FOSSEE Winter Internship Report

On

Animation of Steel Structures and Frontend Development of Osdag Web

Submitted by

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Chapter 1

Introduction

1.1 National Mission in Education through ICT

The National Mission on Education through ICT (NMEICT) is a scheme under the Department of Higher Education, Ministry of Education, Government of India. It aims to leverage the potential of ICT to enhance teaching and learning in Higher Education Institutions in an anytime-anywhere mode.

The mission aligns with the three cardinal principles of the Education Policy—**access, equity, and quality**—by:

- Providing connectivity and affordable access devices for learners and institutions.
- Generating high-quality e-content free of cost.

NMEICT seeks to bridge the digital divide by empowering learners and teachers in urban and rural areas, fostering inclusivity in the knowledge economy. Key focus areas include:

- Development of e-learning pedagogies and virtual laboratories.
- Online testing, certification, and mentorship through accessible platforms like EduSAT and DTH.
- Training and empowering teachers to adopt ICT-based teaching methods.

For further details, visit the official website: www.nmeict.ac.in.

1.1.1 ICT Initiatives of MoE

The Ministry of Education (MoE) has launched several ICT initiatives aimed at students, researchers, and institutions. The table below summarizes the key details:

No.	Resource	For Students/Researchers	For Institutions
Audio-Video e-content			
1	SWAYAM	Earn credit via online courses	Develop and host courses; accept credits
2	SWAYAMPRABHA	Access 24x7 TV programs	Enable SWAYAMPRABHA viewing facilities
Digital Content Access			
3	National Digital Library	Access e-content in multiple disciplines	List e-content; form NDL Clubs
4	e-PG Pathshala	Access free books and e-content	Host e-books
5	Shodhganga	Access Indian research theses	List institutional theses
6	e-ShodhSindhu	Access full-text e-resources	Access e-resources for institutions
Hands-on Learning			
7	e-Yantra	Hands-on embedded systems training	Create e-Yantra labs with IIT Bombay
8	FOSSEE	Volunteer for open-source software	Run labs with open-source software
9	Spoken Tutorial	Learn IT skills via tutorials	Provide self-learning IT content
10	Virtual Labs	Perform online experiments	Develop curriculum-based experiments
E-Governance			
11	SAMARTH ERP	Manage student lifecycle digitally	Enable institutional e-governance
Tracking and Research Tools			
12	VIDWAN	Register and access experts	Monitor faculty research outcomes
13	Shodh Shuddhi	Ensure plagiarism-free work	Improve research quality and reputation
14	Academic Bank of Credits	Store and transfer credits	Facilitate credit redemption

Table 1.1: Summary of ICT Initiatives by the Ministry of Education

1.2 FOSSEE Project

The FOSSEE (Free/Libre and Open Source Software for Education) project promotes the use of FLOSS tools in academia and research. It is part of the National Mission on Education through Information and Communication Technology (NMEICT), Ministry of Education (MoE), Government of India.

1.2.1 Projects and Activities

The FOSSEE Project supports the use of various FLOSS tools to enhance education and research. Key activities include:

- **Textbook Companion**: Porting solved examples from textbooks using FLOSS.
- **Lab Migration**: Facilitating the migration of proprietary labs to FLOSS alternatives.
- **Niche Software Activities**: Specialized activities to promote niche software tools.
- **Forums**: Providing a collaborative space for users.
- **Workshops and Conferences**: Organizing events to train and inform users.

1.2.2 Fellowships

FOSSEE offers various internship and fellowship opportunities for students:

- Winter Internship
- Summer Fellowship
- Semester-Long Internship

Students from any degree and academic stage can apply for these internships. Selection is based on the completion of screening tasks involving programming, scientific computing, or data collection that benefit the FLOSS community. These tasks are designed to be completed within a week.

For more details, visit the official FOSSEE website.

