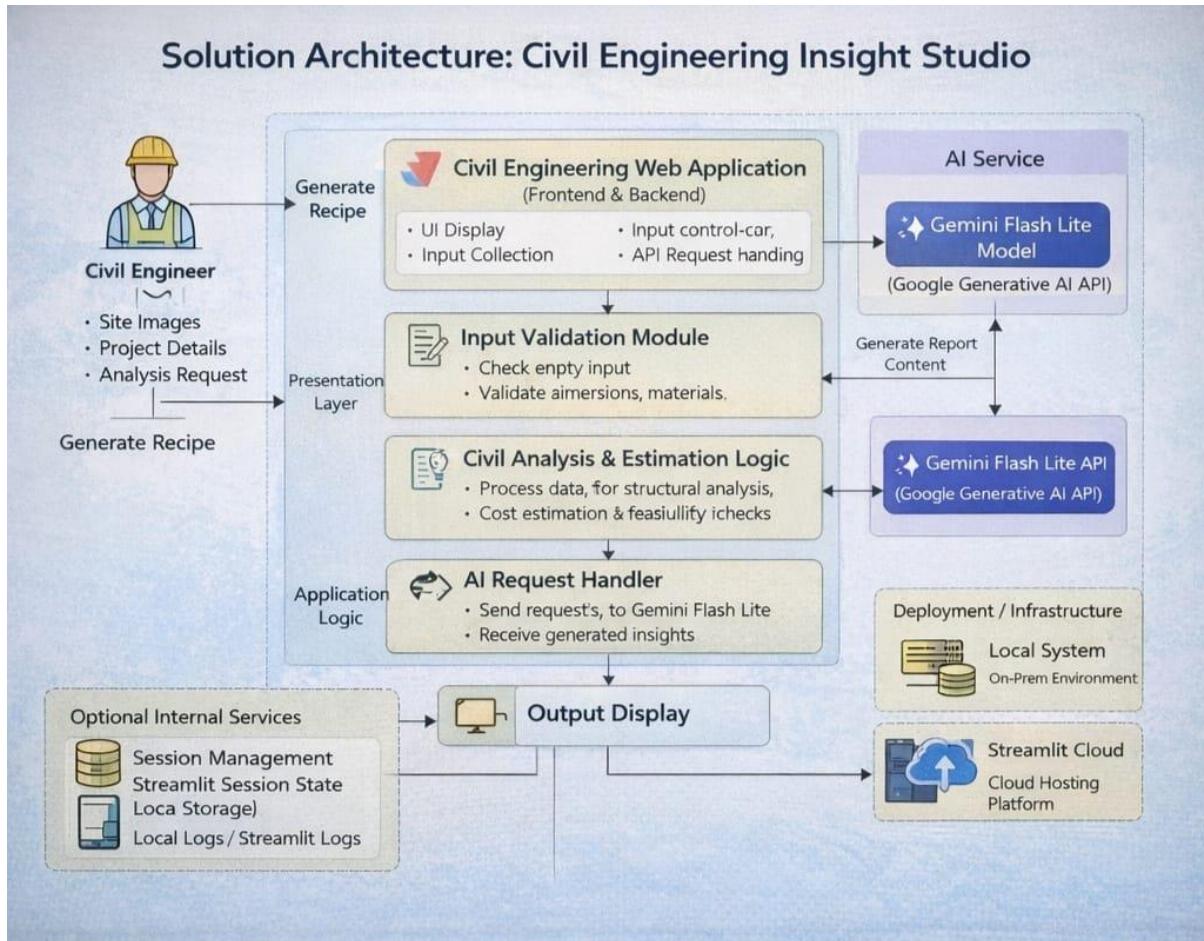
Project team shall fill the following information in the proposed solution template.

