DETAILED REPORT ON SHEAR FORCE AND BENDING MOMENT ANALYSIS (Approximately 3 Pages)

1. INTRODUCTION This report presents a detailed explanation of how shear forces and bending moments were extracted from a structural dataset and how the Shear Force Diagram (SFD) and Bending Moment Diagram (BMD) were generated for a selected sequence of beam elements. The workflow includes dataset handling, force component selection, chainage computation, and engineering interpretation of the resulting diagrams. These tasks are essential for evaluating the behavior, safety, and internal force distribution of the central longitudinal girder.

2. DATASET OVERVIEW AND ELEMENT SELECTION The dataset is provided in NetCDF format and accessed using the Xarray library. It contains multi-component internal force results for beam elements. The variable ‘forces’ has dimensions ('Element', 'Component'), where components include axial force, torsion, shear forces, and bending moments. For this study, the analysis focuses on a specific set of elements forming the central girder: [15, 24, 33, 42, 51, 60, 69, 78, 83] These elements are selected because they lie along the structural centerline, making them critical for evaluating global bending behavior.

3. WORKFLOW FOR EXTRACTING SHEAR AND MOMENT COMPONENTS

3.1 Data Loading The dataset is loaded using: ds = xr.open_dataset("screening_task1.nc") F = ds["forces"] This provides direct access to force and moment values indexed by element and component.

3.2 Shear Force Selection Shear forces act perpendicular to the longitudinal axis of the beam. Depending on the coordinate system, the vertical shear is obtained from: Vy = F.sel(Element=elem_ids, Component="Vy") This component directly contributes to the SFD, indicating load transfer along the girder.

3.3 Bending Moment Selection Bending moments cause rotation and curvature in the beam. The typical bending moment component used is: Mz = F.sel(Element=elem_ids, Component="Mz") This component represents bending about the horizontal (strong) axis, producing the primary BMD shape.

3.4 Force Continuity Through Node Chaining Beam elements share nodes, so forces must be reorganized into node order for clear plotting. Helper functions identify the starting and ending nodes for each element, extract corresponding force values, and ensure continuity along the chain. This process produces node-wise arrays for both shear and bending moment.

4. CHAINAGE GENERATION Chainage refers to the cumulative distance measured along the girder. It is computed using the coordinates of each node (x, y, z) by calculating the Euclidean distance between consecutive nodes. The cumulative sum of these distances forms the chainage array, which becomes the x■axis for SFD and BMD. Accurate chainage ensures that diagrams reflect true geometric spacing between structural segments.

5. PLOTTING OF SFD AND BMD

5.1 Shear Force Diagram To generate the SFD, the shear values are plotted against chainage: plt.plot(chainage, shear_vals) The SFD displays the internal shear distribution along the girder. Key features include: • Sudden jumps representing concentrated loads or reactions • Constant shear segments indicating uniformly distributed loads • Alternating positive and negative values showing load direction changes

5.2 Bending Moment Diagram Similarly, the BMD is plotted from moment values: plt.plot(chainage, moment_vals) Important characteristics include: • Maximum bending moment at mid-span under typical loading • Zero-crossings marking points of contraflexure • Smooth curvature indicating distributed loading conditions The BMD is essential for determining maximum structural stresses.

6. ENGINEERING INTERPRETATION

6.1 Shear Distribution The shear force diagram communicates how vertical loads travel through the girder: • Large shear values near supports indicate reaction concentrations • Sudden changes in shear correspond to load application points • Regions of high shear require adequate web thickness or stiffeners

6.2 Bending Behavior The BMD describes the bending stresses and curvature along the girder: • Maximum bending moments typically occur mid-span • High bending regions require larger moment of inertia or reinforcement • The sign of bending indicates sagging (positive) or hogging (negative)

6.3 Combined Structural Significance Together, SFD and BMD form the foundation of structural design: • Shear governs web sizing and connection design • Bending moment governs flange sizing and overall section capacity • Identifying critical zones helps prevent overstress and structural failure

7. CONCLUSION This report detailed the workflow for extracting shear forces and bending moments from a structured Xarray dataset and generating SFD/BMD diagrams. The process included selecting the relevant components, chaining nodes, computing chainage, and interpreting the diagrams in engineering terms. These analyses provide critical insight into the behavior of the central longitudinal girder and support informed structural design decisions.