Figure 1.1: FOSSEE Projects and Activities

1.3 Osdag Software

Osdag (Open steel design and graphics) is a cross-platform, free/libre and open-source software designed for the detailing and design of steel structures based on the Indian Standard IS 800:2007. It allows users to design steel connections, members, and systems through an interactive graphical user interface (GUI) and provides 3D visualizations of designed components. The software enables easy export of CAD models to drafting tools for construction/fabrication drawings, with optimized designs following industry best practices [1, 2, 3]. Built on Python and several Python-based FLOSS tools (e.g., PyQt and PythonOCC), Osdag is licensed under the GNU Lesser General Public License (LGPL) Version 3.

1.3.1 Osdag GUI

The Osdag GUI is designed to be user-friendly and interactive. It consists of

- **Input Dock**: Collects and validates user inputs.
- **Output Dock**: Displays design results after validation.
- **CAD Window**: Displays the 3D CAD model, where users can pan, zoom, and rotate the design.
- **Message Log**: Shows errors, warnings, and suggestions based on design checks.

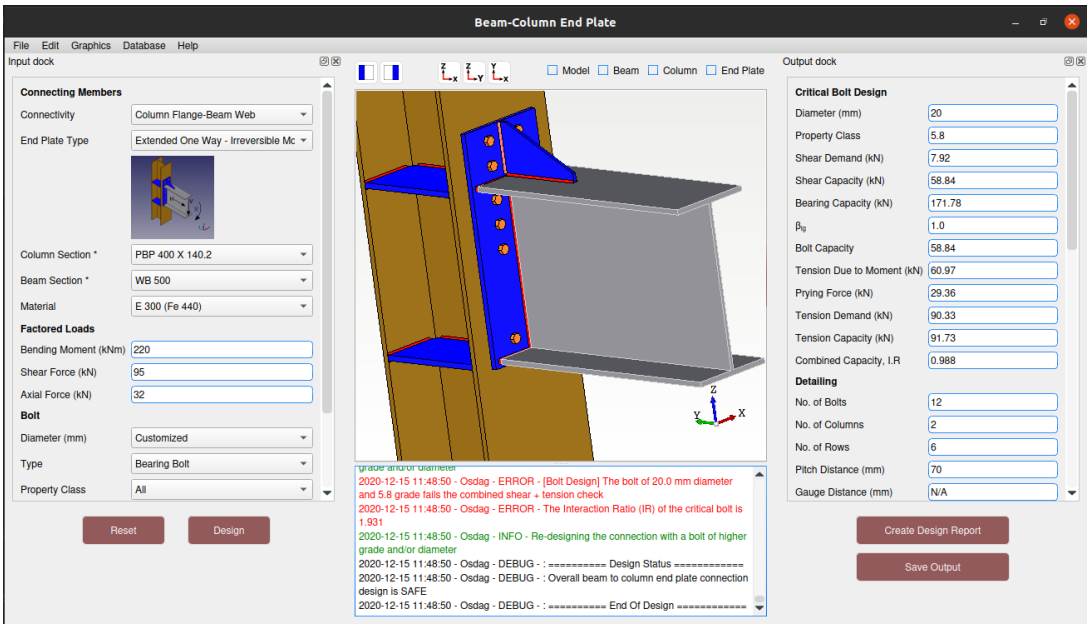


Figure 1.2: Osdag GUI

1.3.2 Features

- **CAD Model**: The 3D CAD model is color-coded and can be saved in multiple formats such as IGS, STL, and STEP.
- **Design Preferences**: Customizes the design process, with advanced users able to set preferences for bolts, welds, and detailing.
- **Design Report**: Creates a detailed report in PDF format, summarizing all checks, calculations, and design details, including any discrepancies.

For more details, visit the official Osdag website.

Chapter 2

Screening Task

2.1 Problem Statement

2.1.1 Problem Statement 1: Bending of Steel Structure Under Load

2.1.2 Problem Statement 2: Rupture Between Plates Under Tension Forces

2.2 Tasks Done

2.2.1 Screening Tasks – Documentation

During the screening phase, I was assigned two technically focused animation tasks, both of which were executed using **open-source software tools** as per the guidelines. The primary applications used were:

- **Blender** – for 3D modeling, structural simulation, and animation.
- **Audacity** – for integrating and editing sound effects to enhance the final output.