S.No.	Parameter	Description
1.	Problem Statement (Problem to be solved)	Many civil engineering students, site engineers, and project managers face difficulties in performing quick structural analysis, cost estimation, and technical documentation. Manual calculations and report preparation are time-consuming, prone to errors, and require advanced expertise. There is a need for an automated system that provides accurate analysis, structured reports, and intelligent insights efficiently.
2.	Idea / Solution description	Civil Engineering Insight Studio is an AI-powered web application that assists users in structural analysis, material estimation, and project documentation. Users enter project details such as dimensions, material type, and site data, and the system processes the information using predefined logic and a generative AI model to produce structured technical reports and recommendations.
3.	Novelty / Uniqueness	Unlike traditional engineering tools that focus only on calculations, this platform integrates Generative AI to provide explanations, design suggestions, and detailed report generation. It combines engineering computation with intelligent insights in a single user-friendly interface.
4.	Social Impact / Customer Satisfaction	The solution supports students, engineers, and construction professionals by saving time and improving productivity. It reduces manual errors, enhances understanding through AI-generated explanations, and provides accessible engineering assistance even for beginners.
5.	Business Model (Revenue Model)	The application can follow a freemium model where basic structural analysis is free, and advanced features such as detailed AI reports, downloadable documentation, and premium project templates are available through subscription. Revenue can also be generated through institutional licenses and enterprise solutions.
6.	Scalability of the Solution	The application is cloud-deployable and designed with scalable architecture. It can handle multiple users simultaneously and can be expanded to include additional modules such as 3D visualization, BIM integration.

4.3 Solution Architecture

Solution Architecture:

The solution architecture of Flavour Fusion consists of a Streamlit-based web application that collects user inputs and validates them. The application constructs a structured prompt and sends it to the Gemini Flash Lite generative AI model through an API call. The AI model generates a structured recipe blog, which is then formatted and displayed to the user. The system can be deployed locally or on a cloud platform such as Streamlit Cloud.



5. PROJECT PLANNING & SCHEDULING

5.1. Project Planning

Product Backlog, Sprint Schedule, and Estimation (4 Marks)

Use the below template to create product backlog and sprint schedule

Sprint	Functional Requirement (Epic)	User Story Number	User Story / Task	Story Points	Priority	Team Members
Sprint-1	User Interface Setup	USN-1	As a user, I can access a Streamlit-based interface to enter a recipe topic and word count.	2	High	All Team Members
Sprint-1	Input Validation	USN-2	As a user, I want the application to validate my inputs before generating the recipe.	1	High	All Team Members
Sprint-2	AI Model Integration	USN-3	As a user, I want the system to generate a recipe blog using the Gemini Flash Lite model.	3	High	All Team Members
Sprint-2	Joke Generation	USN-4	As a user, I want to see a programming joke while the recipe is being generated.	1	Medium	All Team Members
Sprint-3	Output Display	USN-5	As a user, I want to view the generated recipe blog clearly on the screen.	2	High	All Team Members
Sprint-3	Deployment	USN-6	As a user, I want the application to be deployed and accessible through the internet.	2	Medium	All Team Members

Project Tracker, Velocity & Burndown Chart: (4 Marks)

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint 1	20	4 Days	28 January 2026	31 January 2026	20	31 January 2026

Sprint	Total Story Points	Duration	Sprint Start Date	Sprint End Date (Planned)	Story Points Completed (as on Planned End Date)	Sprint Release Date (Actual)
Sprint 1	20	4 Days	28 January 2026	31 January 2026	20	31 January 2026
Sprint 2	20	8 Days	02 February 2026	09 February 2026	20	09 February 2026
Sprint 2	20	8 Days	02 February 2026	09 February 2026	20	09 February 2026
Sprint 3	20	7 Days	12 February 2026	18 February 2026	20	18 February 2026
Sprint 3	20	7 Days	12 February 2026	18 February 2026	20	18 February 2026

6. FUNCTIONAL AND PERFORMANCE TESTING

6.1 Performance Testing

Test Scenarios & Results

Test Case ID	Scenario (What to test)	Test Steps (How to test)	Expected Result	Actual Result	Pass/Fail
PT-01	Image Upload Response Time	Upload a valid JPG/PNG image and click “Describe Structure”	Image loads within 2–3 seconds	Within Limit	Pass
PT-02	AI Response Time Test	Upload image and trigger analysis	Structural analysis generated within 3–6 seconds	Within Limit	Pass
PT-03	Large Image Handling	Upload high-resolution image (>5MB)	System processes image without crashing	Stable	Pass
PT-04	Multiple Request Handling	Perform analysis multiple times consecutively	Application handles requests without lag or crash	Stable	Pass
PT-05	API Retry Mechanism	Simulate temporary API failure (503 error)	System retries automatically and recovers	Working as Expected	Pass
PT-06	Memory Usage Test	Monitor RAM usage during repeated analysis	Memory usage remains within acceptable range (<70%)	Within Limit	Pass