These tasks were aimed at visually explaining two advanced structural failure modes in steel structures using realistic and educational animation techniques.

Task 1: Lateral Torsional Buckling Animation

Objective:

To model and animate a steel I-section beam experiencing **lateral torsional buckling (LTB)**, a critical failure mode that occurs when a slender, unrestrained beam subjected to bending about its major axis begins to twist and laterally deflect.

Process Overview:

- Created a realistic I-section beam in **Blender** with appropriate boundary conditions to reflect a simply supported system.
- Simulated a gradually increasing vertical load applied at mid-span, representing real-world conditions.
- Animated the lateral displacement and twisting behavior, accurately reflecting the LTB phenomenon.
- Incorporated supporting elements such as arrows, labels, and deformation markers to highlight torsional behavior.
- Used **BlenderKit** for material realism and **Audacity** with **Pixabay** sound assets to provide subtle ambient sound effects, enhancing viewer understanding and engagement.

Outcome:

The final animation clearly demonstrated how a beam can fail through lateral torsional buckling, serving as a valuable visual aid for structural analysis education.

Task 2: Tension Member Block Shear Failure Animation

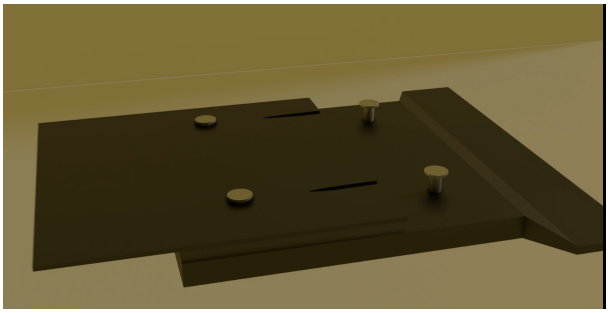
Objective:

To develop an animation depicting **block shear failure** in a tension member — a composite failure mechanism that combines tensile and shear rupture along the connection region of a steel plate.

Process Overview:

- Modeled a steel tension plate connected via bolts in **Blender**, replicating a typical tension connection detail.

Figure 2.1: steel structure under load



- Applied opposing tensile forces on either side of the member to simulate increasing load.
- Animated the initiation and progression of failure along the **shear planes (parallel to the force)** and **tensile rupture path (perpendicular to the force)**, forming the characteristic block shear pattern.
- Emphasized critical regions using stress indicators, crack propagation visuals, and zoomed-in views for clarity.
- Final compositing included relevant background sounds added via **Audacity** and sound assets from **Pixabay** to enhance the realism and instructional quality of the animation.

Outcome:

The animation effectively visualized how block shear failure occurs in tension members, helping illustrate an often misunderstood failure mode in structural engineering education.

Chapter 3

Internship Task 1: Structural Animation Development

3.1 Task 1: Problem Statement

The primary goal of the internship task was to visualize and communicate structural engineering phenomena through high-quality 3D animation. Specifically, two problems were addressed. The first was to simulate and animate the mechanism of lateral torsional buckling occurring in steel beams under loading conditions. The second required demonstrating the block shear failure in tension members, which represents a critical failure mechanism in structural steel design. These tasks demanded the application of engineering knowledge and creative visualization to effectively convey the real-world behavior of steel members under various force conditions.

3.2 Task 1: Tasks Done

The entire workflow was carried out using open-source tools such as Blender for modeling and animation and Audacity for audio mixing. The steps involved:

- **Scene Planning:** Realistic modeling of steel sections and loading environments based on structural references.
- **Modeling:** Steel beams and connection plates were created using Blender's mesh editing and proportional editing tools.

- **Animation:** Keyframe-based animation techniques were used to depict bending, displacement, and rupture phenomena accurately.
- **Physics-based Deformation:** Shape keys and modifiers such as bend and hook were used to simulate lateral torsional buckling and fracture.
- **Compositing:** Blender's compositor was utilized for visual effects such as camera motion, scene lighting, and render enhancement.
- **Audio Integration:** Sound effects were added using Audacity, and background music was sourced from Pixabay to enhance viewer engagement.