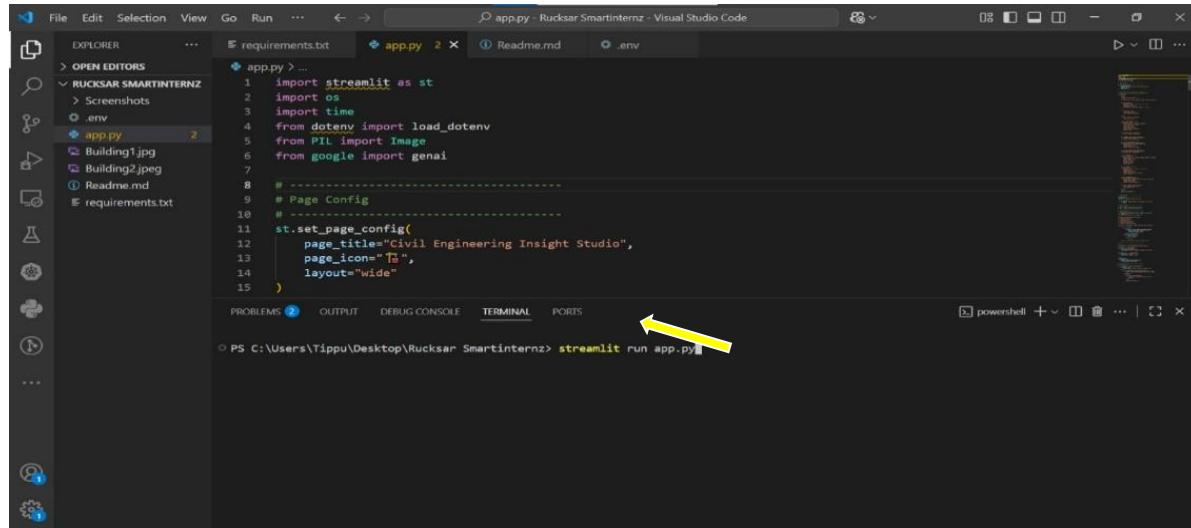
PT-07	UI Rendering Performance	Load the web app in browser	UI loads completely within 2 seconds	Within Limit	Pass
PT-08	Concurrent User Simulation	Simulate 3–5 users accessing app simultaneously	Application remains responsive	Stable	Pass
PT-09	Internet Dependency Check	Disconnect internet and trigger analysis	Error message displayed gracefully	As Expected	Pass
PT-10	Deployment Performance Test	Access deployed app via public link	Application loads and functions correctly	Working	Pass

7. RESULTS

7.1. Output Screenshots

The complete execution of the Civil Engineering Insight Studio application is shown in the images step by step as shown below.

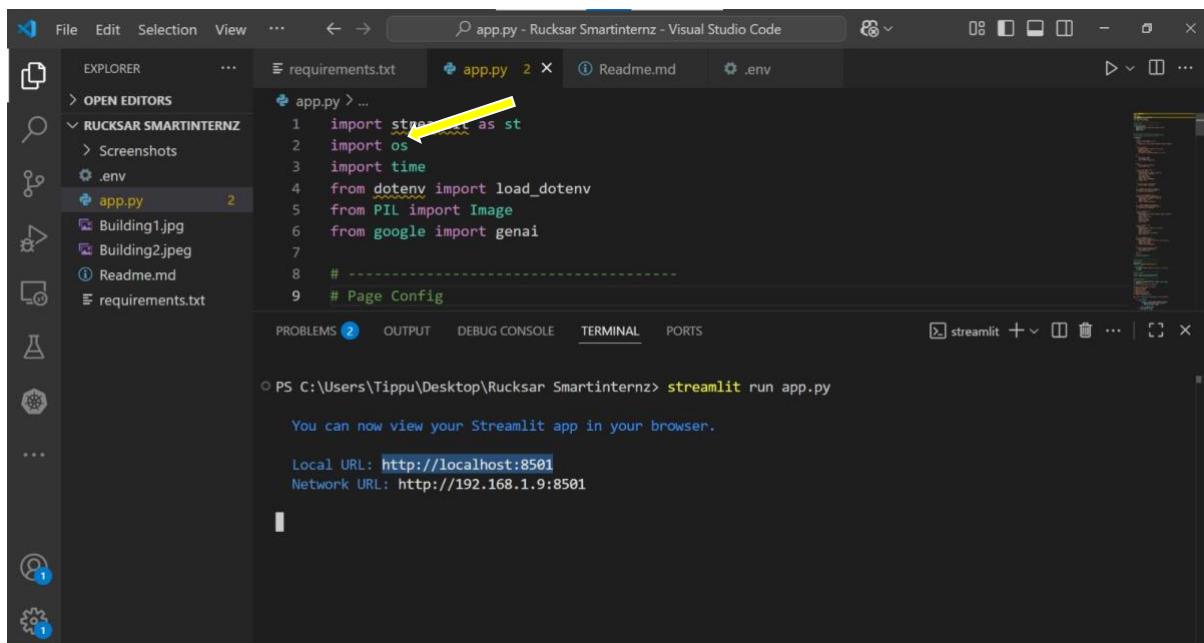
Step 1: Run the app.py code by typing "streamlit run app.py" in the terminal.



A screenshot of the Visual Studio Code interface. The terminal tab is active, showing the command "PS C:\Users\Tippu\Desktop\Rucksar Smartinternz> streamlit run app.py". A yellow arrow points from the text "streamlit run app.py" towards the terminal window. The code editor shows the contents of the app.py file, which imports Streamlit, os, time, dotenv, PIL, and google. It also includes page configuration code for the Streamlit app.

```
import streamlit as st
import os
import time
from dotenv import load_dotenv
from PIL import Image
from google import genai
# -----
# Page Config
# -----
st.set_page_config(
    page_title="Civil Engineering Insight Studio",
    page_icon="",
    layout="wide"
)
```

Step 2: you will get a link in terminal as <https://localhost:8501> to access the output page and to do the other process.