Tools Used:

- **Blender:** For all 3D modeling, rigging, and animation.
- **BlenderKit:** For importing texture materials and environment assets.
- **Audacity:** For post-production audio editing and mixing.
- **Pixabay:** For royalty-free background music and sound effects.

3.3 Task 1: Structural Animation Documentation

This task focused on creatively visualizing structural engineering concepts through animation. Specifically, the objective was to animate the behavior of a cantilever bridge under a distributed load to demonstrate weight distribution, deflection, and overall structural response.

3.3.1 Description of the Animation Task

The animation was designed to highlight how structural weight is transferred and resisted across different sections of a cantilever bridge. Blender, an open-source 3D creation suite, was used for modeling and animation, while textures and materials were sourced from BlenderKit.

- **Modeling:** A realistic cantilever bridge structure was modeled in Blender, including support columns, deck, and bracing.

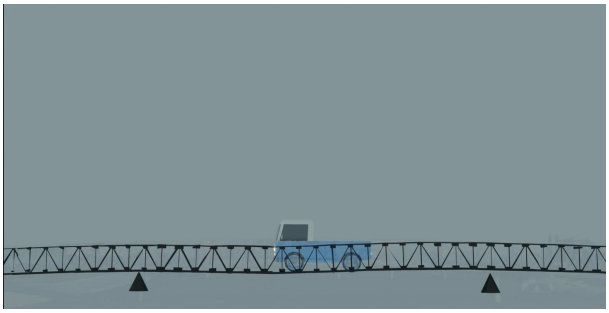
- **Animation:** The bridge deck was animated to simulate deflection under varying load conditions.
- **Rendering:** High-quality rendering was done using Blender's Eevee engine with realistic lighting and camera movement.
- **Sound and Effects:** Background audio and impact sound effects were added using Audacity and royalty-free sources like Pixabay.

3.3.2 Directory Structure

```
CantileverBridgeAnimation
├── bridge_model.blend
├── rendered_animation.mp4
├── assets
│   ├── textures
│   ├── materials
│   └── sound_effects
├── images
│   ├── frame_sample_1.png
│   └── frame_sample_2.png
└── references.txt
```

Execution Environment

All animations were created and rendered using Blender 3.6 on a Windows 10 system. Sound design was completed in Audacity, and all graphical assets were either self-created or sourced from open repositories like BlenderKit and Pixabay.



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Chapter 4

Internship Task 2

4.1 Task 2: Problem Statement

4.1.1 Frontend Development of Osdag Web

The goal of this task was to create a visually structured and interactive frontend interface for the Osdag web application using JSX and React. The frontend would include a tab-based interface, menu bar options, a 3D viewer placeholder, resizable log window, and a detailed input panel titled "Output Dock" to enter engineering parameters. This system aims to help structural engineers interact with steel connection modules easily.

4.1.2 Steel Structure Behavior Animation

The task involved designing an animated visual that demonstrates how various steel structures behave under different types of loads such as axial, shear, and bending. The animations aim to enhance understanding of structural deformation and failure points, which can help in both teaching and practical design assessments.

4.1.3 Rubber Behavior Animation

This task aimed to animate rubber material behavior under load conditions. It focused on visually conveying non-linear deformation, elastic recovery, and stress concentration, especially for structural components that use rubber-like damping or sealing systems. This animation helps visualize how flexible components behave compared to rigid steel

members.

4.2 Task 2: Tasks Done

4.2.1 Animation of Steel Structure Behavior Under Load

Interactive animations were created using 3D modeling and animation software to visualize the response of structural steel components under different load conditions. The deformation, yielding, and failure modes were visually demonstrated.

4.2.2 Rubber Behavior Under Load

Animations of rubber behavior under tensile and compressive loads were developed to demonstrate real-world flexible behavior. These included exaggerated strain visualizations to make the elastic and plastic transitions observable for educational purposes.

4.2.3 Frontend Development for Osdag Web (JSX)

The following JSX code demonstrates the core UI layout of the Osdag Web Application, built using React. It includes tabs, menu bar, a placeholder for a 3D viewer, a resizable log section, and a right-side form panel.