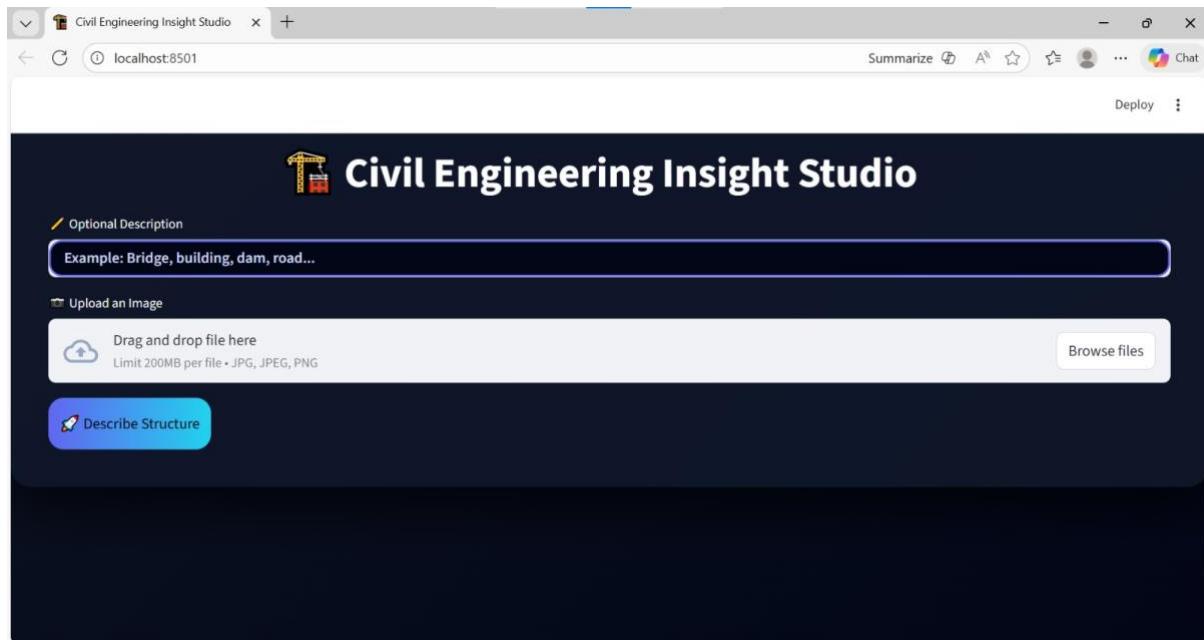


A screenshot of the Visual Studio Code interface, similar to the previous one but with a yellow arrow pointing to the "streamlit" command in the terminal. The terminal output shows the Streamlit application has started and provides the local URL as <http://localhost:8501> and the network URL as <http://192.168.1.9:8501>.

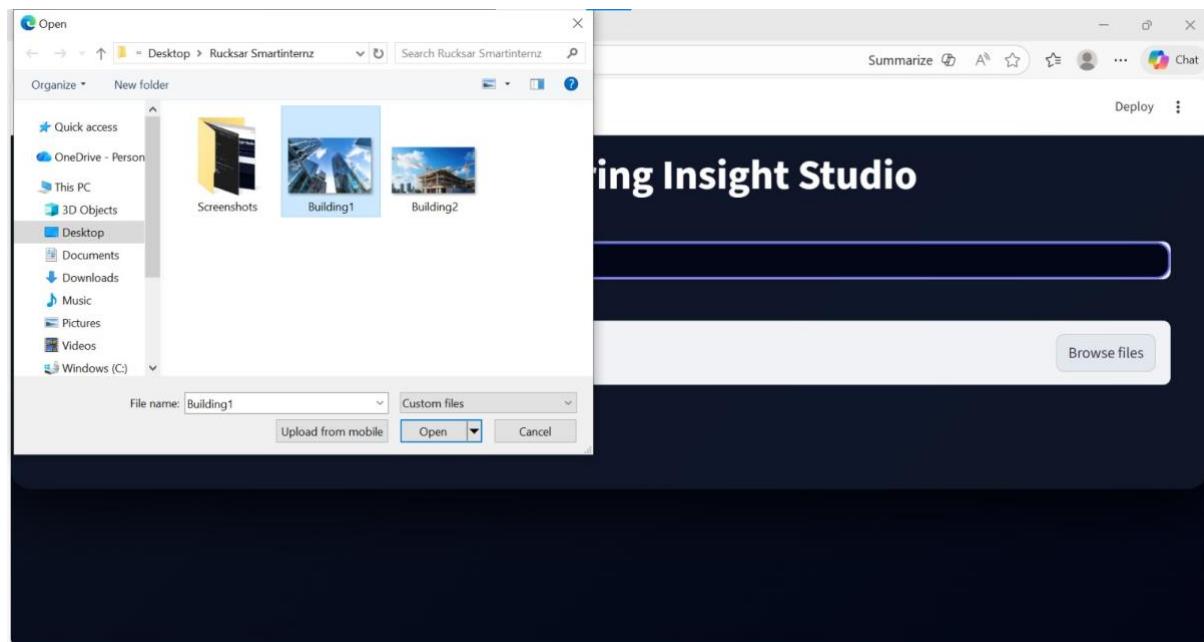
```
You can now view your Streamlit app in your browser.

Local URL: http://localhost:8501
Network URL: http://192.168.1.9:8501
```

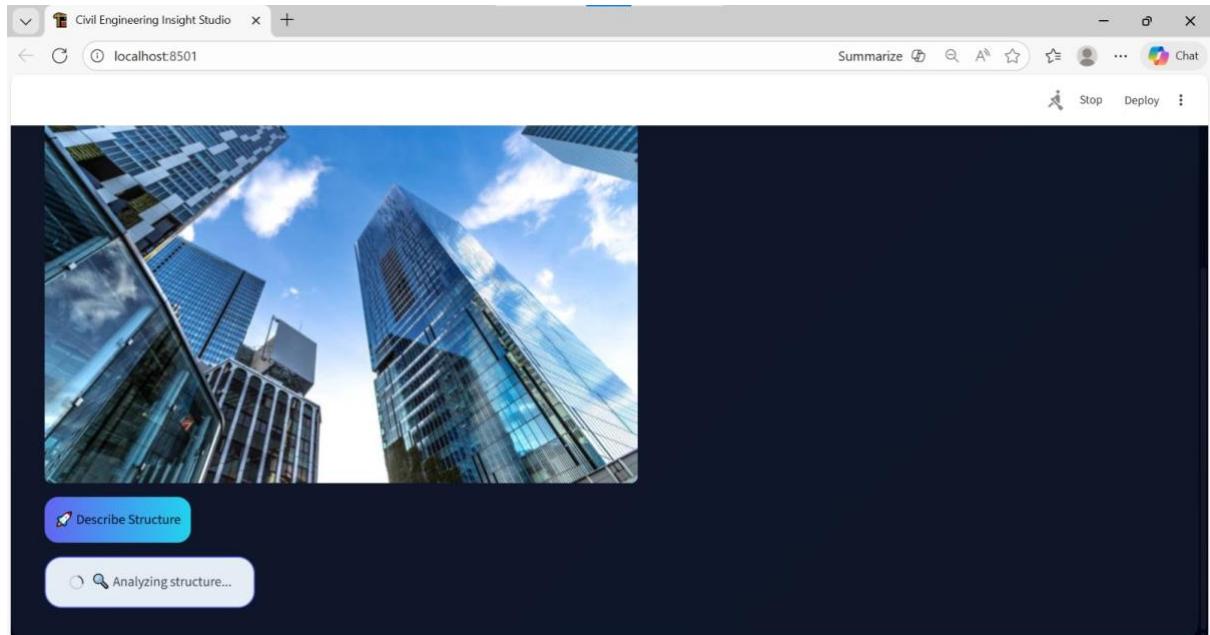
Step 3: By clicking on the optional description search bar and the user can enter the required description.



Step 4: Click on Browse files option to choose the images.



Step 5: The image gets uploaded and then the user clicks on the describe structure option.



Step 6: It analyzes the image and generate insightful descriptions enabling engineers to make informed decisions and communicate effectively about their projects.

A screenshot of the same web browser window after the analysis has completed. The title "Civil Engineering Analysis" is at the top, followed by a sub-section "Engineering Analysis of High-Rise Structures". The first section, "1. Type of Structure", contains a paragraph about the building type and a bulleted list of characteristics. The second section, "2. Structural System", contains a paragraph about the structural requirements and a bulleted list of systems. The overall layout is clean with a dark background and white text.

8. ADVANTAGES AND DISADVANTAGES

Advantages

- Instant structural analysis
- Supports image + text input
- Useful for civil engineering students
- No manual structural database required
- Modern and attractive UI
- Fast processing using Gemini Flash
- Enhances learning and productivity

Disadvantages

- Requires internet connection
- Depends on third-party AI API
- AI output may vary slightly
- Cannot replace professional structural design validation

9. CONCLUSION

The Civil Engineering Insight Studio successfully demonstrates the application of multimodal generative AI in civil engineering analysis. By integrating Streamlit with Gemini Flash AI, the project provides instant structure identification, professional structural explanation, enhanced learning experience, automated engineering insight generation. The system bridges the gap between AI technology and civil engineering education, making structural analysis more accessible and efficient.

10. FUTURE SCOPE

The Flavour Fusion project can be enhanced further by adding support for multiple languages to reach a wider audience. Future improvements may include generating recipe images along with text, adding user accounts to save favorite recipes, and providing personalized recipe recommendations. The application can also be extended to support voice-based input and mobile platform deployment, making it more accessible and user-friendly.

11. APPENDIX

11.1. Source Code

The source code for the Civil Engineering Insight Studio: AI-Powered Structural Analysis Application includes the implementation of the Streamlit user interface, integration of the Gemini Flash model using the Google Generative AI API, image analysis logic, structured output generation, and error-handling mechanisms. The application is developed using Python and follows a modular, clean, and readable structure.

11.2. Github& Project Demo Link

Github Repository Link:

<https://github.com/ShaiRucksar123/Civil-Engineering-Insight-Studio>

Demo Link:

<https://drive.google.com/file/d/1mh9k619qjylvpth4XZvxMuO3HmlNp6W8/view?usp=drivesdk>