Listing 4.1: JSX code for Osdag Web UI

```
import React, { useRef, useState, useEffect } from "react";

export default function StructuralInterface() {
  const logRef = useRef(null);
  const [logHeight, setLogHeight] = useState(140);
  const [isResizing, setIsResizing] = useState(false);

  useEffect(() => {
    const handleMouseMove = (e) => {
      if (!isResizing) return;
      const newHeight = window.innerHeight - e.clientY;
      setLogHeight(newHeight < 100 ? 100 : newHeight);
```

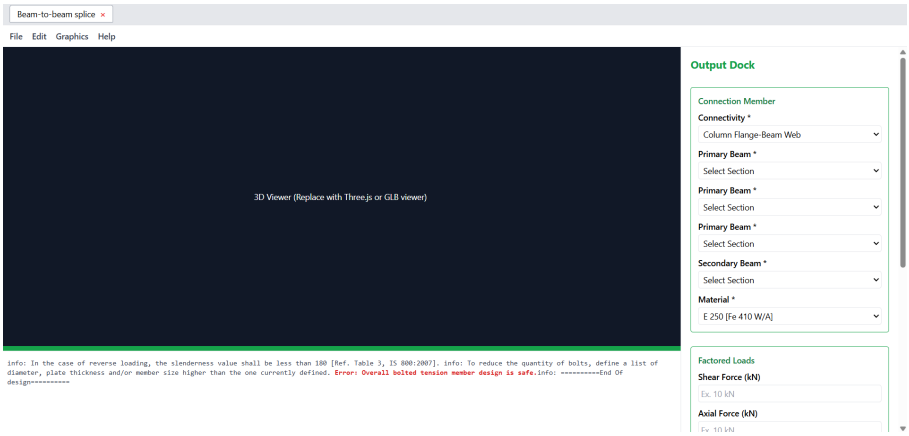
```
    };
    const handleMouseUp = () => setIsResizing(false);

    window.addEventListener("mousemove", handleMouseMove);
    window.addEventListener("mouseup", handleMouseUp);
    return () => {
      window.removeEventListener("mousemove", handleMouseMove);
      window.removeEventListener("mouseup", handleMouseUp);
    };
  }, [isResizing]);

  const [tabs, setTabs] = useState([{ id: 1, label: "Beam-to-beam
      splice" }]);
  const closeTab = (id) => setTabs(tabs.filter((tab) => tab.id
     !== id));

  return (
    <div className="w-screen h-screen flex flex-col bg-gray-100
       text-sm font-sans overflow-hidden">
      {/* Tabs, menu, 3D viewer, log panel and form inputs */}
    </div>
  );
}
```

4.3 Task 2: Code Explanation

The user interface is designed to offer structural engineers an interactive environment for steel design simulations. At the top, a tab system lets users switch between multiple design modules. Below this, a menu bar provides access to general options like File, Edit, Graphics, and Help.

The main view is split into two sections:

- **Left Side:** Contains a placeholder for a 3D viewer (for future integration of GLTF/Three.js-based models) and a resizable log window showing real-time mes-



sages, warnings, and errors.

- **Right Side:** A structured input panel titled "Output Dock" that lets users select design parameters including member type, material, bolt diameter, plate thickness, and loads.

Every section is visually enclosed in a green border and uses intuitive dropdowns and text fields for user input.

4.4 Task 2: Directory Structure

The directory structure used for the Osdag Web project is organized as follows:

```
osdag-web/

 public/
    index.html

 src/
    components/
       StructuralInterface.jsx
       InputSection.jsx
    styles/
       index.css
    App.jsx
    main.jsx
```

`package.json`

`vite.config.js`

This modular structure supports scalability and maintainability of the frontend application.

Chapter 5

Conclusions

5.1 Tasks Accomplished

During the internship, I contributed to both animation and frontend development tasks with a focus on structural engineering visualization and user interface design.

1. Animation Projects

- **Cantilever Bridge Under Load:** Created a detailed animation demonstrating how a cantilever bridge bends and deforms when subjected to external load.
- **Structural Bracing Impact:** Developed an animation showing the effect of steel structural bracing, emphasizing its role in enhancing stability.
- **Steel Structure Behavior:** Produced a simulation visualizing how a general steel structure responds under various loading conditions.

2. Frontend Development

- **Osdag Web Frontend (JSX):** Worked on building the user interface for the Osdag web application using React and JSX. This included implementing structural interaction features, UI components, and ensuring responsive design.

5.2 Skills Developed

Through this internship, I enhanced my skills in Blender animation for structural simulations and React-based web development. I gained a deeper understanding of engineering visualization and interactive UI design for technical applications.

Chapter A

Appendix

A.1 Work Reports

Internship Work Report

Name: Sasank Navuri

Project: Osdag Web and Animation

Internship: FOSSEE Winter Fellowship 2024

Detailed Work Log

Date	Day	Task	Hours Worked
15-May-2024	Thursday	First day introduction and Info session about the internship	0
16-May-2024	Friday	Installed Osdag software and tried to get familiar with the software	4
17-May-2024	Saturday	Got a grip on the Osdag software and modules to be developed	5
18-May-2024	Sunday	Non-Working day	
19-May-2024	Monday	Brushed up Blender skills before tasks began	8
20-May-2024	Tuesday	Assigned first task: steel structure bracing animation	7
21-May-2024	Wednesday	Worked on scene building and animation requirements	6
22-May-2024	Thursday	Researched steel structure properties and physics	6
23-May-2024	Friday	Animated and composed the steel bracing scene	8
24-May-2024	Saturday	Analyzed second task requirements	4
25-May-2024	Sunday	Non-Working day	
26-May-2024	Monday	Planned requirements for steel cantilever bridge animation	4

27-May-2024	Tuesday	Sourced reference for animation (Taylor Southgate Bridge)	8
28-May-2024	Wednesday	Replicated Taylor Southgate Bridge	7
29-May-2024	Thursday	Animated using Google Render Engine	5
30-May-2024	Friday	Scene building for cantilever bridge	4
31-May-2024	Saturday	Highlighted bridge behavior scene	4
01-Jun-2024	Sunday	Non-Working day	
02-Jun-2024	Monday	Completed Phase 1 and began Phase 2 with car models	8
03-Jun-2024	Tuesday	Worked on vehicle motion and bridge behavior	7
04-Jun-2024	Wednesday	Rendered and compiled the entire sequence	6
05-Jun-2024	Thursday	Started working on Osdag web development	7
06-Jun-2024	Friday	UI work for steel structure page	6
07-Jun-2024	Saturday	ReactJS development for UI	6
08-Jun-2024	Sunday	Non-Working day	
09-Jun-2024	Monday	Debugged and improved the frontend	6
10-Jun-2024	Tuesday	Submitted UI code for steel structure bracing	7
11-Jun-2024	Wednesday	Started steel structure behavior project	6
12-Jun-2024	Thursday	Studied steel structure load properties	7
13-Jun-2024	Friday	Worked on steel under different forces	8
14-Jun-2024	Saturday	Updated realism in steel structure animation	8

15-Jun-2024	Sunday	Review meeting with mentor	2
16-Jun-2024	Monday	Used colors to indicate forces and submitted	7
17-Jun-2024	Tuesday	Started rubber response to forces animation	6
18-Jun-2024	Wednesday	Analyzed rubber behavior and replication	6
19-Jun-2024	Thursday	Scene setup, lighting and materials	7
20-Jun-2024	Friday	Rendered rubber scene	6
21-Jun-2024	Saturday	Compiled rubber animation video	7
22-Jun-2024	Sunday	Implemented bug fixes from mentor	3
23-Jun-2024	Monday	Composed and submitted rubber animation	6
24-Jun-2024	Tuesday	Started compiling internship report	7
25-Jun-2024	Wednesday	Drafted case study improvements report	6
26-Jun-2024	Thursday	Submitted report for mentor feedback	7
27-Jun-2024	Friday	Improved Osdag web UI	7
28-Jun-2024	Saturday	Final review and updates	6
29-Jun-2024	Sunday	Prepared final report and compilation	4
30-Jun-2024	Monday	Final internship day and mentor discussion	0

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